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ORIGINAL ARTICLE

Accuracy of arterial occlusion pressure perception in practical blood flow restriction training after 6 weeks

Ratanyoo Longrak[ABCDE]

Faculty of Sport Science, Burapha University, Chon Buri, Thailand

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim: The low-intensity resistance training with blood flow restriction became a popular area of research due to its ability to promote key physiological adaptations. Nevertheless, the standard pneumatic blood flow restriction equipment was expensive and limiting its accessibility. The elastic wrap was proposed to be the effective alternative to standard pneumatic cuffs. However, the estimate occlusion pressure accuracy was questionable. Therefore, this study aimed to investigate the retention of arterial occlusion pressure perception used for practical blood flow restriction training in untrained individuals after 6 weeks following acclimation.

Material and Methods: Eighteen untrained participants (mean age: 21.1 years; height: 174.1 cm; body mass: 68.8 kg) were recruited. Each participant underwent assessment to determine their individual 100% arterial occlusion pressure (100%AOP) for the right leg and arm. Following this familiarization, they acclimated to a 40%AOP. After six weeks, participants returned for a reassessment of their perception of 40%AOP. Paired-samples t-tests were employed to analyze the differences between perceived and actual 40%AOP.

Results: Statistically significant differences were observed between perceived and actual 40%AOP for both the right leg ($p = 0.000$) and the right arm ($p = 0.01$). The 95% confidence intervals for estimated pressure error were 11.6 – 26.5 mm Hg for the right leg and 2.5 – 16.4 mm Hg for the right arm.

Conclusions: This study revealed significant differences between perceived and actual 40%AOP in both the right leg and arm after six weeks following acclimation. However, the perceived 40%AOP remained within the effective range for promoting muscle hypertrophy.

Keywords: arterial occlusion pressure, blood flow restriction, perception, practical BFR, resistance training

Introduction

Recently, low-intensity resistance training has become a popular area of research due to its ability to promote key physiological adaptations, such as increases in muscle size and strength [1]. To further enhance the benefits of low-intensity resistance training, the blood flow restriction (BFR) technique has been introduced as a supplementary method [2]. This technique involves the use of adjustable pneumatic cuffs applied to the proximal region of the upper or lower limbs, restricting blood flow during exercise [3]. The literature demonstrates that when combined with low-intensity resistance training, BFR can amplify hypertrophic adaptations to a greater extent [4].

Mechanistically, BFR operates by partially limiting venous return while reducing arterial inflow, thereby inducing a hypoxic environment within the muscle [5]. This localized hypoxia increases metabolic stress, which triggers several physiological adaptations, including heightened recruitment of fast-twitch muscle fibers [6], enhanced production of growth factors such as insulin-like growth factor-1 [7], and increased muscle protein synthesis [8]. Moreover, the accumulation of metabolites, such as lactate, may further activate anabolic signaling pathways [9]. Consequently, BFR allows for significant muscle adaptations even when low external loads are used, as opposed to traditional high-load resistance training.

In most cases, Pneumatic cuff systems are commonly used to apply pressure for restricting blood flow to muscles [10]. To individualize this pressure, arterial occlusion pressure (AOP) is typically measured using devices such as handheld Dopplers [11] or pulse oximeters [12]. Once an individual's AOP is determined, a specific percentage - such as 40% - is applied for training. Studies have explored various percentages of AOP, such as 40%, 50%, or 80% [11, 13, 14]. However, the primary limitation of this method is the high cost and limited accessibility of standard pneumatic blood flow restriction equipment, making its application in real-world training settings more challenging.

To make BFR training more accessible and reduce the costs associated with equipment, non-pneumatic option such as elastic wrap [11] was used and developed as practical blood flow restriction (pBFR) methods [15]. Research has shown that pBFR is effective in enhancing muscle growth and

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strength in both general populations and athletes. For example, a previous study found notable improvements in sprint performance and muscle thickness in active individuals after six weeks of sprinting training with pBFR [16] while the other study reported increased strength and muscle size in football players following a four-week low-load resistance training program using pBFR [17].

A significant challenge with pBFR is the standardization of its protocols. The use of elastic wrap makes it difficult to accurately measure the applied pressure, which is a major limitation of this method. Previous studies have sought to address this issue. For instance, Wilson and team introduced the perceived pain pressure method, where individuals wrap the elastic wrap until they reach a pain level of 7 out of 10 [15]. More recently, Bell and colleague proposed a method for standardizing pBFR by training individuals to sense the degree of occlusion [18]. This technique involves applying certain pressure such as 40% AOP and releasing pressure in a controlled manner for many intervals of 12 seconds on and 22 seconds off. Results showed that participants could effectively recall the sense of occlusion with an accuracy of less than 5 mmHg 24 hours later [18]. However, the retention of this sense over longer periods, such as weeks, has not yet been studied. Therefore, this study aims to investigate the retention of arterial occlusion pressure perception in untrained individuals after 6 weeks following acclimation.

Materials and Methods

Participants

This study represents the first phase of an investigation into the effects of resistance training on muscle hypertrophy. Sample size was justified by using G*Power version 3.1.9.7 software, based on input parameters from a previous study [19]. The parameters included an effect size of 0.75, $\alpha = 0.05$, and power = 0.80. The total number of participants in the study was 20. All participants met the following inclusion criteria: age under 22 years, no prior resistance training experience, no functional limitations affecting training, and no history of using pharmacological substances, ergogenic aids, performance-enhancing supplements, or anabolic steroids that could influence blood pressure.

Research Design

This study used a within-subject repeated-measures design to evaluate differences between the actual 40% arterial occlusion pressure (AOP) and the retention of perceived 40%AOP in the right leg and right arm at two time points: week 1 and after week 6. At baseline in week 1, participants were measured for both 100%AOP and 40%AOP in the right leg and right arm to allow them to acclimate to the 40%AOP. A re-test of their retention of perception of 40%AOP was conducted after 6 weeks. The study was conducted in accordance with the Declaration of Helsinki, with written informed consent obtained from all participants. The Institutional Review Board of the Burapha University Ethics Committee approved the study (Code: G-HS046/2566(C1)).

Arterial occlusion pressure measurement

To measure arterial occlusion pressure (AOP) for each participant, we used a pneumatic cuff (H+CUFF, USA) applied to the upper right leg or right arm in a random order. The cuff pressure was gradually increased by approximately 10 mmHg increments until blood flow could no longer be detected using a vascular Doppler (EDAN SD3, USA), indicating complete occlusion (100%AOP) (Figure 1) [1]. Once 100%AOP was established, we followed a previous protocol by reducing the pressure to 40%AOP without informing participants of the exact value. Participants then underwent an acclimation process, with alternating pressure cycles: 12 seconds with pressure on and 22 seconds with pressure off, all at their individual 40%AOP [18]. This cycle was repeated 15-20 times until participants became accustomed to the 40%AOP. Six weeks after, participants returned to the laboratory for follow-up measurements. The pneumatic cuff was re-applied to the same areas (upper right leg or right arm, in random order). This time, the pressure was increased by about 10 mmHg every 2 seconds, and participants were instructed to inform the researcher when they perceived the tightness to match their previous 40%AOP.

Statistical Analysis

For the statistical analysis, descriptive statistics were used to calculate the mean, standard deviation (SD), minimum and maximum for participants' baseline characteristics, and 100%AOP of right leg and right arm. Paired-samples t-tests were conducted to compare participants' perceived 40%AOP with their actual 40%AOP for both the right leg and right arm. All analyses were performed using IBM SPSS Statistics software version 20. Statistical significance was set at $p < 0.05$.

Results

Out of a total of 20 participants, 2 participants withdrew. The final analysis included 18 participants (Table 1).

The average 100%AOP for the right leg was 254 ± 32.7 mm Hg, while for the right arm it was 143.8 ± 17.9 mm Hg. From 100%AOP, the average 40%AOP for the right leg was 101.5 ± 13.1 mm Hg, and for the right arm, it was 57.5 ± 7.2 mm Hg.

After 6 weeks following acclimation, participants reported a perception of 40%AOP at 120.6 ± 14.3 mm Hg for the right leg, significantly different from actual 40%AOP (CI95% = 11.6–26.5 mm Hg, $p = 0.000$). Similarly, participants reported a perception

Figure 1. A pneumatic cuff (Left) and a vascular Doppler (Right)

Table 1. Baseline characteristics of participants

Measurement	Mean (n =18)	SD	Minimum	Maximum
Age (years)	21.1	0.5	20	22
Height (cm)	174.1	5.3	165	180
Body mass (kg)	68.8	11.3	56	94
100%AOP leg (mm Hg)	254	32.7	180	300
100%AOP arm (mm Hg)	143.8	17.9	120	180

Note: SD - Standard deviation; AOP -Arterial occlusion pressure.

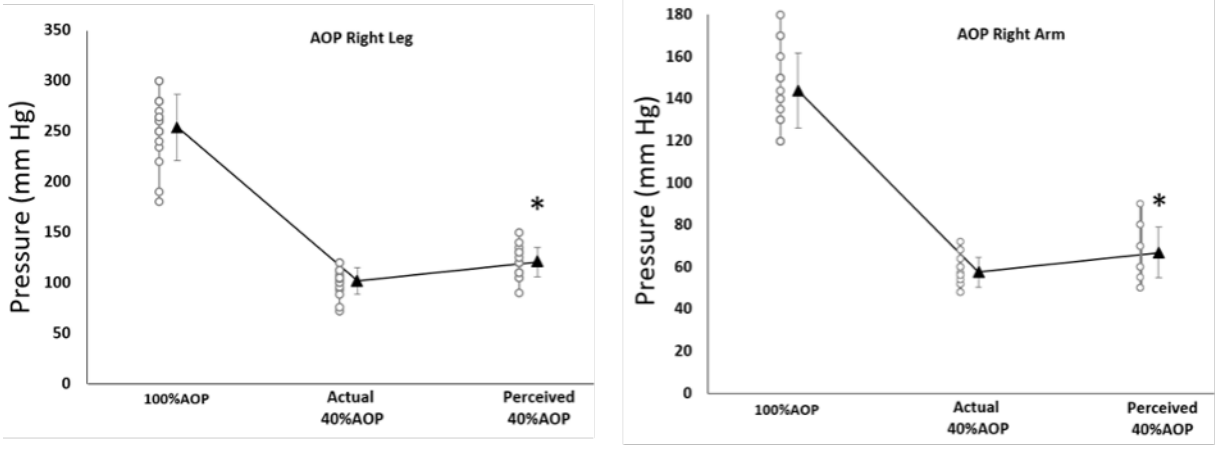

Figure 2. The average AOP for the right leg (Left) and the right arm (Right) at 100%AOP, actual 40%AOP, and perceived 40%AOP, with individual analyses: AOP - Arterial occlusion pressure; * indicates significant different from Actual 40%AOP.

of 40%AOP at 66.9 ± 12 mm Hg for the right arm, significantly different from actual 40%AOP (CI95% = 2.5–16.4 mm Hg, p = 0.01) (Figure 2).

Discussion

To the best of our knowledge, this was the first study to investigate the perception of arterial occlusion pressure after a 6-week period. Our findings indicated that, following an extended time after the familiarization session, participants' perception of arterial occlusion pressure changed significantly. Our finding did not support the use of practical blood flow restriction with elastic wraps that standardizing protocol by familiarizing practitioners to percentage of arterial occlusion pressure only in the first session [18].

A previous study reported that following a brief familiarization period of 5 minutes, the error in estimating AOP was just minimal, with participants achieving a target pressure close to the desired value (57 vs. 53 mm Hg). Even after 24 hours, the error remained small (57 vs. 54 mm Hg) [18]. Similarly, a recent study by Song and team demonstrated that individuals could learn to sense target pressures, although this ability diminishes over time [20]. Their study explored participants' perception of 40% AOP and found that after familiarization, the participants reported pressure estimations which were just slightly higher than target pressure, with deviations of 7.9 mm Hg at 5 minutes and 2.9 mm Hg at 30 minutes [20]. Our current findings extended the current literature by showing the

ability to accurately perceive AOP diminished more substantially over longer periods, such as after 6 weeks, which contrasted with previous studies indicating minimal error following short-term familiarization.

From a practical standpoint, the utilization of BFR to enhance low-intensity resistance training for inducing muscle hypertrophy had been suggested to be effective within an AOP range of 40-80% [2]. Although our study showed that participants were unable to accurately recall the exact perception of 40%AOP after 6 weeks, their perceived occlusion pressures were still approximately 48% for the right leg and 47% for the right arm. These values remained within the effective range for BFR, making it a viable approach for promoting hypertrophy. Furthermore, we proposed that regularly training the perception of occlusion pressure, such as by using an elastic wrap each week, might enhance the retention of the feeling of AOP after learning the actual 40%AOP from a pneumatic cuff [11].

Moreover, comparing to other practical applications of blood flow restriction, such as the widely-used method of perceived tightness of 7 out of 10 [15], the familiarization approach offered some greater precision and consistency. The subjective nature of the 7/10 method introduced variability, as individuals' perceptions of tightness could fluctuate based on factors like discomfort tolerance and prior experience. In contrast, this method, which was based on familiarization with a specific percentage of pressure, provides a more objective and measurable way to ensure that the occlusion pressure remained within the effective range for training. This reduced the risk of under- or overestimating the pressure, which can impact training efficacy and safety.

This study was not without limitations. The main limitation was the relatively short investigation period and the small number of participants, which could have been considered insufficient for standardizing the protocol. Therefore, we encouraged future studies to investigate the retention of perception over longer periods, such as 8–12 weeks, with a larger sample size.

Conclusions

In conclusion, this study was the first to investigate the retention of perception of arterial occlusion pressure over a 6-week period, revealing significant difference between perceived and actual 40%AOP for both the right leg and arm. Despite these differences, the perceived pressures remained within the effective range for inducing muscle hypertrophy. For practical application, we recommend tightening the elastic wrap slightly beyond perceived 40%AOP to maintain effective training pressures for hypertrophy.

Conflict of interests

The authors declare that there is no conflict of interests.

References

1. Dinyer TK, Byrd MT, Garver MJ, Rickard AJ, Miller WM, Burns S, et al. Low-Load vs. High-Load Resistance Training to Failure on One Repetition Maximum Strength and Body Composition in Untrained Women. *Journal of Strength and Conditioning Research*, 2019;33(7): 1737–1744. https://doi.org/10.1519/JSC.0000000000003194
2. Patterson SD, Hughes L, Warmington S, Burr J, Scott BR, Owens J, et al. Blood Flow Restriction Exercise: Considerations of Methodology, Application, and Safety. *Frontiers in Physiology*, 2019;10: 533. https://doi.org/10.3389/fphys.2019.00533
3. Perera E, Zhu XM, Horner NS, Bedi A, Ayeni OR, Khan M. Effects of Blood Flow Restriction Therapy for Muscular Strength, Hypertrophy, and Endurance in Healthy and Special Populations: A Systematic Review and Meta-Analysis. *Clinical Journal of Sport Medicine*, 2022;32(5): 531–545. https://doi.org/10.1097/JSM.0000000000000991
4. Loenneke JP, Wilson JM, Marín PJ, Zourdos MC, Bemben MG. Low intensity blood flow restriction training: a meta-analysis. *European Journal of Applied Physiology*, 2012;112(5): 1849–1859. https://doi.org/10.1007/s00421-011-2167-x
5. Törpel A, Herold F, Hamacher D, Müller NG, Schega L. Strengthening the Brain—Is Resistance Training with Blood Flow Restriction an Effective Strategy for Cognitive Improvement? *Journal of Clinical Medicine*, 2018;7(10):337.https://doi.org/10.3390/jcm7100337
6. Burd NA, Mitchell CJ, Churchward-Venne TA, Phillips SM. Bigger weights may not beget bigger muscles: evidence from acute muscle protein synthetic responses after resistance exercise. *Applied Physiology, Nutrition, and Metabolism*, 2012;37(3): 551–554. https://doi.org/10.1139/h2012-022
7. Aram S, Khodaei K, Zolfaghar Didani M. The effect of low-intensity suspension training with blood flow restriction on GH , IGF -1, and their association with physical fitness in young women. *Physiological Reports*, 2024;12(15): e16154. https://doi.org/10.14814/phy2.16154
8. Burd NA, West DWD, Staples AW, Atherton PJ, Baker JM, Moore DR, et al. Low-Load High Volume Resistance Exercise Stimulates Muscle Protein Synthesis More Than High-Load Low Volume Resistance Exercise in Young Men. Lucia A (ed.) *PLoS ONE*, 2010;5(8): e12033. https://doi.org/10.1371/journal.pone.0012033
9. Lawson D, Vann C, Schoenfeld BJ, Haun C. Beyond Mechanical Tension: A Review of Resistance Exercise-Induced Lactate Responses & Muscle Hypertrophy.

Journal of Functional Morphology and Kinesiology, 2022;7(4): 81. https://doi.org/10.3390/jfmk7040081
10. Ladlow P, Coppack RJ, Dharm-Datta S, Conway D, Sellon E, Patterson SD, et al. Low-Load Resistance Training With Blood Flow Restriction Improves Clinical Outcomes in Musculoskeletal Rehabilitation: A Single-Blind Randomized Controlled Trial. *Frontiers in Physiology*, 2018;9: 1269. https://doi.org/10.3389/fphys.2018.01269
11. Thiebaud RS, Abe T, Loenneke JP, Garcia T, Shirazi Y, McArthur R. Acute Muscular Responses to Practical Low-Load Blood Flow Restriction Exercise Versus Traditional Low-Load Blood Flow Restriction and High-/Low-Load Exercise. *Journal of Sport Rehabilitation*, 2020;29(7): 984–992. https://doi.org/10.1123/jsr.2019-0217
12. Hill EC, Housh TJ, Keller JL, Smith CM, Schmidt RJ, Johnson GO. Early phase adaptations in muscle strength and hypertrophy as a result of low-intensity blood flow restriction resistance training. *European Journal of Applied Physiology*, 2018;118(9): 1831–1843. https://doi.org/10.1007/s00421-018-3918-8
13. Santos A, Neves Jr M, Gualano B, Laurentino G, Lancha Jr A, Ugrinowitsch C, et al. Blood flow restricted resistance training attenuates myostatin gene expression in a patient with inclusion body myositis. *Biology of Sport*, 2014;31(2): 121–124. https://doi.org/10.5604/20831862.1097479
14. Laurentino GC, Loenneke JP, Teixeira EL, Nakajima E, Iared W, Tricoli V. The Effect of Cuff Width on Muscle Adaptations after Blood Flow Restriction Training. *Medicine & Science in Sports & Exercise*, 2016;48(5): 920–925. https://doi.org/10.1249/MSS.0000000000000833
15. Wilson JM, Lowery RP, Joy JM, Loenneke JP, Naimo MA. Practical Blood Flow Restriction Training Increases Acute Determinants of Hypertrophy Without Increasing Indices of Muscle Damage. *Journal of Strength and Conditioning Research*, 2013;27(11): 3068–3075. https://doi.org/10.1519/JSC.0b013e31828a1ffa
16. Behringer M, Behlau D, Montag JCK, McCourt ML, Mester J. Low-Intensity Sprint Training With Blood Flow Restriction Improves 100-m Dash. *Journal of Strength and Conditioning Research*, 2017;31(9): 2462–2472. https://doi.org/10.1519/JSC.0000000000001746
17. Yamanaka T, Farley RS, Caputo JL. Occlusion Training Increases Muscular Strength in Division IA Football Players. *Journal of Strength and Conditioning Research*, 2012;26(9): 2523–2529. https://doi.org/10.1519/JSC.0b013e31823f2b0e
18. Bell ZW, Spitz RW, Wong V, Yamada Y, Song JS, Abe T, et al. Can Individuals Be Taught to Sense the Degree of Vascular Occlusion? A Comparison of Methods and Implications for Practical Blood Flow Restriction. *Journal of Strength and Conditioning Research*, 2022;36(12): 3359–3365. https://doi.org/10.1519/JSC.0000000000004151
19. Zaroni RS, Brigatto FA, Schoenfeld BJ, Braz TV, Benvenutti JC, Germano MD, et al. High Resistance-Training Frequency Enhances Muscle Thickness in Resistance-Trained Men. *Journal of Strength and Conditioning Research*, 2019;33(1): S140–S151. https://doi.org/10.1519/JSC.0000000000002643
20. Song JS, Hammert WB, Kataoka R, Yamada Y, Kang A, Loenneke JP. Individuals Can be Taught to Sense the Degree of Vascular Occlusion: Implications for Practical Blood Flow Restriction. *Journal of Strength & Conditioning Research*, 2024;38(8): 1413–1418. https://doi.org/10.1519/JSC.0000000000004807

Information about the author:

Ratanyoo Longrak; https://orcid.org/0000-0001-6117-7617; addmuscleclinicz@gmail.com; Faculty of Sport Science, Burapha University; Chon Buri, Thailand.

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ORIGINAL ARTICLE

Development of Wellness Culture through corrective gymnastics

Darinka Ignatova[ABCDE]

Sofia University "St. Kliment Ohridski", Bulgaria

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim: Immobility leads to a decrease in the adaptive functions of the body, which is expressed in a weakening of the immune system and disorders in the psycho-emotional state. In addition, it harms the musculoskeletal system. The aim is to establish the influence of corrective spinal gymnastics on the development of the wellness culture, through optimal motor load in the tracked age period.

Material and Methods: The study subjects are 26 eight-year-old students from the initial stage of education at a metropolitan school. The dynamics of motor activity indicators based on spinal straightening complexes between boys and girls were monitored in five motor tests to determine the level of motor capacity. A comparative analysis of empirical values was carried out between the beginning and end of the study period from September 2023 to May 2024.

Results: Different types of sports stress different muscle groups, so progress is different in tests. All adolescents should be encouraged to play sports. The students in the study group are heterogeneous, showing progress in different tests. At the end of the school year, some students show no progress in results or maintain the levels from the beginning of the school year.

Conclusions: The decisive improvement of students' motor development is of extreme importance for their general working ability and their future realization in various areas of life. For this reason, complex effective measures are needed, especially in schools, so that physical education becomes a truly decisive factor for the high level of motor development, comprehensively affirming the Wellness Culture.

Keywords: corrective gymnastics, wellness culture, spinal gymnastics, motor development

Introduction

The promotion of wellness culture has gained significant attention as an integral part of enhancing physical and mental health in modern society. Wellness culture encompasses a holistic approach to health, integrating physical activity, mental well-being, and healthy lifestyle practices. It serves as a foundation for promoting lifelong habits that enhance quality of life, particularly when introduced during formative years. Through activities like corrective gymnastics, wellness culture offers opportunities to address physical development while fostering resilience and overall well-being in children.

Numerous studies highlight the significance of "Wellness Culture" and "Wellness Practices" in promoting physical health, mental well-being, and a balanced lifestyle. Nesheva and Chipeva [1] studied the integration of cheerleading into school wellness programs as part of physical education. They assert that cheerleading promotes physical fitness, social skills, and emotional well-being among students. The authors also highlight the importance of ensuring safety and supervision in cheerleading activities to maximize its benefits and foster a holistic approach to student wellness.

Ignatova [2] explored the integration of smart educational models in wellness practices, emphasizing their role in enhancing physical activity and promoting emotional intelligence among students. The study highlights the potential of innovative methodologies, including distance learning technologies, to support the development of wellness culture and motor potential. Author asserts that these approaches can effectively improve physical, mental, and emotional well-being in educational settings.

Dimitrova [3] investigated the standards for wellness services and the certified skills of specialized staff within the Bulgarian niche tourism industry. The study highlights the critical need for well-trained personnel to meet the increasing demands of the wellness sector and emphasizes the importance of standardization in service quality. Author concludes that collaboration between institutions and organizations is essential for developing state standards and certification programs to ensure high-quality wellness services and enhance Bulgaria's competitiveness in the global market.

Ustymenko [4] analyzed the influence of wellness culture on the formation and development of the wellness industry. The study introduced the concepts of "wellness culture" and "wellness industry," emphasizing their structural components and social functions. Author highlights the need

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for effective integration between tourism and the wellness industry, focusing on innovative recreational approaches, modernization of facilities, and national programs to promote wellness tourism as a means to enhance quality of life.

Authors of studies on "Wellness Culture" emphasize its essential role in fostering lifelong health and well-being. They highlight the necessity of integrating wellness practices into daily routines and educational settings to build a strong foundation for physical and mental resilience.

Numerous studies emphasize the importance of "Corrective Gymnastics" particularly in school-aged children and younger populations, for addressing postural issues, enhancing motor skills, and promoting overall physical development. In a study by Palhares [5], the theoretical principles of corrective gymnastics were examined with a focus on postural biomechanics. The author highlights the importance of the pelvis as the central structure for posture and emphasizes exercises that address the entire locomotor system while respecting individual limits. The findings suggest that corrective gymnastics, by incorporating systematic and holistic exercises, can improve musculoskeletal function, postural alignment, and overall balance.

In research conducted by Živković and Buišić [6], the role of corrective gymnastics in early childhood education was examined, with a focus on its integration into curricula for educators and teachers. The study emphasizes the importance of preventive and corrective exercises in addressing postural disorders and body deformities in preschool and young school-age children. The authors argue for the inclusion of corrective gymnastics as a mandatory subject in teacher training programs, highlighting its potential to promote proper posture, support motor development, and enhance overall health from an early age.

In research conducted by Kinov [7], the role of corrective gymnastics was examined in physical education lessons for students in special schools for individuals with mental retardation. The author highlights the effectiveness of specially designed gymnastic exercises in addressing scoliosis and other postural deformities common in this population. Author findings demonstrate that regular application of corrective exercises significantly reduced the prevalence and severity of scoliosis, showcasing the potential of targeted physical activities to improve musculoskeletal health and overall physical function in children with mental disabilities.

A study by Rokicka-Hebel [8] evaluated the impact of corrective gymnastics on motor skills in five- and six-year-old preschool children. The author revealed that while participants demonstrated slight improvements in specific skills, such as walking on a balance bench and throwing a ball against a wall, the overall contribution of corrective gymnastics to motor development was limited. The study concluded that the effectiveness of these activities depends heavily on the quality of implementation and the engagement of educators.

Research on "Corrective Gymnastics" underscores its critical role in supporting the healthy physical development of children. The findings advocate for the inclusion of corrective exercises in early education programs to address postural issues and enhance motor coordination effectively.

Evidence supporting this is presented in other studies on various aspects of the application and use of corrective exercises for different conditions and age groups. Corrective exercises are very necessary for today's immobile and physically unprepared teenagers [9, 10, 11, 12]. Physical education, along with moral, aesthetic, mental, and work education, supports the all-round development of the personality, making it equally beneficial for the individual and society [13, 14, 15, 16]. Different types of corrective exercises are incorporated into each of the presented lesson units, with emphasis on proper execution to achieve the goals and objectives of the research [17, 18, 19, 20].

Despite the growing body of evidence highlighting the benefits of wellness culture and corrective gymnastics, significant challenges remain in their practical implementation. Many educational institutions still lack structured programs that effectively integrate these practices into the daily routines of children and adolescents. Moreover, the variability in execution quality and the limited engagement of educators often hinder achieving the desired outcomes. Addressing these gaps requires continued research and a concerted effort to develop comprehensive strategies that align with the diverse needs of different age groups and conditions.

The aim of this study is to evaluate the influence of corrective spinal gymnastics on the development of wellness culture through optimal motor load during the observed age period. The object of the study is the process of pedagogical interaction and the impact of corrective exercises on posture correction.

Materials and Methods

Participants

The study included 26 eight-year-old students from the initial stage of education at a metropolitan school. Ethical standards for research involving human participants were strictly adhered to, in compliance with the principles outlined in the Declaration of Helsinki. The study was approved by the Ethics Committee of Sofia University "St. Kliment Ohridski." Written informed consent was obtained from the parents or legal guardians of all participants prior to the commencement of the study.

Study Design

Tests

The study utilized several motor tests, each designed to assess specific physical qualities and performed under modified or group methods:

1. *30m Run (Modified Method)*. This test evaluates speed and acceleration over a short distance. Participants start from a standing position and sprint 30 meters as quickly as possible, with the time recorded for each student.
2. *Standing Long Jump (Modified Method)*. The standing long jump measures explosive leg power. Participants jump forward from a standing position, landing on both feet. The distance is measured from the take-off line to the nearest point of contact on landing.
3. *Throwing a Solid Ball (Modified Method)*. This test assesses upper body strength and coordination. Students throw a heavy, solid ball as far as possible using a two-handed overhead technique. The distance of the throw is recorded.
4. *Shuttle Run (Modified Method) 4 x 50m*. The shuttle run tests endurance and speed over a longer distance. Participants run back and forth between set markers, completing multiple lengths to cover a total distance of 200 meters.
5. *Agility T-Test (Modified Method)*. This combined test was modified based on the well-known "Agility T-test," which evaluates change-of-direction speed during forward sprinting, lateral shuffling to the left and right, and back-pedaling [21, 22]. The test was further enhanced by incorporating a tennis ball throw. Additionally, a rubber hoop was used as part of the test.

The dynamics of motor activity indicators based on spinal straightening exercises were monitored through five motor tests to assess the level of motor capacity in boys and girls. A comparative analysis of empirical values was conducted between the beginning and end of the study period, spanning from September 2023 to May 2024.

Assessment of Motor Activity

The evaluation of motor activity was performed as follows:

- Assessment of individual test results.
- Calculation of the final physical capacity score.

The assessment of individual test results was conducted using two methods:

1. A 20-point scale.
2. Interval determination according to a six-point scoring system.

To evaluate individual test results using the 20-point scale:

- The points assigned for each result were determined based on the age and gender of the students, using standardized tables.
- This process was repeated for all tests.
- The scores obtained were converted to the six-point grading system, and the final physical capacity score was calculated as the arithmetic mean of the scores from all tests.

Using a 20-point scale provides better comparability between individual tests and highlights how many points are needed to achieve a higher score.

To evaluate results using the six-point scoring system:

- The scores were determined according to the age and gender of the students, referencing standardized tables.
- Scores from all tests were averaged to calculate the final physical capacity score.

The final assessment of a student's physical capacity was calculated only when results from all five tests were available.

Statistical Analysis

The statistical analysis was conducted to evaluate the effectiveness of corrective spinal gymnastics on motor capacity and posture correction in eight-year-old students. Data collected from motor fitness tests were analyzed quantitatively and qualitatively, with comparisons drawn between the beginning (September 2023) and end (May 2024) of the academic year.

For each test, results were assessed using a 20-point scale and a six-point grading system. The final physical capacity score for each participant was calculated as the arithmetic mean of the scores across all five motor tests. Comparative analysis included evaluating differences in the dynamics of motor activity indicators between boys and girls. The significance of progress within the academic year was determined by comparing mean scores at the two time points.

The results were further analyzed to identify trends in motor development, taking into account factors such as individual variability and the impact of regular participation in physical education lessons. Descriptive statistics and graphical methods, such as bar charts, were used to illustrate group performance and highlight differences in test results over the study period.

Results

The study assessed the maximum percentage improvement in performance indicators for each motor test among all participants. Figure 1 summarizes the results, showcasing the highest percentage increase in performance across various physical tests, including speed, power, and agility. These improvements highlight the effectiveness of the applied corrective spinal gymnastics program. As shown in Figure 1, the *Standing Long Jump* demonstrated the highest maximum improvement (33%), indicating significant gains in explosive leg power among participants. The

remaining tests showed consistent improvements of 16% to 17%, reflecting balanced progress in speed, strength, and agility. These results suggest that the corrective spinal gymnastics program effectively enhanced physical performance across various motor domains. The differences in improvement percentages may be attributed to the specific nature of each test and its emphasis on particular physical qualities.

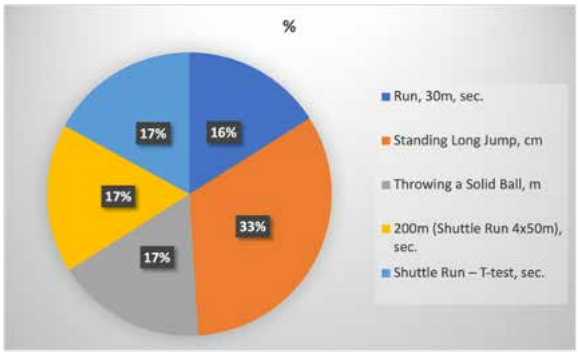

Figure 1. Maximum Performance Improvements in Motor Tests

The study also analyzed the average relative increase in motor activity for boys and girls across various physical tests. Figure 2 presents the results, highlighting gender-specific differences in the improvement of motor performance. These findings provide insights into the effectiveness of corrective spinal gymnastics in enhancing physical capabilities for both genders. Figure 2 highlights gender-based variations in the relative increase in motor activity across the tests. Boys demonstrated the highest improvement in one of the power-based tests, while girls showed greater progress in tests emphasizing agility and coordination. In some tests, boys exhibited higher average relative increases, while girls performed better in others, suggesting that gender differences influence the development of specific motor skills. These variations may be attributed to differences in physical attributes, training response, or baseline performance. These results confirm and align well with the findings of our previous study [23].

Discussion

The primary aim of this study was to evaluate the influence of corrective spinal gymnastics on motor activity and posture correction in eight-year-old students. The results indicate significant improvements in motor capacity among participants, particularly in specific tests such as the standing long jump and the 1kg medicine ball push at the end of the experimental period. However, variations in performance were observed, with some students maintaining similar levels of motor ability throughout the study.

The present study builds upon the author's prior research [12-18, 23], affirming the effectiveness and relevance of implementing innovative methodologies in physical education to promote Wellness Culture and enhance motor capacity. Previous studies demonstrated the benefits of integrating specialized systems, such as the Blaze-Pod Trainer, to develop agility and general motor readiness in school-aged children, while highlighting the critical role of structured physical education in addressing motor deficits caused by modern sedentary lifestyles and e-learning environments [12, 16]. Furthermore, earlier findings emphasized the importance of fostering speed, strength, and coordination abilities, aligning them with the developmental characteristics of younger students [14]. The current results corroborate these conclusions, extending their practical applicability by validating corrective gymnastics as a means to address postural issues and support motor improvement in primary education settings. These findings underscore the necessity of adopting comprehensive and innovative approaches to physical education to ensure sustained progress in motor skills and overall wellness [2].

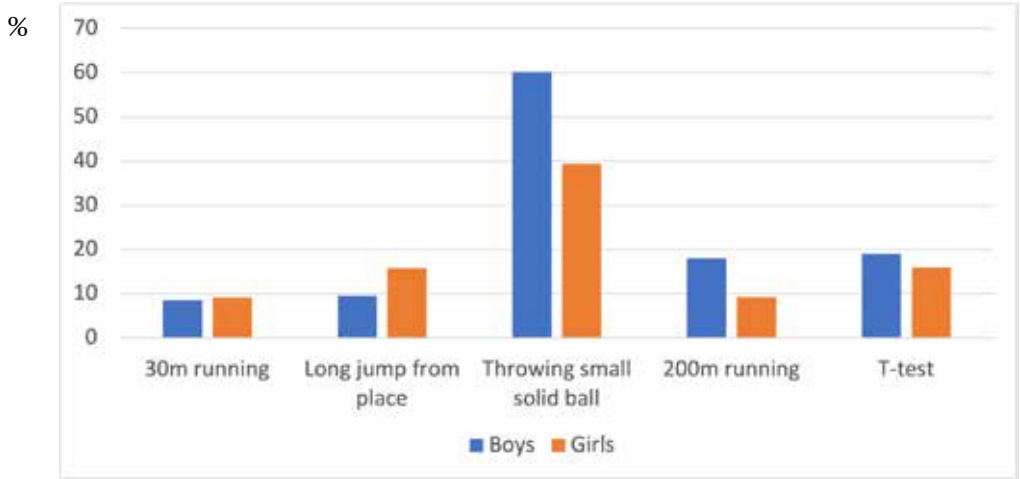

Figure 2. Analysis of Average Relative Increase in Motor Activity

The findings align with existing research emphasizing the importance of Wellness Culture and corrective gymnastics in improving physical capacity and promoting overall health. For instance, Nesheva and Chipeva [1] demonstrated how wellness practices, including physical activities, foster social skills and emotional well-being, which is consistent with the observed positive effects on the students' motivation and participation in this study. Similarly, Ignatova [2] highlighted the role of innovative approaches in wellness education, suggesting that modern methodologies can further enhance the effectiveness of corrective gymnastics [1, 2].

The present results also resonate with Dimitrova's [3] analysis, which underscored the significance of structured wellness programs in institutional settings. Author emphasis on standardization and high-quality implementation parallels the need for well-prepared and thoroughly executed physical education lessons observed in this study [3].

In the context of corrective gymnastics, the findings reinforce earlier conclusions about its role in addressing postural issues and enhancing motor skills. Palhares [5] emphasized the biomechanical principles of corrective gymnastics, particularly its focus on improving the stability and alignment of the spinal region, which is central to the exercises applied in this study. Moreover, Živković and Buišić [6] stressed the importance of incorporating corrective gymnastics into early education curricula, a practice reflected in the current research's integration of spinal exercises into the physical education program [6].

Ustymenko's work on the structural components of wellness culture and its social functions further supports the significance of combining corrective gymnastics with wellness practices to optimize health outcomes [4]. This aligns with the emphasis in this study on achieving both motor improvements and broader wellness goals through tailored physical activities [4].

The role of teacher engagement and the quality of exercise implementation, highlighted by Kinov [7] and Rokicka-Hebel [8], is evident in this study. These authors pointed out that the success of corrective gymnastics largely depends on the involvement of educators and their ability to adapt exercises to individual needs. This study observed similar trends, where teacher involvement directly influenced the progress of students in motor tests [7, 8].

While the results affirm the benefits of corrective gymnastics, they also highlight existing challenges, such as variability in student progress and the impact of factors like attendance, motivation, and extracurricular activity levels. The heterogeneity of the study group underscores the importance of individualized approaches and the need for further research to optimize training programs for diverse populations.

To emphasize the connection between upbringing at the age of eight and potential manifestations in adulthood, it is essential to recognize that habits and physical activity patterns established during childhood significantly influence health outcomes later in life. Evidence suggests that early interventions targeting motor skill development, posture correction, and wellness culture lay the foundation for improved physical fitness, reduced risk of chronic diseases, and better overall quality of life in adulthood. These findings are supported by studies that highlight the long-term impact of early childhood education and physical activity on adult health and well-being:

- The relationship between burnout and wellness culture has been observed in emergency medicine providers, where moderate correlations were found between wellness culture domains, such as value alignment and provider appreciation, and lower burnout rates [24].
- Social media plays a significant role in promoting wellness culture, as seen in plastic surgery residency programs, where Instagram had the highest engagement rates, and wellness-related content primarily focused on work-life balance and educational events [25].
- Research has questioned the inclusivity of wellness culture, examining how it often excludes certain demographics, highlighting the need for more equitable approaches [26, 27].
- The use of innovative methodologies, such as Blaze-Pod Trainer systems, has demonstrated effectiveness in developing motor potential and agility in primary education, affirming the role of structured physical education programs in fostering wellness culture [16].
- The positioning of continuous glucose monitors (CGMs) as luxury wellness technologies highlights broader trends in health and wellness culture, raising concerns about accessibility and equity in preventative health measures [28].
- Digital wellness culture is expanding through email marketing strategies, offering a perceived escape from mainstream healthcare timelines while promoting personal engagement and global adoption of wellness ideals [29].
- Higher perceptions of wellness culture and workplace appreciation have been linked to improved mental health outcomes and reduced burnout among academic faculty, emphasizing the importance of institutional support in fostering wellness [30, 31].
- The interplay between wellness culture and participatory social media affordances has been shown to enable the spread of misinformation and extremism, raising concerns about its ethical and social implications [32].

In this context, the results of our study not only complement previous findings but also confirm and provide new insights into addressing the problem. By focusing on corrective spinal gymnastics and its impact on motor development and wellness culture among school-aged children, our research highlights the practical application of tailored physical education methodologies. These findings reinforce the importance of structured, age-appropriate interventions to enhance motor skills, promote healthy habits, and support overall well-being, while also addressing gaps identified in previous studies related to accessibility and long-term effectiveness.

Limitations of the Study

This study has certain limitations that should be considered when interpreting the results. Firstly, the sample size of 26 students, though sufficient for initial observations, may limit the generalizability of the findings to broader populations. Secondly, the study focused solely on eight-year-old students, which restricts the applicability of the results to other age groups.

Additionally, the influence of external factors, such as varying levels of extracurricular physical activity, parental involvement, and nutritional habits, was not controlled. These factors could have contributed to differences in motor development and physical performance among participants.

Finally, the study period of one academic year may not fully capture long-term trends or the sustained impact of corrective spinal gymnastics on motor development and wellness. Future research should consider longitudinal designs and larger, more diverse samples to validate and extend these findings.

Practical Recommendations

Systematic inclusion of spinal-rectifying complexes in physical education lessons is essential. Regular monitoring and consistent application during each session help address individual needs and support overall motor development.

Motor fitness test data should be used to identify strengths and weaknesses of individual students and the class as a whole. Tracking the dynamics of physical qualities over time allows teachers to adjust training methods and improve their effectiveness. Analytical assessments provide valuable insights into the success of applied training methods and help refine them for better outcomes.

The systematic evaluation of results enables teachers to identify athletically gifted students and guide them toward specialized training activities. Schools should implement multi-faceted approaches to ensure that physical education becomes a decisive factor in achieving high levels of motor development and fostering Wellness Culture.

Progress within the academic year can be measured by comparing test scores from the beginning and the end of the year, focusing on the impact of training while considering limitations related to ontogenetic factors.

Conclusions

The findings of this study underscore the importance of integrating corrective spinal gymnastics into physical education programs to support the development of motor skills and wellness culture among young students. This approach aligns with broader educational objectives, emphasizing the holistic development of children and the promotion of healthy habits from an early age.

The study highlights the need for structured, systematic methodologies in physical education, tailored to the diverse needs and abilities of students. The effectiveness of such programs depends significantly on the active engagement of educators and the consistent implementation of evidence-based practices.

Conflict of interests

The authors declare that there is no conflict of interests.

References

1. Nesheva I, Chipeva M. Wellness at school by practicing cheerleading. *Trakia Journal of Sciences*, 2023;21(Suppl 1):474–9. https://doi.org/10.15547/tjs.2023.s.01.079.
2. Ignatova D. Smart educational models of wellness practices. *International Scientific Journal for Smart Innovations,* 2024;6:15–23.
3. Dimitrova B. Quality assessment about standards for wellness services and certified skills of specialized staff. *Trakia Journal of Sciences*, 2019;17(2): 143–149. https://doi.org/10.15547/tjs.2019.02.007
4. Ustymenko L. Wellness culture as a factor of formation of wellness-industry. *Culture and Arts in the Modern World*, 2020;(21): 182–190. https://doi.org/10.31866/2410-1915.21.2020.208253
5. Palhares D, Rodrigues JA, Rodrigues LM. Theoretical principles for postural corrective gymnastics. *Brasília Med.* 2008;45(2):116–121.
6. Živković Vuković JA, Buišić S. Corrective Gymnastics - Compulsory Course for Teachers and Educators. *Sportske nauke i zdravie - APEIRON,* 2021;21(1). https://doi.org/10.7251/SSH2101108V
7. Kostov K, Kinov S, Dokova N. Corrective gymnastics in the physical education lessons with students in special schools for mentally retarded. *Phys Educ Sport Kinesither Res J.* 2016;1(1):1–5.
8. Rokicka-Hebel M. Corrective gymnastics and motor skills of fiveand six-year-old children. *Balt J Health Phys Act.* 2014; 6(2): 114–126. https://doi.org/10.2478/bjha-2014-0011
9. Dimitrova B, Izov N, Alexandrova V, Iosifov R, Ignatova D, Trendafilov D, et al. *Smart kognitiven*

instrumentatium. Sofia: NSA Pres; 2021. (In Bulgarian).
10. Dimitrova B. Relationships between education and innovations in the recreational industry in Bulgaria. *Trakia J Sci.* 2018;18(2):143–149.
11. Dimitrova B. *New smart educational model "Wellness instructor".* 1st ed. Sofia: Avangard Prima; 2019.
12. Ignatova D. Affirming Wellness Culture through Innovative Methodology Related to Blaze-Pod Trainer System. *Strategies for Policy in Science and Education-Strategii na Obrazovatelnata i Nauchnata Politika*, 2023;31(2): 212–225. https://doi.org/10.53656/str2023-2-7-aff
13. Ignatova D. Specificity of the motor potential for achieving scholar wellness. *Trakia J Sci.* 2021;19(1):867-873.
14. Ignatova D. Motor activity based on learning – contemporary trends in school wellness. *Smart Innov Recreative Wellness Ind Niche Tourism Sci J.* 2023;5(1-2):22–26.
15. Ignatova D. The effects of swimming on preschool children with spinal abnormalities. *17th International Balkan Society for Pedagogy and Education (BASOPED) Conference "Traditions and Innovations in the Education of the Balkan Countries";* 2018. P. 207–212.
16. Ignatova D. Implementation of Motor Complexes Based on Specialized Application System Blaze-pod Trainer. *Strategies for Policy in Science and Education-Strategii na Obrazovatelnata i Nauchnata Politika*, 2023;31(6): 653–667. https://doi.org/10.53656/str2023-6-6-imp
17. Ignatova D. Study the influence of yoga specialised practices on the formation of correct body posture and corrections of spinal deformities. *Smart Innov Recreative Wellness Ind Niche Tourism Sci J.* 2023;4(1-2):17–22.
18. Ignatova D. Reliable Instruments in the Assessment of Schoolar Wellness in the Primary Educational Level. *Strategies for Policy in Science and Education-Strategii na Obrazovatelnata i Nauchnata Politika*, 2022;30(1): 70–81. https://doi.org/10.53656/str2022-1-4-rel
19. Ignatov G. Comparative analysis of the technical actions of female university students practicing football. *Series on Biomechanics*, 2022;36(2). https://doi.org/10.7546/SB.36.2022.02.08
20. Ignatov G, Petkova I. The changes in the professional and personal profile of the students in the physical education and sports programme at Sofia University "St. Kliment Ohridski" as a result of COVID-19. *Int J Kinesiol Other Relat Sci.* 2022;50(1):15-20.
21. Sassi RH, Dardouri W, Yahmed MH, Gmada N, Mahfoudhi ME, Gharbi Z. Relative and Absolute Reliability of a Modified Agility T-test and Its Relationship With Vertical Jump and Straight Sprint. *Journal of Strength and Conditioning Research*, 2009;23(6): 1644–1651. https://doi.org/10.1519/JSC.0b013e3181b425d2
22. Foqha BM, Schwesig R, Ltifi MA, Bartels T, Hermassi S, Aouadi R. A 10-week FIFA 11+ program improves the short-sprint and modified agility T-test performance in elite seven-a-side soccer players. *Frontiers in Physiology*, 2023;14: 1236223. https://doi.org/10.3389/fphys.2023.1236223
23. Ignatova D. Tracking functional dynamics in motor potential for development of wellness culture. *Trakia Journal of Sciences,* 2023;21(Suppl. 1):583–590. https://doi.org/10.15547/tjs.2023.s.01.097
24. Jyothindran R, d'Etienne JP, Marcum K, Ho AF, Robinson RD, Tijerina A, et al. Association between burnout and wellness culture among emergency medicine providers. *Clinical and Experimental Emergency Medicine*, 2021;8(1): 55–64. https://doi.org/10.15441/ceem.20.074
25. Maisner RS, Kapadia K, Keenan E, Ravikumar V, Ayyala HS, Lee ES. A Social Media Analysis of Wellness Culture in Plastic Surgery Residency. *Annals of Plastic Surgery*, 2022;88(3): S250–S256. https://doi.org/10.1097/SAP.0000000000003191
26. Faucheux D. Who Is Wellness For? An Examination of Wellness Culture and Who It Leaves Behind. *Library Journal*, 2022;147(9): 79–79.
27. Hoffert B. Who Is Wellness For?: An Examination of Wellness Culture and Who It Leaves Behind. *Library Journal*, 2022;147(1): 46–46.
28. Brady P. Wearing Wellness: A Comparative Analysis of Diabetic and Non-Diabetic Continuous Glucose Monitoring in a Self-Surveilling Wellness Culture. *Proceedings of The 42nd International Conference on Design Of*, 2024;: 158–165. https://doi.org/10.1145/3641237.3691664
29. Hendry NA. 'Hey lovely! Don't miss this opportunity!' Digital temporalities of wellness culture, email marketing, and the promise of abundance. *Journal of Sociology*, 2023;59(3): 664–681. https://doi.org/10.1177/14407833221101397
30. Melnyk BM, Strait LA, Beckett C, Hsieh AP, Messinger J, Masciola R. The state of mental health, burnout, mattering and perceived wellness culture in Doctorally prepared nursing faculty with implications for action. *Worldviews on Evidence-based Nursing*, 2023;20(2): 142–152. https://doi.org/10.1111/wvn.12632
31. Melnyk BM, Strait LA, Beckett C, Hsieh AP, Messinger J, Masciola R. The state of mental health, burnout, mattering and perceived wellness culture in Doctorally prepared nursing faculty with implications for action (vol 20, pg 142, 2023). *Worldviews on Evidence-based Nursing*, 2023;20(4): 415–415. https://doi.org/10.1111/wvn.12662
32. Baker SA. Alt. Health Influencers: how wellness culture and web culture have been weaponised to promote conspiracy theories and far-right extremism during the COVID-19 pandemic. *European Journal of Cultural Studies*, 2022;25(1): 3–24. https://doi.org/10.1177/13675494211062623

Information about the author:

Darinka Ignatova; DSc. of Medical Sciences, Associate Professor; https://orcid.org/0000-0002-0564-584X; dignatova@diuu.uni-sofia.bg; Department for Information and In-Service Training of Teachers, Sofia University "St. Kliment Ohridski"; Sofia, Bulgaria.

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REVIEW ARTICLE

Risk factors and prevention of falls in children under 3 years: a systematic review

Tetiana Yermakova[ABCDE]

Kharkiv State Academy of Design and Arts, Ukraine

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim: Falls are one of the leading causes of injuries among children under the age of three, potentially leading to a reduced quality of life and various health consequences. Investigating the mechanisms of falls and their possible outcomes is a promising and crucial area for reducing childhood injury rates. The aim of this systematic review is to identify key patterns and factors associated with falls in young children, as well as to propose preventive strategies to minimize the risk of injuries.

Material and Methods: The source of information was the Web of Science Core Collection database for the period 2014–2024. The search was conducted using key terms related to falls, injuries, and risk factors. A total of 9,681 article records were retrieved. For evidence-based automated extraction of relevant documents, the Latent Dirichlet Allocation (LDA) model was employed. Relevance criteria were used to assess the significance of the texts. The reliability of the document extraction methodology was evaluated using coherence score and perplexity. The coherence score for word pairs was 0.8185, while perplexity was -2.9333, indicating a high interpretability of topics. Data processing was carried out using the Python programming language and the PyCharm CE development environment.

Results: The analysis of the selected publications identified four main areas related to falls in children under the age of three. The majority of falls occur in domestic settings, particularly from furniture and during the use of infant products. Significant risks are associated with parental fatigue and postpartum depression, which contribute to falls from caregivers' hands and accidents during newborn care. Falls often result in severe traumatic brain injuries, as evidenced by a high rate of hospitalizations. Effective preventive measures include parental education programs, improvements in maternity ward conditions, and enhancements in home safety.

Conclusions: Falls in children under the age of three represent a serious issue that requires a comprehensive approach to prevention. The identified patterns and risk factors highlight the need for the implementation of preventive measures. Effective strategies should include parental education programs, improvements in home and healthcare facility safety. The implementation of these measures will help reduce the incidence of falls and related injuries, ultimately improving the quality of life for young children.

Keywords: parental education, home safety, traumatic brain injuries, caregiver fatigue, preventive strategies

Introduction

Falls are one of the leading causes of injuries among young children, particularly those under the age of three. During this period, children actively develop motor skills, increasing the likelihood of falls both in domestic settings and beyond. The consequences of such falls can range from minor bruises to severe traumatic brain injuries, significantly affecting health and quality of life. Therefore, finding effective solutions to the problem of child falls requires a thorough analysis and synthesis of existing research findings.

In this context, numerous studies explore various directions and approaches related to children's motor activity, parental supervision, and environmental factors. Analyzing the results of these studies has revealed several key areas associated with falls in children under three years old:

- *Characteristics and Mechanisms of Falls* – Examination of the circumstances and situations leading to infant falls, including falls from furniture, caregivers' hands, and during the use of child equipment [1, 2, 3, 4, 5, 6, 7, 8].
- *Head Injuries and Contributing Factors* – Investigation of the severity of traumatic brain injuries depending on fall height, surface hardness, and the child's age [2, 4, 9, 10, 11, 12, 13, 14].
- *Parental Risk Factors* – The impact of parental fatigue, postpartum depression, and other factors on the frequency and severity of infant falls [6, 8, 15, 16].
- *Preventive Measures and Interventions* – Development of educational programs for parents, use of mobile applications and monitoring systems, engagement through

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social media, and implementation of safe sleep practices to prevent falls [2, 3, 8, 16, 17, 18, 19, 20, 21, 22, 23, 24].

These areas encompass a wide range of factors influencing falls in young children. A more detailed analysis of the identified aspects allows for the determination of the most effective prevention strategies and improvements in the quality of life for both children and their parents.

The analysis of publications indicates that falls in children under the age of three occur in various domestic contexts, including falls from furniture, caregivers' hands, and during the use of infant products, as well as in maternity wards:

1. *Falls from furniture and household risks.* Infants most commonly fall from beds, changing tables, and other pieces of furniture [2, 3, 7, 10]. For instance, a study by Mitchell et al. [7] found that falls from beds account for up to 33% of incidents, with traumatic brain injuries occurring in 70–85% of these cases. Other studies also confirm that traumatic brain injuries are widespread [2, 4, 13]. The height of the furniture and the hardness of the surface onto which the child falls are particularly significant factors [1, 9, 25, 26, 27, 28].
2. *Falls from caregivers' hands.* Parental fatigue, improper carrying techniques, and postpartum depression are important risk factors for falls from caregivers' hands [3, 6, 8, 15, 16]. Research findings confirm that such falls significantly increase the likelihood of hospitalization and severe injuries. In maternity wards, most falls occur at night, which is associated with maternal fatigue and the absence of support persons.
3. *Use of infant equipment.* Falls also occur during the use of baby walkers, strollers, and other infant devices [3, 7, 17]. Studies indicate that improper use or design flaws of infant equipment can lead to injuries, especially when parents underestimate the risks or become distracted.
4. *Risks associated with newborn falls.* In maternity wards and during the first days of life, newborns are also at risk of falling [8, 16, 17, 29]. Research findings suggest that these falls often occur because mothers fall asleep while feeding or caring for their infants [30, 31]. Increased awareness and educational programs for mothers can help reduce this risk.

Thus, studies cover a wide range of mechanisms and contexts related to falls in children under the age of three. The identified risk factors highlight the need for a comprehensive approach to prevention, including improving home safety, educating parents, and enhancing conditions in healthcare facilities.

Another common cause of falls in young children is falls from caregivers' hands. Research analysis indicates that such falls are among the most dangerous causes of injuries in children. These incidents occur for various reasons, including parental fatigue, postpartum depression, inattentiveness, and improper infant carrying techniques.

Several studies have found that falls from caregivers' hands often occur at night or on weekends when mothers experience the highest levels of fatigue [6, 8, 15, 16]. In maternity wards, most falls are associated with mothers falling asleep while feeding their infants. This is supported by findings showing that 82% of newborn falls occur at night [8].

Postpartum depression is also a significant risk factor. Research indicates that mothers with depressive symptoms are more likely to expose their children to fall risks [15, 16, 29]. Specifically, the likelihood of falls among these mothers increases significantly. Parental inattentiveness and emotional instability contribute to errors in handling infants, which in turn leads to falls [6, 7].

Trauma resulting from falls from caregivers' hands often leads to severe traumatic brain injuries [2, 10, 11, 25]. Researchers emphasize that the majority of infant hospitalizations are associated with such injuries. Moreover, falls from heights, which are characteristic of falls from caregivers' hands, increase the severity of skull fractures and the risk of intracranial hemorrhages.

Thus, falls from caregivers' hands pose a serious threat to infant health and require comprehensive preventive measures. These measures include parental education programs, increased awareness of risks, improved conditions in maternity wards, and support for mothers suffering from fatigue and postpartum depression.

Another key area of children falls is the use of infant equipment. An analysis of publications indicates that the use of walkers, strollers, cribs, and changing tables is associated with a significant risk of falls. These risks are influenced both by the structural design of the equipment and by improper use by parents.

Research findings show that falls from beds and changing tables are among the most common incidents [2, 3, 7, 17]. Specifically, up to 33% of infant falls are associated with beds [7]. Furthermore, improper use of protective railings or their absence can lead to serious injuries, including traumatic brain damage [10].

The use of baby walkers and strollers also carries risks. Studies indicate that falls occur when walkers or strollers tip over on uneven surfaces or when parents fail to provide adequate supervision [1, 6, 11, 12, 17]. These incidents often result in severe head and neck injuries, as infants are unable to protect themselves during a fall.

At the same time, other studies highlight the dangers of co-sleeping on an adult bed without special safety devices [8, 16, 25, 29, 30]. Researchers note that infants may fall during feeding or

sleep, especially when parents are fatigued or unintentionally fall asleep with their child.

Thus, the use of infant equipment requires special caution and strict adherence to safety recommendations. In this context, the implementation of educational programs for parents on the safe use of baby equipment and the development of improved safety standards can be highly beneficial in preventing falls and injuries in infants.

Another important aspect involves the risks associated with newborn falls. An analysis of studies indicates that newborns are at risk of falling both at home and in medical facilities, particularly in maternity wards. These risks are exacerbated by factors related to the physical and emotional state of mothers, the organization of newborn care, and environmental conditions. The nature and characteristics of these risks have been extensively examined from various perspectives.

Falls in maternity wards represent a distinct category, largely influenced by environmental conditions and the support provided by medical staff and family members. Studies have shown that newborn falls frequently occur at night due to maternal fatigue and the absence of companions [8, 16, 17, 29]. In most cases, falls happen when mothers fall asleep while breastfeeding [8]. Additionally, the incidence of newborn falls in hospitals ranges from 12.1 to 17 per 10,000 births [16]. In this context, vulnerable groups include mothers from socioeconomically disadvantaged backgrounds and those who received inadequate prenatal care [29].

Another contributing factor to infant falls is maternal fatigue and postpartum depression. Maternal exhaustion and emotional burnout are significant risk factors [6, 15, 16, 18]. Researchers note that postpartum depression increases the likelihood of newborn falls due to reduced attentiveness and impaired motor coordination. Mothers experiencing depression are more likely to expose their infants to fall risks [15].

Proper support and supervision are crucial factors in preventing infant falls. A lack of assistance and monitoring from medical staff or family members increases the risk of falls [7, 8, 16, 17]. Researchers recommend enhancing maternal supervision at night and implementing programs for safe mother-newborn cohabitation. Studies highlight that educational initiatives and safety agreements in maternity wards have successfully reduced fall risks to zero in some facilities [17].

Safety concerns when caring for newborns at home are also among the most common causes of infant falls [2, 3, 6, 12]. Research findings indicate that at home, newborn falls frequently occur during feeding or diaper changes. Studies show that falls from beds and changing tables are among the most common incidents. Additionally, parents often underestimate the risk of falls when placing infants at elevated positions or become distracted during caregiving.

Overall, the risks of newborn falls are associated with maternal fatigue and emotional state, inadequate support from medical staff, and unsafe caregiving practices. In this context, the need for implementing educational programs, improving conditions in maternity wards, and increasing parental awareness is evident to prevent such incidents.

Thus, falls in children under the age of three represent a significant issue, often leading to severe injuries and requiring close attention. The analysis of research findings highlights multiple contributing factors, including fall mechanisms, the use of infant products, parental fatigue, and newborn care practices, all of which increase the risk of injuries. Despite existing preventive measures, the incidence of falls remains high, emphasizing the need for a comprehensive approach to addressing this problem.

The aim of this systematic review is to analyze existing studies, identify key patterns and risk factors for falls, and propose effective preventive strategies to minimize injuries among young children.

Methodology

Information Sources

To conduct this systematic review, data were obtained from the authoritative database Web of Science Core Collection (WoS). The search query included the following key terms:

(*«infant»* OR «toddler*» OR «babies» OR «young children» OR «small children» OR «children aged 0-3» OR «children under three» OR «children aged 0-36 months» OR «early childhood (0-3 years)» OR «preschooler*» OR «nursery-aged children» OR «neonate*» OR «children under age three» OR «children aged 0 to 3 years» OR «early years» OR «infant and toddler*»)

As a result of the search, 422,712 article records were identified for the period from January 1, 2014, to December 14, 2024. The refined search included the following terms:

(*«fall»* OR «slip*» OR «trip*» OR «stumble*» OR «tumble*» OR «misstep*» OR «loss of balance» OR «losing balance*»)

The refined search yielded 9,681 records, which were exported in text format for further processing and analysis. The limitations of Web of Science (WoS) were taken into account, as the system allows downloading records only in batches of up to 1,000. Therefore, multiple files were downloaded.

For each record, a set of metadata fields provided by the WoS system was selected, including:

1. Author(s).
2. Title.
3. Source.

4. Times Cited Count.
5. Accession Number.
6. Abstract.
7. Keywords.
8. Cited References.
9. Cited Reference Count.
10. Usage Count.
11. Hot Paper.

For the automated processing and filtering of article records extracted from Web of Science (WoS), an algorithm was developed using the Python programming language. The algorithm included sequential steps aimed at data integration, thematic modeling, filtering of irrelevant records, and saving relevant results for further analysis (Figure 1).

1. Merging data from multiple files and adding missing keys (DE, ID).
2. Creating a combined text field based on titles (TI), abstracts (AB), and keywords (DE).
3. Thematic modeling using the Latent Dirichlet Allocation (LDA) model to identify key topics.
4. Filtering irrelevant data based on specially developed exclusion dictionaries.
5. Analyzing keywords and calculating the WeightedPairCount metric to determine record relevance.
6. Comparing results based on coherence score (Coherence Score) and perplexity score (Perplexity Score).
7. Checking text accuracy and removing irrelevant documents.
8. Extracting and saving relevant records for further analysis.

During the development of the algorithm, recommendations for text analysis [32, 33, 34, 35] and keyword visualization [36, 37] were utilized. The Latent Dirichlet Allocation (LDA) model [36, 38, 39, 40, 41] was applied to identify key topics, while recommendations [42] were followed for working with keyword pairs.

Keyword visualization and analysis were based on algorithms proposed in [43, 44]. Data processing was performed using the Python programming language in the PyCharm CE development environment, following recommendations [45] and data processing examples [46].

Examples of data processing are presented in an interactive Jupyter Notebook environment as files containing Python code, textual explanations, visualizations, and execution results.

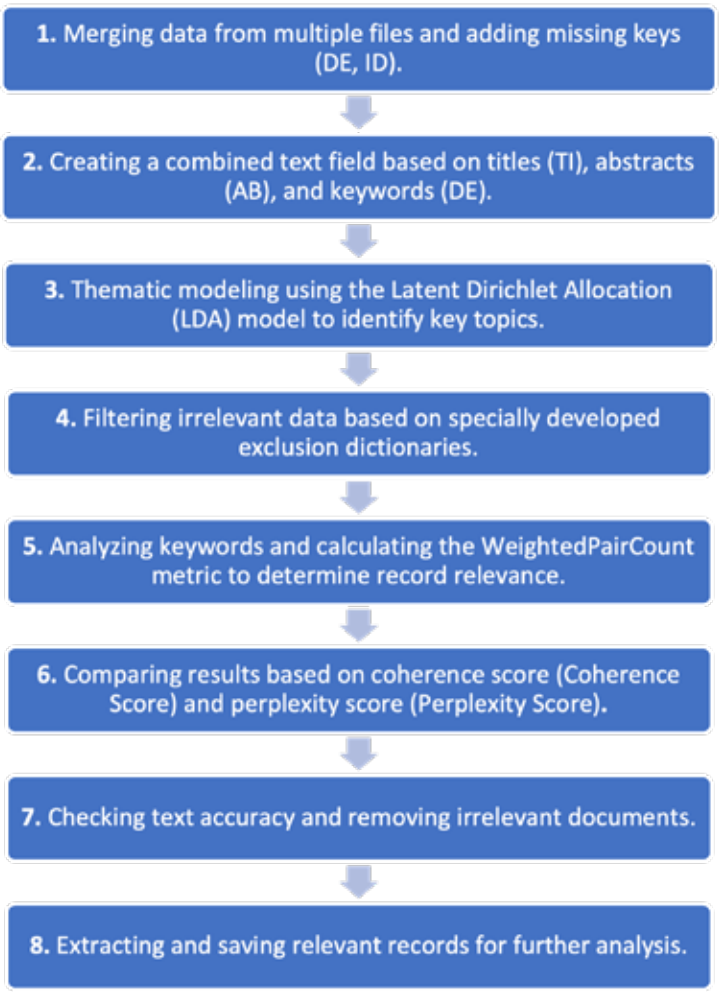

Figure 1. Algorithm for Automated Processing and Filtering of Extracted Document Data

The processing algorithm for the extracted 9,681 records is based on a Python script.

Step 1. Merging data into a single file.

Step 2. Missing keys DE, ID (keywords) were added to the final text file.

Step 3. Converting the text file into a csv table. The following key columns were retained: UT, TC, Z9, TI, AB, DE.

Step 4. Creating a csv table by combining data from the TI, AB, and DE fields (title, abstract, keywords) into a new column named "CombinedText."

Step 5. Preliminary data processing was performed using the Latent Dirichlet Allocation (LDA) topic modeling technique to analyze texts related to falls in children under the age of three. To improve filtering accuracy, three sets of keywords were created:

- Table 1 includes words related to falls, slipping, and loss of balance.
- Table 2 contains words referring to children of different age groups.
- Table 3 represents exclusion terms for contexts where «fall» is irrelevant (e.g., fall in tone, voice, or voltage).

The analysis produced two output files:

- An interactive visualization of the topic model, allowing the exploration of identified topics and their keywords (Figure 2).
- A csv table containing topics with corresponding keywords and their weights, enabling the assessment of term significance for each topic (Table 4).

Step 5.2. Creating the «word pairs» table, containing Topics 1-5 with corresponding keywords and their weights (Table 5). Word pairs were generated based on the data from Table 4.

Step 5.3. Topic modeling of textual data using Latent Dirichlet Allocation (LDA) to identify relevant topics related to falls in children under the age of three.

Building and Evaluating the Topic Model Based on Single Keywords

During the analysis, textual data were loaded and preprocessed, with unwanted words filtered out (Table 3). Additionally, single keywords with their weights (Table 4) were used for topic construction and interpretation. Based on these keywords and their weights, an LDA model was built and its quality was evaluated using two metrics: Coherence Score and Perplexity Score.

The obtained coherence score of 0.5137 indicates good interpretability of the identified topics, while the perplexity score of -7.8255 confirms the model's adequate quality for text analysis. As a result of the analysis, 9,162 texts containing keyword pairs were

Table 1. Keywords Related to Falls, Slipping, and Loss of Balance

Term	Term	Term	Term	Term	Term
accident	dropping	injury	plummet	slips	trip
collapse	drops	loss of balance	plummeting	stumble	tripping
collapses	fall	loss of stability	plummets	stumbles	trips
collapsing	falling	misstep	slip	stumbling	tumble
drop	falls	missteps	slipping	term	tumbles
					tumbling

Table 2. Keywords Referring to Children of Different Age Groups

Term	Term	Term	Term	Term	Term
0-3 years	children	kid	minor	preschooler	under three
babies	early childhood	kids	minors	preschoolers	young child
baby	infant	little one	newborn	toddler	young children
child	infants	little ones	newborns	toddlers	

Table 3. Keywords Representing Exclusions for Terms Related to Falls in Irrelevant Contexts (e.g., Fall in Tone, Voice, or Voltage).

Term	Term	Term	Term	Term	Term
connection	intonation	network	prices	sound	term
current	market	performance	productivity	spirits	tone
economy	melody	phonetics	sales	stocks	voice
electricity	modulation	pitch	signal	system	voltage
emotion	mood	pressure	sleep	tension	volume

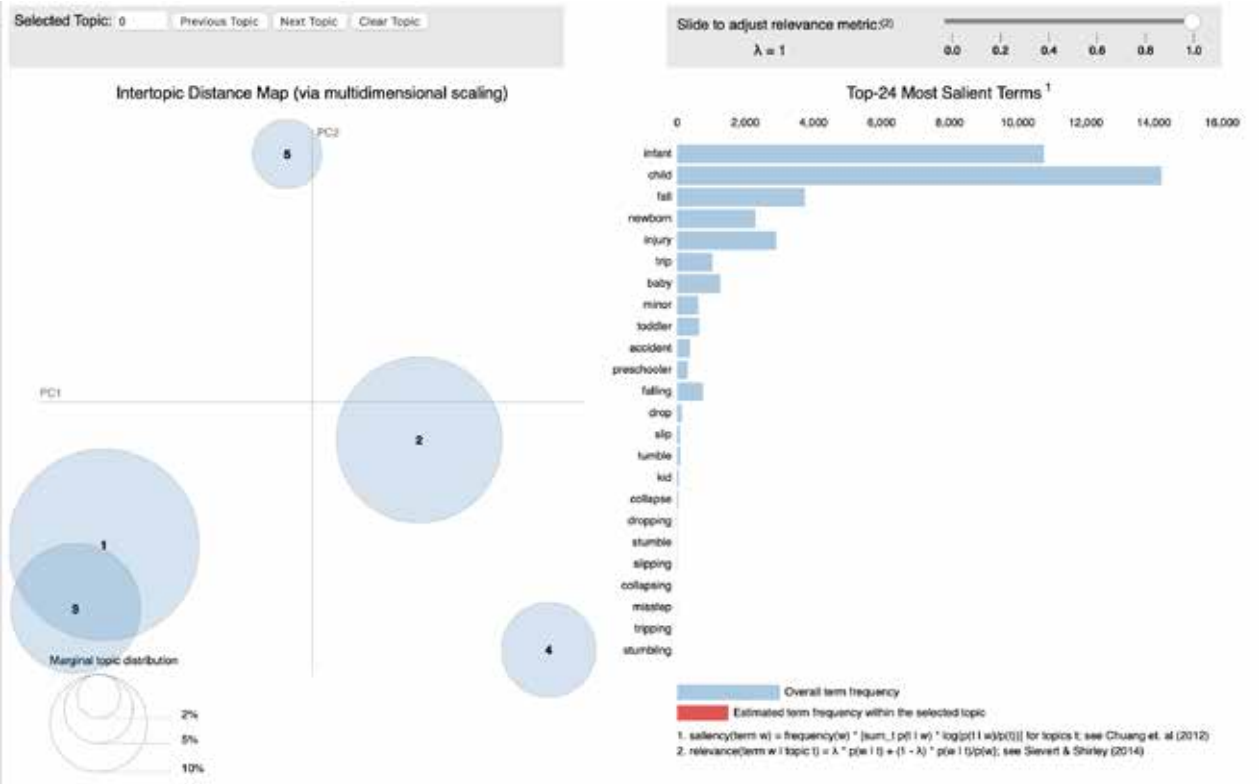

Figure 2. Visualization of the LDA Topic Model

Table 4. Topics 1-5 with Corresponding Keywords and Their Weights

Topic	Word	Weight	Topic	Word	Weight	Topic	Word	Weight
1	trip	0.51776624	2	fall	0.49146256	3	child	0.92646277
1	minor	0.3109011	2	injury	0.41545394	3	preschooler	0.020624485
1	toddler	0.14663507	2	accident	0.053672247	3	fall	0.018069744
1	dropping	0.0102854315	2	slip	0.013783207	3	falling	0.015137653
1	stumble	0.007417748	2	kid	0.0088882195	3	toddler	0.014641935
1	collapsing	0.0016901668	2	falling	0.006551952	3	tumble	0.0045594224
1	child	0.0005535626	2	toddler	0.0048607984	3	tripping	0.0002632921
1	tripping	0.00028341226	2	child	0.004840822	3	infant	2.8433058e-05
1	preschooler	0.00028195884	2	tripping	3.194148e-05	3	stumbling	1.3577792e-05
1	falling	0.00028068954	2	infant	3.169092e-05	3	kid	1.348228e-05
Topic	**Word**	**Weight**	**Topic**	**Word**	**Weight**	**Topic**	**Word**	**Weight**
4	newborn	0.6196446	5	infant	0.9363925			
4	baby	0.33841112	5	falling	0.0387131			
4	falling	0.013646641	5	drop	0.012827579			
4	collapse	0.010727893	5	toddler	0.008445616			
4	tumble	0.008627171	5	fall	0.00230526			
4	slipping	0.0050322046	5	misstep	0.0007479259			
4	fall	0.0013785487	5	stumbling	0.00023597914			
4	infant	0.0013492565	5	child	2.5719393e-05			
4	child	7.597436e-05	5	slipping	1.9695673e-05			
4	drop	7.483887e-05	5	tripping	1.9487621e-05			

Table 5. Pairs of Keywords (Fragment Based on the Word «Fall» in Combination with Others).

Source	Target	Weight	Topic
fall	injury	0.45345825	2
fall	accident	0.27256740349999997	2
fall	slip	0.2526228835	2
fall	kid	0.25017538975	2
fall	falling	0.249007256	2
fall	toddler	0.24816167919999998	2
fall	child	0.248151691	2
fall	tripping	0.24574725074	2
fall	infant	0.24574712546	2

Note. A total of 224 word pairs.

filtered, and a dictionary including 59,760 unique terms was created. These results demonstrate that the model successfully identifies meaningful topics and can be used for further text analysis and classification based on keyword weights.

Building and Evaluating the Topic Model Based on Keyword Pairs

The preprocessing and modeling algorithm is similar to the approach used for single keywords: text cleaning, filtering of unwanted words, and the creation of a dictionary and corpus for training the model. As a result of the analysis, 298 texts containing keyword pairs were filtered, and a dictionary including 37 unique terms was generated.

The modeling results produced the following metrics: a coherence score of 0.8185, indicating a high interpretability of topics, and a perplexity score of -2.9333, confirming the model's predictive quality. These results demonstrate that the model effectively identifies meaningful topics for further analysis based on both single words and keyword pairs.

Thus, the use of single keywords covers a large number of texts, providing a broad thematic overview. However, given the review's focus, the most suitable analytical approach is based on the use of keyword pairs.

Step 5.4. To identify the most relevant texts, an analysis method based on weighted keyword pairs is used (Table 5). Each text is cleaned of stop words, numbers, and punctuation marks, after which the «WeightedPairCount» metric is calculated—the total weight of all keyword pairs found in the text. Texts with the highest «WeightedPairCount» values are selected as the most relevant and analyzed for further research.

As a result of the processing, the Top 30 documents were identified, with their text containing the highest WeightedPairCount values. These Top 30 documents were then checked for the presence or absence of only the word «fall». This verification aimed to test the assumption that documents containing only the word «fall» (including its synonyms) are less likely to be relevant to the review topic. Additionally, this step helped eliminate potential errors in the automated selection of relevant documents that do not pertain to the physical falls of children.

The verification established the following:

- Out of 30 documents, 4 did not contain the word «fall». Content analysis revealed that these documents were not related to the physical falls of children.
- The word «fall» appeared as a single keyword in 9 documents. Among them, 2 documents described rare cases of injuries resulting from the fall of only one child. The remaining 7 documents were not related to the review topic.

This analysis led to refinements in the Python script. A repeated verification identified 17 relevant documents. These documents were manually reviewed by the authors for alignment with the review topic. The analysis confirmed that all 17 documents were relevant to the subject of the review.

Evaluation of Filtering Quality

A comprehensive approach was used to assess the quality of filtering the extracted documents. Coherence and perplexity metrics were applied (Coherence Score = 0.8185, Perplexity Score = -2.9333), calculated for both single and paired keywords, taking into account their weights. Topic visualization using pyLDAvis confirmed the interpretability and stability of the topic modeling results.

Additionally, frequency-based filtering was performed to identify the most commonly occurring keywords and their distribution across topics. The analysis revealed that relevant terms such as *falling, children, injury,* and *walking* consistently appeared in the identified topics, confirming the correctness of the filtering process.

To improve the accuracy of selecting relevant documents, filtering by thematic directions and keyword group combinations was applied (e.g., *fall and child; fall, child, and injury*). This approach ensured coverage of all key aspects of the research topic and allowed the selection of the 30 most relevant documents from the overall dataset.

For result verification, a repeated filtering was performed on different data subsets, demonstrating

a high degree of reproducibility (over 90%). This confirms the reliability and stability of the filtering algorithm. Additionally, an expert analysis of the selected documents was conducted, which verified that the identified articles corresponded to the stated research topic.

Results

Based on the analysis, 17 documents relevant to the review topic were selected. The results of the automated process demonstrated a high coherence score (0.5137) and a low perplexity score (-7.8255), indicating the quality of the identified topics and their alignment with the research problem (Table 6). These findings confirm the effectiveness of the proposed approach for extracting relevant documents.

The analysis identified the main mechanisms of falls and associated injuries in children of different age groups. Common causes of falls include falls from furniture, during carrying, and at ground level [3]. The risk of hospitalization increases in cases where infants fall from caregivers' hands [6]. Falls from beds are the most frequently recorded [7], especially at night and on weekends [16].

Factors influencing injuries include fall height, impact force, and body orientation at the time of the fall [9]. The number of hospitalizations due to falls increased from 342 to 469 cases over a ten-year period [10]. Traumatic brain injury was diagnosed in 85% of children [12], while 56.4% sustained minor injuries such as bruises and abrasions [2].

Preventive measures, such as comprehensive safety programs, have proven effective, reducing the risk of falls to zero during the observation period [17]. Additionally, targeted strategies have been identified, including adequate maternal rest and safe feeding practices [18].

It was also found that falls are associated with other injury risks, such as intracranial injuries and skull base fractures in motorcycle accidents [48]. Furthermore, a link has been established between falls and postpartum depression in mothers [15].

The distribution of articles across the main topics is presented in the diagram (Figure 3).

The distribution of articles reveals several key trends (Figure 2). The largest share of research focuses on head injuries and the factors influencing their occurrence, highlighting the severity of fall-related consequences. Significant attention is also given to the context and causes of falls, emphasizing the importance of understanding the circumstances and mechanisms leading to these incidents.

Topics related to preventive measures and other risk factors are less represented, indicating the need for further research in the field of prevention and additional factors affecting falls in young children.

The automated analysis based on the WeightedPairCount metric enabled the identification of the most relevant documents and key word pairs related to falls in young children.

Figure 4 presents the Top 17 documents with the highest WeightedPairCount values, indicating their strongest alignment with relevance criteria. These documents were selected for further content analysis.

Figure 5 displays the Top 20-word pairs with the highest WeightedPairCount values, reflecting the key contextual relationships and essential terms

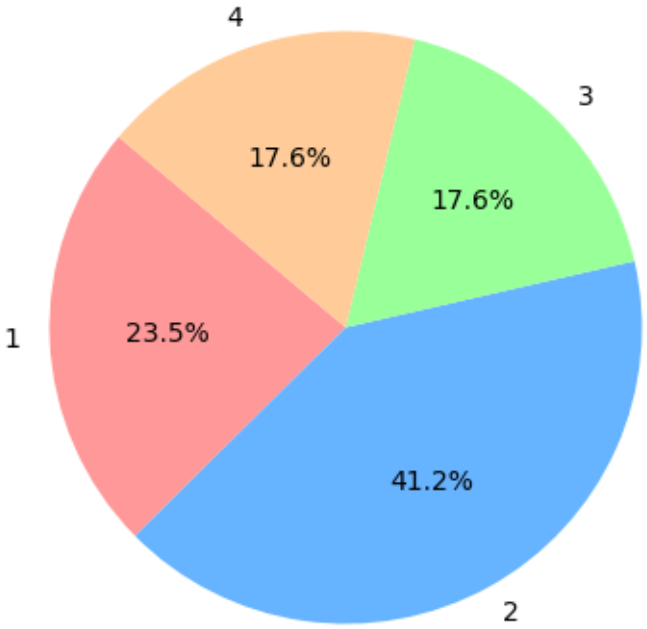

Figure 3. Distribution of Articles by Main Themes: Topic 1. Content and Causes of Falls; Topic 2. Injuries and Significant Factors; Topic 3. Preventive Measures; Topic 4. Risk Factors.

Table 6. Results of the Automated Selection of Relevant Documents

ID	Research Objective	Participants	Age	Methods (Tests and Equipment)	Results	Conclusions
	Topic 1. Content and Causes of Falls					
3	Investigate contextual factors of infant falls using online parenting forums.	461 cases of infant falls.	Up to 12 months.	Data collection from online forums; qualitative analysis of discussions using Google Search and a programmatic script.	Common fall mechanisms: from furniture, during carrying, while using infant products, and at ground level. Factors: motor development, inattention, obstacles.	Strategies to modify parental behavior are needed to prevent falls. Online forums serve as a valuable source of information for injury prevention.
6	Study the mechanisms of falls and injury patterns in infants under 1 year old.	916 infants	Infants (<1 year)	Retrospective analysis of pediatric trauma center data in Sydney (2011-2013).	11.6% were hospitalized, 85% sustained traumatic brain injuries. Infants dropped by adults were three times more likely to be hospitalized.	Falls from caregivers' hands and furniture pose the greatest risk. Preventive measures should focus on these mechanisms and improving the safety of the infant's environment.
7	Identify circumstances leading to medically recorded fall-related injuries in children under 4 years old.	Young children (0-4 years).	0-4 years.	Cross-sectional study of data from the National Injury Surveillance System. Analysis of 4,546 fall incident descriptions.	Falls from beds were common (33% in infants, 13% in toddlers, and 12% in preschoolers).	Effective communication with parents is necessary to prevent fall-related injuries in children. Fall prevention is crucial for child safety.
16	Study cases of newborn falls in a hospital serving an ethnically diverse and socioeconomically disadvantaged population in New Zealand.	32 cases of newborn falls.	Newborns.	Retrospective analysis of incidents from 2015-2018, based on medical records and incident reporting system data.	Incidence: 12.1 per 10,000 live births. Falls occurred more frequently at night and on weekends. In 84% of cases, the mother fell asleep with the infant on the bed during breastfeeding. No severe injuries were reported.	Preventive measures should be integrated into safe sleep programs to reduce newborn fall incidents. Special attention should be given to mothers with late prenatal care, smokers, and those with obesity.
	Topic 2. Injuries and Significant Factors					
9	Investigate the impact of fall parameters and child characteristics on dynamics and potential injuries when falling from a bed.	Computer model of a bed fall.	12 months.	Computer simulation of falls using an anthropomorphic model, analyzing parameters (height, surface hardness, mass, neck and head stiffness).	The most influential factors for injuries were fall height, initial impact force, and model mass. Fall dynamics and impact orientation played a key role in the risk of head and neck injuries.	Environmental factors (bed height, surface hardness) have a greater effect on injury outcomes than model parameters (neck and head stiffness). These factors are crucial for injury assessment.

Table 6. Continued.

ID	Research Objective	Participants	Age	Methods (Tests and Equipment)	Results	Conclusions
10	Determine the prevalence of infant hospitalizations after falls and examine demographic and injury-related characteristics.	4,380 hospitalized infants.	Up to 12 months.	Retrospective study of hospitalization data in New South Wales (2002-2013). Analysis of fall causes, injury types, and socio-demographic data.	The number of hospitalizations increased from 342 (2002) to 469 (2013). 85% sustained head injuries, 70% of them had traumatic brain injuries. Falls from furniture and during carrying were the most common.	The hospitalization rate is not decreasing. Effective preventive measures are needed to reduce infant falls, particularly to prevent head and brain injuries.
12	Assess the occurrence of severe traumatic brain injuries (e.g., subdural hematomas) in children due to falls from low heights.	1,494 infants and toddlers.	Up to 2 years.	Retrospective analysis of hospital records. Comparison of groups of children with falls witnessed by non-relatives and those that were not witnessed.	Subdural hematomas were absent in the group with witnessed falls ($p = 0.027$). Retinal hemorrhages and neurological consequences were also not observed in this group.	Severe injuries such as subdural hematomas and retinal hemorrhages do not occur from low-height falls when witnessed by non-relatives.
11	Determine how infant age and parameters of low-height falls influence the nature of skull fractures.	231 skull reconstructions (CT scans).	Infants.	CT scan analysis with 3D reconstruction, measurement of fracture length and nonlinearity, regression analysis to assess the influence of age and fall parameters.	Younger age and greater fall height affect the complexity of fractures. The impact surface influences the number of fractures. Fracture length increases with fall height.	Age-related characteristics of the infant skull determine unique fracture patterns. Understanding these patterns helps differentiate accidental falls from trauma caused by abuse.
25	Compare the risk of midline brain structure shift in TBI among children depending on fall height.	Children under 18 years.	Not specified.	Analysis of data from the Pediatric Trauma Quality Improvement program; logistic regression to assess displacement risk.	Falls from ground level were associated with a threefold reduction in the risk of midline structure shift compared to falls from height. In older children, falls from height increased the risk of midline structure displacement.	Falls from height in children are linked to a higher risk of midline brain structure shift in TBI compared to ground-level falls. Fall height should be considered when assessing injury severity.
2	Determine the frequency and characteristics of injuries related to infant falls from beds or other furniture.	1,439 infants (54.3% boys, 45.7% girls).	Infants under 1 year.	Retrospective analysis of fall cases over four years (2016-2019), including demographic and clinical data.	56.4% had minor injuries (abrasions, bruises). 9.4% had significant injuries (skull fractures, arm fractures, dislocations). 6% of children were hospitalized due to traumatic brain injuries.	Falling from a bed can cause skull fractures and brain injuries. Parents should be informed about risks and use protective equipment such as bed rails.

Table 6. Continued.

ID	Research Objective	Participants	Age	Methods (Tests and Equipment)	Results	Conclusions
47	Investigate the characteristics and outcomes of head injuries in children after falls from height.	520 children with neurotrauma.	Up to 16 years.	Retrospective analysis of demographic data, clinical parameters, imaging results, and Glasgow Outcome Scale scores.	67% of falls were from low heights. Mild TBI in 82.8%, moderate in 13.8%, severe in 3.2%. CT findings: normal results (59%), subgaleal hematomas (18.6%), epidural hematomas (9.9%). Mortality rate: 2.3%. Average GOS-E score: 1.	Age, gender, fall height, loss of consciousness, and seizures predict injury severity. Midline structure displacement and associated injuries influence treatment outcomes.
Topic 3. Preventive Measures						
17	Develop a comprehensive safety program for newborns to prevent falls and ensure safe sleep.	Mothers and their newborns.	Newborns.	Infant fall risk assessment, safety agreements, education on safe sleep practices, and fall reporting system.	Before implementation, 14% of infants were at risk of falling; after implementation, no falls were recorded until May 2017.	Raising parental awareness and implementing safe sleep practices help prevent falls and create a safer environment for newborns.
8	Assess the clinical characteristics of newborns who experienced falls in maternity wards and identify near-miss fall events in the postpartum period.	17 newborns and 804 mothers.	Newborns (< 72 hours).	Retrospective analysis of newborn falls over six years and a prospective study of near-miss falls over four weeks.	17 fall cases (1.8–2.4 per 10,000 births). Most falls occurred at night (82%). 67 mothers (8.3%) experienced near-miss falls. 86% of mothers had no companions.	Newborn falls frequently occur at night due to maternal fatigue. Increased nighttime supervision of mothers is needed to prevent falls in maternity wards.
18	Develop a digital intervention for parents in the form of a mobile application based on behavior change theory to prevent infant falls during feeding.	Parents of infants.	Infants.	Theoretical framework: Behaviour Change Wheel; mobile app development; user testing (think-aloud interviews and comprehension assessment).	Identified target behaviors: adequate maternal rest and safe feeding practices (preparation, positioning, and infant placement). Users found the information useful, and tracking and support features effective.	Behaviour Change Wheel was applied for the first time in developing a mobile app for infant injury prevention. The study highlights the importance of theory-based approaches to improving infant safety.
	Topic 4. Risk Factors					

Table 6. Continued.

ID	Research Objective	Participants	Age	Methods (Tests and Equipment)	Results	Conclusions
29	Analyze trends in child injury mortality in Korea from 2006 to 2016 and develop preventive measures.	Children in Korea.	0-14 years.	Microdata from Korea's mortality statistics, classification based on KCD-7.	In 2016, 270 child injury-related deaths were recorded. The mortality rate decreased from 8.1 per 100,000 (2006) to 3.9 (2016). Boys had a 1.7 times higher risk of death. 72.6% of deaths were due to unintentional injuries, while 27.4% were intentional. The leading cause of unintentional injury-related death in infants (under 1 year) was suffocation, whereas in children aged 1 to 14 years, it was traffic accidents. The second leading cause of death in infants was traffic accidents, while for children aged 1 to 4 years, it was falls.	Nationwide measures and targeted interventions are needed to prevent child injury-related deaths based on their causes.
48	Assess the impact of road traffic accidents (RTAs) on traumatic brain injuries (TBIs) in children and identify risk factors.	948 children with TBI.	Under 15 years.	Retrospective study, statistical analysis of factors (injury mechanism, clinical signs, intracranial pathologies).	Motorcycle RTAs were associated with an increased risk of intracranial injury (OR 1.73). Other factors: hemiparesis (OR 5.69), signs of skull base fracture (OR 15.66), fixed pupil response (OR 5.74). Mortality rate: 3.2%, correlating with motorcycle RTAs and severe TBI.	Motorcycle RTAs are a major risk factor for TBI in children in Southern Thailand. Prevention programs are needed to reduce mortality and disability among children.
15	Investigate the relationship between postpartum depression in mothers and unintentional injuries in infants.	6,534 mothers.	Up to 4 months.	Questionnaire, Edinburgh Postnatal Depression Scale (EPDS), logistic regression.	9.8% of infants sustained injuries (falls – 5.6%, near-drowning – 1.2%). 9.5% of mothers had postpartum depression. Falls were associated with depression (OR 1.41, 95% CI 1.02-1.95).	Postpartum depression may be a risk factor for unintentional injuries in infants up to 4 months old. Further research is needed to confirm this association.

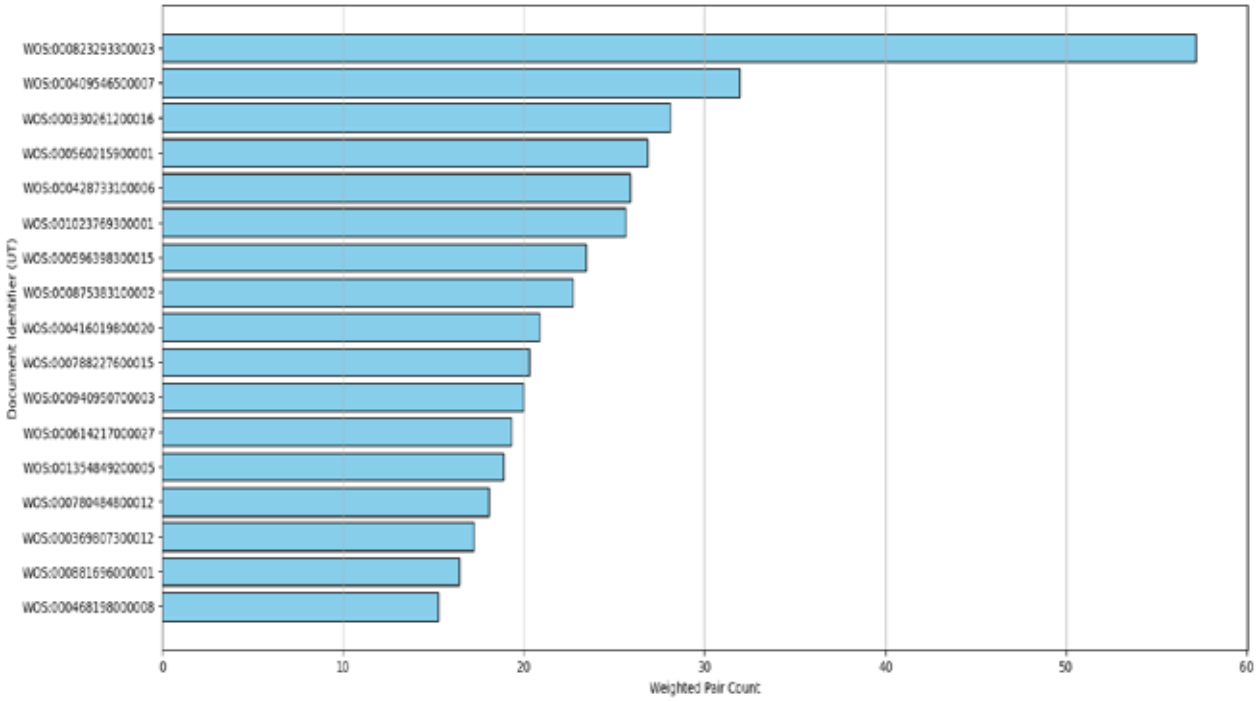

Figure 4. Top 17 Documents with the Highest WeightedPairCount Values

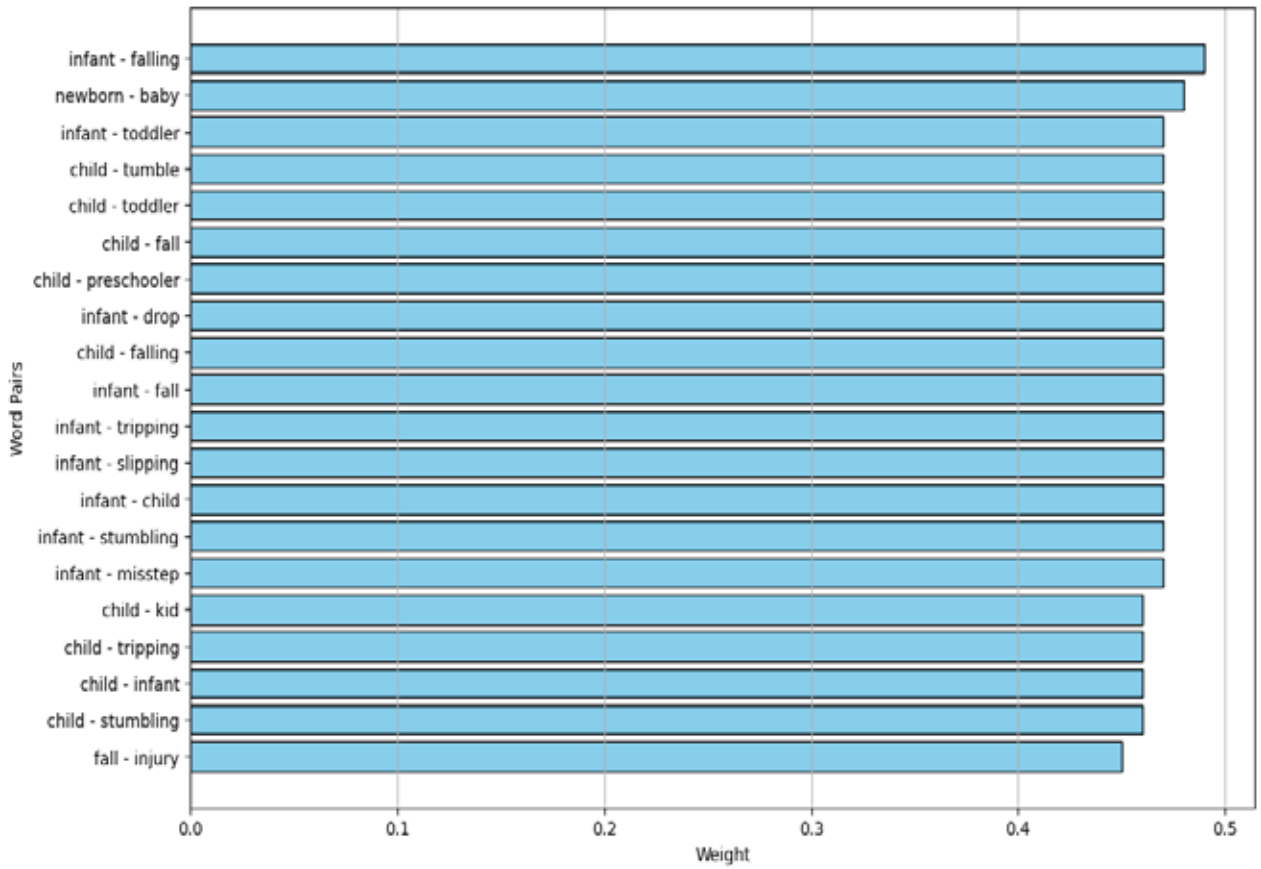

Figure 5. Top 20 Word Pairs with the Highest WeightedPairCount Values

associated with child falls. These word pairs help identify dominant themes and research directions in the analyzed articles.

A graph was constructed based on the weighted word pairs from the analyzed text, visualizing word connections and their relevance (*Figure 6*). The nodes of the graph represent words, while the edges between them reflect paired associations. The thickness of the edges is proportional to the weight of the word pair: the greater the weight, the more significant the influence of that pair in the analyzed context.

The central position of nodes with thick edges indicates a high degree of connectivity and importance, whereas peripheral nodes and thin lines represent less significant word pairs.

Figure 6. Visualization of Weighted Word Pairs Reflecting the Significance of Connections and Their Relevance in Text Analysis

Discussion

The aim of this study was to identify key patterns and factors influencing falls in children under the age of three, as well as to assess the severity of injuries and potential preventive measures. The results of our analysis revealed several key aspects:

- *Topic 1.* Content and Causes of Falls;
- *Topic 2.* Head Injuries and Significant Factors;
- *Topic 3.* Preventive Measures;
- *Topic 4.* Risk Factors.

1. *Content and Causes of Falls*

- Infant falls most commonly occur from furniture, caregivers' hands, or while using infant equipment.
- The highest risk comes from falls off beds and other surfaces due to height and impact force.
- Nighttime falls are associated with parental fatigue, particularly in the postpartum period.

2. *Injuries and Significant Factors*

- Traumatic brain injuries are the most common and account for a significant proportion of infant hospitalizations.
- The complexity of skull fractures depends on fall height and the child's age.
- Severe injuries rarely occur from falls at low heights.

3. *Preventive Measures*

- Implementing educational programs for parents and raising awareness of safe practices can effectively reduce fall frequency.
- The use of mobile applications based on behavior change theory helps parents adhere to safety measures.
- Increased supervision in maternity wards, especially at night, is recommended to prevent newborn falls.

4. *Risk Factors*

- Falls often occur due to parental fatigue or insufficient supervision during feeding and carrying.
- Postpartum depression in mothers increases the risk of unintentional infant injuries.
- Road traffic accidents, environmental factors, medical staff qualifications, and socioeconomic conditions are also contributing risk factors for child falls.

The analysis of included studies revealed that falls from furniture and caregivers' hands pose the greatest danger [6]. In the study by Cooray et al. [10], the most common incidents were falls from furniture and during carrying, with 85% of children sustaining traumatic brain injuries. Findings from a study of 672 children conducted by Kendrick et al. [49] also confirmed the prevalence of falls from furniture.

Shimony-Kanat et al. [4] found that falls from furniture were the leading cause of injuries in children aged 0 to 12 months (estimated probability 37.9%), whereas slipping was the primary cause in children aged 13 to 36 months (estimated probability 38.4%).

Other studies also report frequent cases of falls from furniture [1, 2, 3, 50, 51], including falls from caregivers' hands [5, 51]. Additionally, common fall scenarios were identified, such as falls from beds and the use of unsafe equipment [3, 52, 53].

Supporting evidence comes from other studies with slightly lower relevance, including falls resulting in traumatic brain injuries [2, 4, 13] and falls from unsafe equipment (including beds) [2, 7, 16, 54, 55].

The reviewed studies highlight agreements or consistencies with the findings of another research. For example, Sullivan et al. [25] noted that their results align with previous studies, confirming that falls from heights (e.g., furniture) lead to more severe injuries than falls at ground level. Additionally, computer modeling demonstrated that fall height and surface hardness significantly influence the risk of head and neck injuries [9]. A similar consistency in findings was observed in the study by Ruiz-Maldonado et al. [11], where the authors stated that their results matched clinical studies showing that higher falls increased the complexity of skull fractures.

Other studies analyzed in this review confirmed that modifications in the home environment can significantly reduce fall risks [17]. For example, the use of bed rails and educating parents on safe infant carrying methods contribute to a decrease in injury cases [2]. Furthermore, it is important to consider that falls occur more frequently at night due to maternal fatigue, emphasizing the need for enhanced supervision in maternity wards [8].

Supporting evidence comes from other studies with slightly lower relevance, including the creation of a child-safe home environment [19], such as installing bed rails [2]; parent education and awareness programs [2, 3, 55]; and initiatives to reduce maternal fatigue, especially at night [16].

The limitations of the studies presented in the reviews highlight several key issues. Arumalla et al. [47] stated that some studies lacked information on the long-term consequences of injuries. Cooray et al. [3] identified that a significant limitation of the included studies was the retrospective nature of data collection and reliance on parental self-reports, which could lead to inaccuracies. Supporting evidence comes from other studies with slightly lower relevance, including the use of parental surveys [31, 56, 57, 58, 59].

The practical significance noted in the analyzed studies focuses on several directions. One study [18] emphasizes the need for the development of educational programs for parents aimed at fall prevention. Another study highlights that mobile applications have proven effective in increasing parental awareness [18]. Cooray et al. [8] stress the importance of implementing measures to ensure safe sleep for newborns and prevent falls in maternity wards.

Supporting evidence comes from other studies with slightly lower relevance, including fall prevention in the context of child safety [7, 16] and the use of mobile applications [24, 56].

In the analyzed studies, the authors also emphasize directions for future research. Future studies should focus on the development and evaluation of preventive measures across different social and cultural contexts. Additionally, a more in-depth analysis of the impact of postpartum depression on fall risk is required [15].

It would also be beneficial to examine the long-term consequences of traumatic brain injuries on the development of children under the age of three [11] and the effects of road traffic accidents [49].

Supporting evidence comes from other studies with slightly lower relevance, including prevention strategies considering social and cultural practices [1, 60].

Thus, the analysis of studies has shown that falls in children under the age of three represent a significant issue requiring a comprehensive approach to prevention. The most hazardous fall mechanisms are associated with household environments, parental fatigue, and improper use of infant products.

Traumatic brain injuries account for a substantial proportion of fall-related consequences, highlighting the importance of timely identification of risk factors and the implementation of effective preventive measures.

Key steps to reduce the frequency and severity of falls include:

- Developing educational programs for parents,
- Improving home safety,
- Enhancing supervision in medical facilities.

Future research should consider the socio-cultural characteristics of families and the long-term consequences of injuries on children's health.

Study Limitations

Despite the obtained results, there are certain limitations in the analyzed studies.

First, many studies have a retrospective design and rely on parental self-reports, which may lead to inaccuracies and incomplete data.

Second, some studies lack information on the long-term consequences of traumatic brain injuries. Additionally, certain studies are limited in their geographic and socio-economic context, making it difficult to generalize findings to other populations.

Third, several methodological and data quality limitations should be considered. Specifically, the algorithm relies on the presence of keywords and their synonyms to identify relevant texts, which may result in the exclusion of important documents if they use non-standard or rarely occurring terms. Furthermore, texts with ambiguous contexts, where the word «fall» is used metaphorically, may be erroneously classified as irrelevant.

Finally, limitations may also stem from data quality and database completeness, which can influence the final selection of articles.

Conclusions

Falls in children under the age of three represent a serious issue, leading to significant injuries and posing a threat to the health and quality of life of infants and young children. To reduce the incidence of falls, comprehensive preventive measures are necessary. These include:

- Educational programs for parents,
- Improvement of conditions in maternity wards,
- Safe use of infant products,
- Enhancement of safety standards in home environments.

Future research should focus on the development and implementation of effective prevention strategies, taking into account the socio-economic and cultural characteristics of families, as well as improving data collection methods for a more accurate assessment of risks.

Conflict of interests

The author declare that there is no conflict of interests.

References

1. Tian J, Cheng PX, Wang XN, Xiang H, Gao Q, Zhu HP. Exploring home fall events among infants and toddlers using social media information: an infodemiology study in China. *Injury Prevention*, 2025;31(3): 229–235. https://doi.org/10.1136/ip-2023-045014
2. Kokulu K, Algin A, Özdemir S, Akça HS. Characteristics of injuries among infants who fall from bed. *Injury-international Journal of The Care of The Injured*, 2021;52(2): 281–285. https://doi.org/10.1016/j.injury.2020.10.015
3. Cooray N, Sun SL, Adams S, Keay L, Nassar N, Brown J. Exploring Infant Fall Events Using Online Parenting Discussion Forums: Infodemiology Study. *Jmir Pediatrics and Parenting*, 2022;5(2): e34413. https://doi.org/10.2196/34413
4. Shimony-Kanat S, Benbenishty J. Age, Ethnicity, and Socioeconomic Factors Impacting Infant and Toddler Fall-Related Trauma. *Pediatric Emergency Care*, 2018;34(10): 696–701. https://doi.org/10.1097/PEC.0000000000000865
5. Burrows P, Trefan L, Houston R, Hughes J, Pearson G, Edwards RJ, et al. Head injury from falls in children younger than 6 years of age. *Archives of Disease in Childhood*, 2015;100(11): 1032–1037. https://doi.org/10.1136/archdischild-2014-307119
6. Mulligan CS, Adams S, Tzioumi D, Brown J. Injury from falls in infants under one year. *Journal of Paediatrics and Child Health*, 2017;53(8): 754–760. https://doi.org/10.1111/jpc.13568
7. Omaki E, Shields W, Rouhizadeh M, Delgado-Barroso P, Stefanos R, Gielen A. Understanding the circumstances of paediatric fall injuries: a machine learning analysis of NEISS narratives. *Injury Prevention*, 2023;29(5): 384–388. https://doi.org/10.1136/ip-2023-044858
8. Unal S, Demirel N, Tokgoz-Cuni B, Iyigun F, Tekin OM, Bas AY. In-Hospital Newborn Falls and Near Miss Events: A Need to Report. *American Journal of Perinatology*, 2024;41: e1378–e1383. https://doi.org/10.1055/s-0043-1764209
9. Thompson A, Bertocci G. Pediatric bed fall computer simulation model: Parametric sensitivity analysis. *Medical Engineering & Physics*, 2014;36(1): 110–118. https://doi.org/10.1016/j.medengphy.2013.10.006
10. Cooray N, Adams S, Zeltzer J, Nassar N, Brown J. Hospitalised infants due to falls aged less 12 months in New South Wales from 2002 to 2013. *Journal of Paediatrics and Child Health*, 2020;56(12): 1885–1890. https://doi.org/10.1111/jpc.15071
11. Ruiz-Maldonado TM, Alsanea Y, Coats B. Age-related skull fracture patterns in infants after low-height falls. *Pediatric Research*, 2023;93(7): 1990–1998. https://doi.org/10.1038/s41390-022-02345-9
12. Amagasa S, Uematsu S, Tsuji S. Occurrence of traumatic brain injury due to short falls with or without a witness by a nonrelative in children younger than 2 years. *Journal of Neurosurgery-pediatrics*, 2020;26(6): 696–700. https://doi.org/10.3171/2020.6.PEDS20314
13. Balogun JA, Koko AM, Adebayo A, Aniaku I, Lasseini A, Balogun FM, et al. Fall-related traumatic brain injury in a Nigerian pediatric population. *Journal of Clinical Neuroscience*, 2023;109: 26–31. https://doi.org/10.1016/j.jocn.2023.01.007
14. Reisz Z, Radics BL, Nemes P, Laxton R, Kaizer L, Gabor KM, et al. Case Report: Brainstem angiocentric glioma presenting in a toddler child-diagnostic and therapeutic challenges. *Pathology & Oncology Research*, 2023;29: 1611231. https://doi.org/10.3389/pore.2023.1611231
15. Yamaoka Y, Fujiwara T, Tamiya N. Association Between Maternal Postpartum Depression and Unintentional Injury Among 4-Month-Old Infants in Japan. *Maternal and Child Health Journal*, 2016;20(2): 326–336. https://doi.org/10.1007/s10995-015-1832-9
16. Mitchell EA, Rajay A, Freeman L, McIntosh C. Falls of newborn infants in a New Zealand hospital: A case series. *Journal of Paediatrics and Child Health*, 2023;59(2): 253–257. https://doi.org/10.1111/jpc.16275
17. Lipke B, Gilbert G, Shimer H, Consenstein L, Aris C, Ponto L, et al. Newborn Safety Bundle to Prevent Falls and Promote Safe Sleep. *Mcn-the American Journal of Maternal-child Nursing*, 2018;43(1): 32–37. https://doi.org/10.1097/NMC.0000000000000402
18. Cooray N, Sun SL, Ho C, Adams S, Keay L, Nassar N, et al. Toward a Behavior Theory-Informed and User-Centered Mobile App for Parents to Prevent Infant Falls: Development and Usability Study. *Jmir Pediatrics and Parenting*, 2021;4(4): e29731. https://doi.org/10.2196/29731
19. Gyedu A, Boakye G, Quansah R, Donkor P, Mock C. Unintentional falls among children in rural Ghana and associated factors: a cluster-randomized, population-based household survey. *Pan African Medical Journal*, 2021;38: 401. https://doi.org/10.11604/pamj.2021.38.401.28313
20. Fakhri AB, Gharghan SK, Zubaidi SL. Accurate Infants Remote Temperature Monitoring System based on Contactless Temperature Sensor and GSM Network. *2020 13th International Conference on Developments in Esystems*, 2020;: 177–182. https://doi.org/10.1109/DeSE51703.2020.9450733
21. Kalina RM, Dlubacz N, Zachwieja J, Pilarska E, Dobosz D, Walczak BG, et al. Innovative method of diagnosing the susceptibility to the body injuries during the fall of children from 2 to 6 years. *Archives of Budo Science of Martial Arts and Extreme Sports*, 2022;18: 211–228.
22. Ossmy O, Han DY, Macalpine P, Hoch J, Stone P, Adolph KE. Walking and falling: Using robot simulations to model the role of errors in infant walking. *Developmental Science*, 2024;27(2):. https://doi.org/10.1111/desc.13449
23. Bisi MC, Stagni R. Evaluation of toddler different strategies during the first six-months of independent walking: A longitudinal study. *Gait & Posture*, 2015;41(2): 574–579. https://doi.org/10.1016/j.gaitpost.2014.11.017

24. Cooray N, Ho CTRE, Bestman A, Adams S, Nassar N, Keay L, et al. Exploring the Potential of a Behavior Theory-Informed Digital Intervention for Infant Fall Prevention: Mixed Methods Longitudinal Study. *Jmir Pediatrics and Parenting*, 2024;7: e47361. https://doi.org/10.2196/47361
25. Sullivan BG, Grigorian A, Lekawa M, Dolich MO, Schubl SD, Barrios C, et al. Comparison of Same and Different Level Height Falls on Subsequent Midline Shift in Pediatric Traumatic Brain Injury. *Pediatric Emergency Care*, 2022;38(5): E1262–E1265. https://doi.org/10.1097/PEC.0000000000002588
26. Han DY, Cole WG, Joh AS, Liu YQ, Robinson SR, Adolph KE. Pitfall or Pratfall? Behavioral Differences in Infant Learning From Falling. *Journal of Experimental Psychology-general*, 2023;152(11): 3243–3265. https://doi.org/10.1037/xge0001453
27. Sullivan S, Coats B, Margulies SS. Biofidelic neck influences head kinematics of parietal and occipital impacts following short falls in infants. *Accident Analysis and Prevention*, 2015;82: 143–153. https://doi.org/10.1016/j.aap.2015.05.020
28. Molocznik A, Omaki E, Wagner K, Shields WC, McDonald EM, Solomon BS, et al. «Before I Could Get Him, He Fell»: Experiences, Concerns, and Fall Prevention Strategies of Parents With Young Children. *Clinical Pediatrics*, 2023;62(11): 1426–1434. https://doi.org/10.1177/00099228231161018
29. Shin HY, Lee JY, Kim LE, Lee S, Huh S. Child injury death statistics from 2006 to 2016 in the Republic of Korea. *Journal of The Korean Medical Association*, 2019;62(5): 283–292. https://doi.org/10.5124/jkma.2019.62.5.283
30. Bartick M, Smith LJ. Speaking Out on Safe Sleep: Evidence-Based Infant Sleep Recommendations. *Breastfeeding Medicine*, 2014;9(9): 417–422. https://doi.org/10.1089/bfm.2014.0113
31. Messayke S, Franco P, Forhan A, Dufourg MN, Charles MA, Plancoulaine S. Sleep habits and sleep characteristics at age one year in the ELFE birth cohort study. *Sleep Medicine*, 2020;67: 200–206. https://doi.org/10.1016/j.sleep.2019.11.1255
32. Afonso AR, Duque CG. Automated Text Clustering of Newspaper and Scientific Texts in Brazilian Portuguese: Analysis and Comparison of Methods. *Journal of Information Systems and Technology Management*, 2014;11(2): 415–436. https://doi.org/10.4301/S1807-17752014000200011
33. Wadnare RJ, Sherekar DrSS, Thakare DrVM. Development of Text Clustering Method with K-Means for Analysis of Text Data. *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*, 2021; 143–151. https://doi.org/10.32628/CSEIT217237
34. Fan W. Application and analysis of text similarity in text clustering in the Chinese context. *Applied and Computational Engineering*, 2023;21(1): 71–77. https://doi.org/10.54254/2755-2721/21/20231120
35. Tahvili S, Hatvani L, Felderer M, Gomes F, Feldt R. *Comparative Analysis of Text Mining and Clustering Techniques for Assessing Functional Dependency between Manual Test Cases*. 2024. https://doi.org/10.21203/rs.3.rs-4014160/v1
36. Xie T, Qin P, Zhu L. Study on the Topic Mining and Dynamic Visualization in View of LDA Model. *Modern Applied Science*, 2018;13(1): 204. https://doi.org/10.5539/mas.v13n1p204
37. Bascur JP, Verberne S, van Eck NJ, Waltman L. Which topics are best represented by science maps? An analysis of clustering effectiveness for citation and text similarity networks. 2024; https://doi.org/10.48550/ARXIV.2406.06454
38. Li C, Yang C, Jiang Q. The research on text clustering based on LDA joint model. Mishra KK (ed.) *Journal of Intelligent & Fuzzy Systems*, 2017;32(5): 3655–3667. https://doi.org/10.3233/JIFS-169300
39. Zhang W, Zhai G, Zhong B, Kong X. Text Semantic Analysis Algorithm Based on LDA Model and Doc2vec. In: Hou Z (ed.) *Advances in Transdisciplinary Engineering*, IOS Press; 2024. https://doi.org/10.3233/ATDE231269
40. Hidayat EY, Firdausillah F, Hastuti K, Dewi IN, Azhari A. Automatic Text Summarization Using Latent Drichlet Allocation (LDA) for Document Clustering. *International Journal of Advances in Intelligent Informatics*, 2015;1(3): 132. https://doi.org/10.26555/ijain.v1i3.43
41. Mittal M, Battineni G, Usharani B, Goyal LM. *Text Analysis with Python: A Research Oriented Guide*. Bentham Science Publishers; 2022. https://doi.org/10.2174/9789815049602122010l
42. Wu D, Yang R, Shen C. Sentiment word co-occurrence and knowledge pair feature extraction based LDA short text clustering algorithm. *Journal of Intelligent Information Systems*, 2021;56(1): 1–23. https://doi.org/10.1007/s10844-020-00597-7
43. Chuang J, Manning CD, Heer J. Termite: visualization techniques for assessing textual topic models. In: *Proceedings of the International Working Conference on Advanced Visual Interfaces*, Capri Island Italy: ACM; 2012. p. 74–77. https://doi.org/10.1145/2254556.2254572
44. Sievert C, Shirley K. LDAvis: A method for visualizing and interpreting topics. In: *Proceedings of the Workshop on Interactive Language Learning, Visualization, and Interfaces*, Baltimore, Maryland, USA: Association for Computational Linguistics; 2014.P.63–70. https://doi.org/10.3115/v1/W14-3110
45. Hovy D. *Text Analysis in Python for Social Scientists: Discovery and Exploration*. 1st ed. Cambridge University Press; 2021. https://doi.org/10.1017/9781108873352
46. Hovy D. *Text Analysis in Python for Social Scientists* [Internet]. 2024 [updated 2024 Jun; cited 2024 Dec 28]. Available from: https://github.com/dirkhovy/text_analysis_for_social_science
47. Arumalla K, Kulkarni A, Sadashiva N, Konar S, Singh GJ, Gopalakrishna N, et al. Fall from Height in Pediatric Age Group: A Retrospective Review from a Tertiary Neurosurgical Center in India. *Journal of Pediatric Neurosciences*, 2023;18(4): 283–290. https://doi.org/10.4103/jpn.jpn_40_23
48. Tunthanathip T, Phuenpathom N. Impact of Road Traffic Injury to Pediatric Traumatic Brain Injury in Southern Thailand. *Journal of*

Neurosciences in Rural Practice, 2017;8(4): 601–608. https://doi.org/10.4103/jnrp.jnrp_381_17
49. Kendrick D, Maula A, Reading R, Hindmarch P, Coupland C, Watson M, et al. Risk and Protective Factors for Falls From Furniture in Young Children Multicenter Case-Control Study. *Jama Pediatrics*, 2015;169(2): 145–153. https://doi.org/10.1001/jamapediatrics.2014.2374
50. Benford P, Young B, Coupland C, Watson M, Hindmarch P, Hayes M, et al. Risk and protective factors for falls on one level in young children: multicentre case-control study. *Injury Prevention*, 2015;21(6): 381–388. https://doi.org/10.1136/injuryprev-2015-041581
51. Morrongiello BA, Corbett M. Parents' perspectives on preschool children's in-home falls: implications for injury prevention. *Vulnerable Children and Youth Studies*, 2016;11(2): 136–145. https://doi.org/10.1080/17450128.2016.1173754
52. Solaiman RH, Navarro SM, Irfanullah E, Zhang J, Tompkins M, Harmon J. Sofa and bed-related pediatric trauma injuries treated in United States emergency departments. *American Journal of Emergency Medicine*, 2023;68: 155–160. https://doi.org/10.1016/j.ajem.2023.03.055
53. Yang ZQ, Tsui BY, Wu ZH. Assessment System for Child Head Injury from Falls Based on Neural Network Learning. *Sensors*, 2023;23(18): 7896. https://doi.org/10.3390/s23187896
54. Cox A, Morrongiello BA. A pilot randomized trial evaluating the Cool 2 Be Safe Junior Playground Safety Program for preschool children. *Journal of Pediatric Psychology*, 2024;49(4): 279–289. https://doi.org/10.1093/jpepsy/jsae003
55. Ghanem MAH, Moustafa TA, Megahed HM, Salama N, Ghitani SA. A descriptive study of accidental skeletal injuries and non-accidental skeletal injuries of child maltreatment. *Journal of Forensic and Legal Medicine*, 2018;54: 14–22. https://doi.org/10.1016/j.jflm.2017.12.006
56. Pietrzak J, Kurdys P, Surówka L, Obuchowicz A. Use of white noise-emitting devices in infants and small children as assessed by their parents. *Pediatria I Medycyna Rodzinna-paediatrics and Family Medicine*, 2019;15(3): 291–296. https://doi.org/10.15557/PiMR.2019.0049
57. DeMasi A, Horger MN, Scher A, Berger SE. Infant motor development predicts the dynamics of movement during sleep. *Infancy*, 2023;28(2): 367–387. https://doi.org/10.1111/infa.12519
58. Feng WW, Zhang Y, Wang HS, Pan XP, Jin X, Xu T, et al. Understanding the Choice of Sleep Arrangements and Soothing Methods and Their Associations with Sleep Problems among Children Under 3 Years Old: A Chinese PopulationBased Study. *Biomedical and Environmental Sciences*, 2022;35(3): 225–233. https://doi.org/10.3967/bes2022.031
59. Akar AS, Yavuzer IH. Investigating the Factors Affecting the Sleep of Babies Between 0-2 Years of Age. *Journal of Child - Cocuk Dergisi*, 2023;23(2): 129–136. https://doi.org/10.26650/jchild.2023.1208970
60. Wadhwaniya S, Alonge O, Ul Baset MK, Chowdhury S, Bhuiyan A, Hyder AA. Epidemiology of Fall Injury in Rural Bangladesh. *International Journal of Environmental Research and Public Health*, 2017;14(8): 900. https://doi.org/10.3390/ijerph14080900

Information about the author:

Tetiana Yermakova; https://orcid.org/0000-0002-3081-0229; yermakova2015@gmail.com; Department of Intercultural Communication in Creative Industries, Kharkiv State Academy of Design and Arts; Kharkiv, Ukraine.

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ORIGINAL ARTICLE

Assessment of factors influencing the citation level of scientific publications in the field of sport and physical activity

Sergii Iermakov[1ABCDE], Georgiy Korobeynikov[2,3ABCDE]

[1] *Kharkiv State Academy of Design and Arts, Ukraine*
[2] *Uzbek State University of Physical Education and Sports, Uzbekistan*
[3] *Institute of Psychology, German Sport University Cologne, Germany*

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim The citation level of scientific publications is a key indicator of their scientific impact and significance. With the increasing number of publications in the field of sport and physical activity, it is crucial to identify the factors influencing citation levels. The aim of this study is to analyze the relationship between the number of cited references and the citation level of publications. Additionally, the study examines the impact of access mode (open or closed) and publication type on citation metrics.

Material and Methods The study is based on the analysis of bibliographic data from the Web of Science database covering the period from 2015 to 2024. The dataset includes 10,000 publications related to sport and physical activity. Metrics such as Cited Reference Count (NR), Times Cited (TC), and Total Times Cited (Z9) were used to evaluate the relationship between the number of cited references and the citation level of publications. The study also analyzed the impact of access mode (open or closed) and publication type (Article, Review, Other) on citation metrics. Data processing involved descriptive statistical methods and nonparametric tests, including Spearman's correlation and the Kruskal-Wallis test.

Results The analysis of bibliographic data revealed the following patterns. The citation level of publications is associated with the number of cited references (NR); however, the correlation remains weak (Spearman's coefficients: 0.1329 for TC and 0.1342 for Z9). The average number of cited references for highly cited articles is 69.56, with a maximum value of 766. Open-access publications exhibit significantly higher citation levels. Among them, the «Green Accepted» (7.19%) and «Green Published, hybrid» (4.45%) formats make a substantial contribution. However, the majority of publications (60.14%) fall into the «Unknown» category, limiting the assessment of their accessibility. An analysis of publication types showed that Review and Article formats have the greatest impact. These account for 21.81% and 75.29% of highly cited works, respectively. In the high-citation category, most publications fall into the «Moderate» citation subcategory (52.5%), followed by «Low High» (46.21%), while only 1.29% are in the «High» and «Very High» subcategories. A temporal analysis demonstrated that the highest number of highly cited publications was from 2015 (1,890 publications), followed by a decline in subsequent years. The lowest citation levels were observed for 2024 publications (only 18 articles), likely due to insufficient time for citation accumulation. These results confirm the influence of factors such as accessibility, publication type, and temporal characteristics on the citation metrics of publications in the field of sport and physical activity.

Conclusions The study highlights the importance of a comprehensive approach to analyzing factors influencing the citation levels of scientific publications. Considering contextual characteristics such as publication accessibility, type, and temporal aspects is key to understanding the mechanisms underlying citation dynamics. The findings provide a foundation for developing strategies to enhance the scientific significance of publications, including optimizing article structure, selecting appropriate access models, and accounting for disciplinary specificity. Further research in this area will deepen the understanding of the relationships between various factors and citation levels, contributing to improved quality and visibility of scientific work.

Keywords: Web of Science, Sport Sciences, citation, analysis, sources

Introduction

In the context of the rapidly growing volume of scientific publications, ensuring their visibility and recognition within the academic community has become a critical task. In this regard, the role and significance of citation metrics are increasing, as they have become one of the key indicators for evaluating publications and journals overall. Therefore, the search for strategies to enhance the scientific impact and accessibility of publications will contribute to advancing knowledge across various fields.

In this context, citation approaches become particularly important, as emphasized in

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recommendations from well-known methodological guides [1], Guidelines for authors [2, 3, 4]. and confirmed by research [5, 6, 7, 8, 9, 10].

All these recommendations focus on the need to refer to reliable, primary sources with the most up-to-date information.

Jawaid et al. [11] and other researchers [12] emphasize the importance of being informed about developments in the last 5-10 years. The authors call for researchers to optimally and balanced inclusion of high-quality and current references in their work. This is confirmed by the scientific consensus, which recognizes the importance of citing works no older than 2–5 years [13, 14, 15, 16, 17]. The authors assert that older references may indicate an incomplete literature review [18].

Other studies [19, 20] draw attention to the need for careful verification and relevance of references. The authors highlight potential errors that can arise, for example, when using artificial intelligence like ChatGPT to compile a bibliography.

The authors highlight the potential errors that may arise when using artificial intelligence tools, such as ChatGPT, to generate reference lists. This concern is supported by research that identifies cases of spontaneous fabrication of false citations. For instance, McGowan et al. [21] note that ChatGPT and similar tools, like Bard, are capable of creating fictitious references when conducting literature searches in psychiatry. Additionally, Walters and Wilder [22] emphasize that errors in bibliographic references generated by ChatGPT stem from both data fabrication and the misrepresentation of existing sources. The studies by Hueber and Kleyer [23] focus on the quality of data in rheumatology, revealing instances of fabricated references, which underscores the need for a critical approach to using such technologies. Citing non-existent sources not only misleads readers and violates academic ethics but also undermines trust in scientific publications. This issue is particularly significant given the increasing use of artificial intelligence in academia.

Comeau et al. [24] analyse a multimillion array of references. The authors demonstrate a tendency to cite literature published in the last 5-10 years. This approach reflects the scientific community's aspiration for the timeliness of research.

Hui et al. [16] limited the search depth for the last 5 years (2013–2018) and for the last 10 years. In another study [9], the authors assert that citation indicators alone cannot provide sufficiently detailed or reliable measurements of quality.

An integral part of a manuscript is the number of cited publications. Recommendations in this context vary widely. For instance, it is suggested to limit the number of references to 50 in an original research article, 40 in a preliminary communication, 30 in a scientific note, and 100–150 in a mini-review and review, respectively [25]. Preferably, the references should include recent international publications, unless they provide an overview of the field. They should reflect the manuscript's topic and demonstrate relevance to the journal.

Other studies highlight limitations on the number of references for certain types of articles [26], such as no more than 40 references [27]. These citation metrics draw the attention of researchers [28].

In general, recommendations regarding the number of references in an article and the depth of coverage in years are provided in journals. These guidelines depend on the journal's thematic focus and the type of article. The number of references can range from 30–150 [25], up to 40 [5], or even be unlimited [6]. Reviewer guidelines often recommend checking for references to recent publications and the most relevant prior research [7].

Other author guidelines impose reference limits for specific types of articles, starting from as few as five references [5]. The validity of such approaches is emphasized in the study by Liang et al. [28], where the authors highlight the importance of addressing citation quality issues.

Among other studies, publications based on bibliometric analysis stand out, particularly those utilizing tools like VoSviewer [29, 30, 31].

This analysis involves extracting bibliographic data from documents, including indicators such as the number of citations, the number of references in the References section, the year of publication, and others. However, this approach has limitations due to the specifics of the algorithm used to process the information retrieved from databases.

Modern research emphasizes the importance of the impact factor as a key indicator of scientific journal quality, linking it to citation counts and publication accuracy [32, 33, 34]. Various aspects are analyzed, including the relationship between alternative metrics and the impact factor [33], citation trends and reference accuracy [35], and broader bibliometric approaches to evaluating academic journals [36]. Some studies highlight prospects for improving publication quality [34] and examine factors influencing the impact factor in specific fields [37], including sports and physical activity [38].

These studies contribute to a trend toward more comprehensive journal evaluations that incorporate both traditional and innovative measures of scholarly impact. Notably, the study by Ariza-Guerrero [39] points to a continuous and substantial increase in citations per article, limited only when journals impose restrictions on the maximum number of pages per article. In some cases, the number of citing documents reaches 400–500 [40, 41, 42] in journals with impact factors of 6.0, 10.9, and 4.5, respectively.

Overall, research highlights the need for a comprehensive approach to evaluating level scientific

journals (articles), incorporating alternative metrics, bibliometric analysis, and citation accuracy control.

Web of Science (WoS) and Scopus are widely recognized as global benchmarks for assessing the scientific quality of journals and articles. Citation indicators derived from these databases play a pivotal role in evaluating the scientific contribution of journals and classifying them into quartiles, which act as a measure of journal quality [43, 44]. These databases are extensively consulted and often utilized in research assessments, though recent studies indicate that systematic differences between them are minimal or non-existent [45, 46]. These findings showed that journals with high citation rates often achieve top quartile rankings, reinforcing the role of citations as an indicator of quality. Furthermore, studies suggest that Web of Science and Scopus databases provide robust metrics for evaluating the impact of individual articles, departments, and institutions [44].

Despite numerous studies analyzing the citation dynamics of scientific publications, there remains a need for a deeper exploration of the factors influencing citation patterns, particularly in the field of sport and physical activity. Existing guidelines for authors and journal editors often prove insufficient in addressing issues related to the quality and relevance of references, as well as the impact of various metrics on citation levels.

In the context of increased use of artificial intelligence and the growing volume of publications, there is a pressing need to develop more effective approaches that enhance the quality of scientific works, minimize errors in bibliographic data, and ensure their significance within the academic community.

Based on the conducted analysis, several hypotheses are proposed, the confirmation or refutation of which could provide new insights into addressing issues related to the citation factors of scientific publications:

1. *Number of Cited References and Citation Level*. The number of references cited in an article may serve as an indicator of the depth of topic coverage and overall publication quality, thereby contributing to increased citation levels. *Hypothesis*: There is a positive relationship between the number of cited references in an article and its citation level.
2. *Access Mode and Citation Level*. Open access enhances the visibility and accessibility of articles, which may positively affect their citation levels. However, the number of cited references is likely independent of the article's access status. *Hypothesis:* Open-access articles exhibit higher citation levels compared to closed-access articles, but access status does not influence the number of cited references.
3. *Impact of Publication Year*. The year of publication determines the opportunities for accumulating citations and may also reflect variations in the amount of available literature over time. *Hypothesis:* The publication year influences both the citation level of an article and the volume and structure of its reference list.

The aim of this study is to analyze the relationship between the number of cited references and the citation level of publications. Additionally, the study examines the impact of access mode (open or closed) and publication type on citation metrics.

Material and Methods

An initial pilot search and analysis were conducted to assess the feasibility of extracting references from the References sections on the scientific journals' web resources. In fact the journals present the References section with some distinctive features. This significantly complicates the data extraction process that would take these differences into account.

Therefore, the need for a unified methodology for extracting references determined the direction of the search – the Web of Science database [47]. In this context, Web of Science provides the ability to extract document data using the same settings for all journals. Similar extractions have already been performed by us in our previous studies [5, 6].

Selection of Search Categories in the WoS Database

The selection of search categories was based on the mandatory inclusion of publications related to the topics of «sport, physical activity» in the context of education, training, recreation, and physical rehabilitation. This choice was guided by the understanding that these topics significantly contribute to promoting a healthy lifestyle, which is a key criterion for the quality of life in the population. Three categories met this criterion: *'Sport Sciences,' 'Hospitality, Leisure, Sport & Tourism,'* and *'Education & Educational Research.'*

Other categories might also include similar topics but are often supplemented by specific focuses—such as medical, technical, or economic perspectives. Another criterion for selecting a category is the ability to extract all cited documents or the maximum possible number of them for analysis. Therefore, only these three categories were selected.

Justification for Information Search Periods

The selection of information search periods was based on the formula for calculating the impact factor in WoS (2024):

$$\text{Impact Factor} = \frac{A}{B},$$

Where, A - Citations in 2023 to items published in 2021 and 2022; B - Number of citable items in 2021 and 2022.

The formula for calculating the CiteScore 2023 metric (Scopus):

$$\text{CiteScore} = \frac{C}{D}$$

,

Where, C - Citations from 2020 to 2023; D - Documents published from 2020 to 2023.

Both metrics are based on a 3-year or 4-year period, respectively. Additionally, WoS provides the option to filter searches for the past 5 years or specify a custom time range. A 5-year period from the current year was selected for the study.

Justification for the Depth of Information Search

The selection of the search depth considered recommendations from previous studies [48, 49, 50]. The authors highlight that both the depth and breadth of research coverage can influence citations.

A 2 × 5-year periodization was chosen:

- 2020–2024**:** For contemporary data.
- 2015–2019**:** For comparison and assessment of changes.

The starting date of the period was clarified as the last complete year (2024). It was noted that publications from the last year may include future dates due to «EARLY ACCESS» articles, which can have publication dates set in the future. Such publications were considered as part of the last year's data.

Justification for the Number of Bibliographic Records Extracted

An equally important factor is the number of bibliographic records extracted for analysis. A review of studies indicates that authors select varying numbers of highly cited articles for analysis: TOP-50 [51]; TOP-96 [52]; TOP-100 [53]; TOP-2000 [54]. In some cases, authors analyzed fewer articles, including for citation analysis [55]. Different criteria were applied to justify the selection of articles for analysis.

A search in the Web of Science Categories 'Sport Sciences; Hospitality, Leisure, Sport & Tourism; Education & Educational Research' yielded 795089 documents.

Sample Size

Steps for determining the minimum sample size from N=795089 bibliographic records:

Formula for Sample Size Calculation (when the total number of documents is known). The calculation is based on a commonly accepted formula for determining sample size, which considers:

- Confidence level: 95% (Z=1.96)
- Margin of error (e)**:** 2% (e=0.02)
- Estimated proportion of success (p)**:** 50% (p=0.5), which ensures maximum variability.

Formula:

$$n = \frac{Z^2 \cdot p \cdot (1-p)}{e^2}$$

Adjustment for finite dataset size:

$$n_{adj} = \frac{n}{1 + \frac{n-1}{N}}$$

Sample size without considering N: 4148 Sample size adjusted for N=795,089: 4126

An analysis of N bibliographic records directly on the WoS search page revealed that citation counts decrease sharply after the first 10000 records. For example, at 10000 records, the minimum citation count is 72. For the subsequent 100 and 650 records, the citation counts drop to 23 and 0, respectively. Therefore, it was decided to limit the extraction to 10000 bibliographic records. This decision aligns with the calculated values. In fact, 5% of the documents that were cited were not considered.

Search Strategy

The search strategy was based on extracting data from the Web of Science (WoS) database. The process of identifying and extracting the required publications followed this sequence:

1. The first 1,000 bibliographic records were selected (due to WoS limitations).
2. The 'Export' field was configured for accurate data extraction.
3. The data was saved to a text file.

Export Configuration:

- Select 'Plain text files.
- In the new window titled 'Export Records to Plain Text File,' choose 'Edit' and select all 29 fields.
- Save the selections using 'Save selections,' which will remain valid for the session.

The first 1,000 records were extracted and saved. Subsequently, the next 1,000 records were selected and saved to another file.

Inclusion and exclusion criteria

Documents in the fields of 'Sport Sciences; Hospitality, Leisure, Sport & Tourism; Education & Educational Research' published between 2015 and 2024 were identified. The criteria for extraction were selected from the 'Web of Science Core Collection Field Tags':

NR - Cited Reference Count;

TC - Web of Science Core Collection Times Cited Count;

Z9 - Total Times Cited Count (Web of Science Core Collection, Arabic Citation Index, BIOSIS Citation Index, Chinese Science Citation Database, Data Citation Index, Russian Science Citation Index, SciELO Citation Index);

U1 - Usage Count (Last 180 Days);

U2 - Usage Count (Since 2015);

PY - Year;

UT - Accession Number;
DT - Document Type;
WC - WoS Categories;
OA - Open Access.

During the processing of the extracted data, documents without a References section were excluded from the analysis. Subsequently, documents lacking the «tag» for either the number of citations or the number of cited sources were also excluded. A total of 95% of the extracted documents were used for analysis, while 5% were excluded.

Statistical Analysis

Descriptive statistical methods and distribution analysis were applied for data processing. Key indicators such as mean, median, standard deviation, minimum, and maximum values were calculated for metrics related to the number of cited references (NR) and citation levels (TC, Z9). The data were processed using the Python programming environment with libraries such as pandas, numpy, and matplotlib for visualization. Distribution diagrams and tables highlighting the key characteristics of the data were employed to enhance result interpretation.

Results

General Characteristics of the Extracted Records

The overall characteristics of the extracted records are presented in Figure 1. The data in Figure 1 illustrate the distribution of publications by year and their respective proportions within the dataset. The highest proportion of records corresponds to publications from 2015, accounting for 19.99% of the total. This is followed by 2016 and 2017, with 17.61% and 16.33%, respectively. The number of records gradually decreases over subsequent years, with notable drops in 2022 (2.12%) and 2023 (1.04%). Publications from 2024 constitute only 0.18% of the dataset, which is expected given the partial availability of publications for this year.

For further analysis, the dataset is divided into two periods:

2020–2024: Representing the most recent data, with a total of 1,999 records (19.99% of the total).

2015–2019: Representing the earlier years, with a total of 8,001 records (80.01% of the total).

Based on the analysis of the extracted records, article characteristics were identified. Table 1 presents the top 10 documents with the highest number of citations in the References section.

The top 10 articles (Table 1) are characterized by high citation counts (TC) and a significant number of cited references (NR). The most cited article (UT: WOS:000474219100010) has TC=7027 and NR=41, indicating its importance within the scientific community. The article with the highest number of references (NR=159, UT: WOS:000464864400007) has relatively lower citation counts (TC=2852), which may reflect its use in a specific context. The publication years span from 2016 to 2021, with the majority of articles published between 2018 and 2020.

Table 2 presents the distribution of documents by categories. The majority of articles (over 98%) demonstrated a strong correlation between the number of cited references (NR) and citation

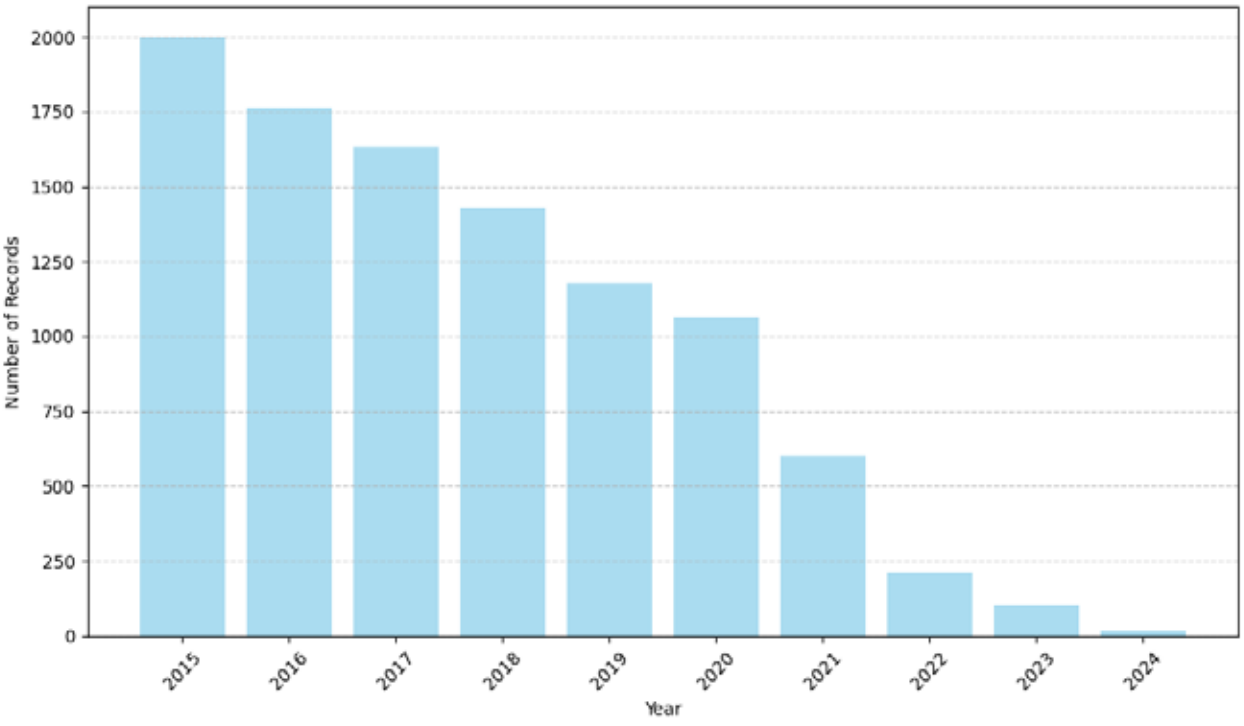

Figure 1. General Characteristics of Extracted Records

metrics (TC and Z9), supporting the hypothesis that an increase in the number of references in an article contributes to its citation count. Medium and low correlations are extremely rare (<2%), which may indicate specific thematic or structural characteristics of these publications. These findings confirm a consistent pattern between the number of references and article citation levels

Table 3 presents the statistical description of the NR, TC, and Z9 metrics. The data in Table 3 demonstrate key statistical indicators for the High category, including mean values, medians, minimum and maximum values, as well as standard deviations for the NR, TC, and Z9 metrics. The presented data indicate significant variation in citation levels and the number of cited references, confirming the diversity of publications within this category.

Figure 2 presents the distribution of publications with a high level of citations by year. The analysis of highly cited publications (High) shows that in 2024, only 18 documents reached this level, 88 in 2023, and 195 in 2022. The highest number of highly cited documents was observed in 2015 (1890).

Table 4 presents the distribution of document types in the high-citation category. The data in Table 4 demonstrate the diversity of publication types within this category. The majority are articles and reviews, highlighting their significant impact in the scientific domain. The category also includes less common document types, such as book chapters, conference materials, and monographs.

Table 5 presents the distribution of high-category documents by citation subcategories. The data in Table 5 shows the division of high-category documents into subcategories based on the number of citations. Most documents fall into the "Moderate" and "Low High" subcategories, indicating a broad range of citation levels. The "High" and "Very High" subcategories contain fewer documents, highlighting their exceptional citation impact.

The results related to open access (OA) data constitute a specific portion of the extracted records. Table 6 presents the distribution of publications by open access types (OA):

Table 1. Top-10 documents with the highest number of citations in the references section

UT	NR	TC	Z9	U1	U2	PY
WOS:000474219100010	41	7027	7874	98	522	2019
WOS:000454273400010	37	4671	5677	49	288	2018
WOS:000605879000004	30	3990	4003	114	819	2020
WOS:000456831900004	31	3306	3467	10	99	2018
WOS:000464864400007	159	2852	2909	2	19	2017
WOS:000573273700003	74	2677	3178	6	16	2016
WOS:000402416500003	46	2547	2848	24	218	2017
WOS:000504687300001	57	2031	2468	51	247	2021
WOS:000532557100001	118	1934	2084	58	161	2021
WOS:000431310400001	46	1539	1564	15	141	2018

Note. UT - Accession Number; NR - Cited Reference Count; TC - Web of Science Core Collection Times Cited Count; Z9 - Total Times Cited Count (all indexes); U1 - Usage Count (Last 180 Days); U2 - Usage Count (Since 2013); PY - year.

Table 2. Distribution of Documents by Categories

Category	Count_TC	Count_Z9
High	9417	9457
Medium	120	82
Low	17	15

Table 3. Statistical Description of Metrics NR, TC, Z9

Metric	NR	TC	Z9
count	9414.0	9414.0	9414.0
mean	69.56	136.97	157.28
std	39.38	147.97	169.44
min	21.0	73.0	73.0
25 %	43.0	84.0	95.0
50 %	62.0	104.0	119.0
75 %	87.0	145.0	168.0
max	766.0	7060.0	7908.0

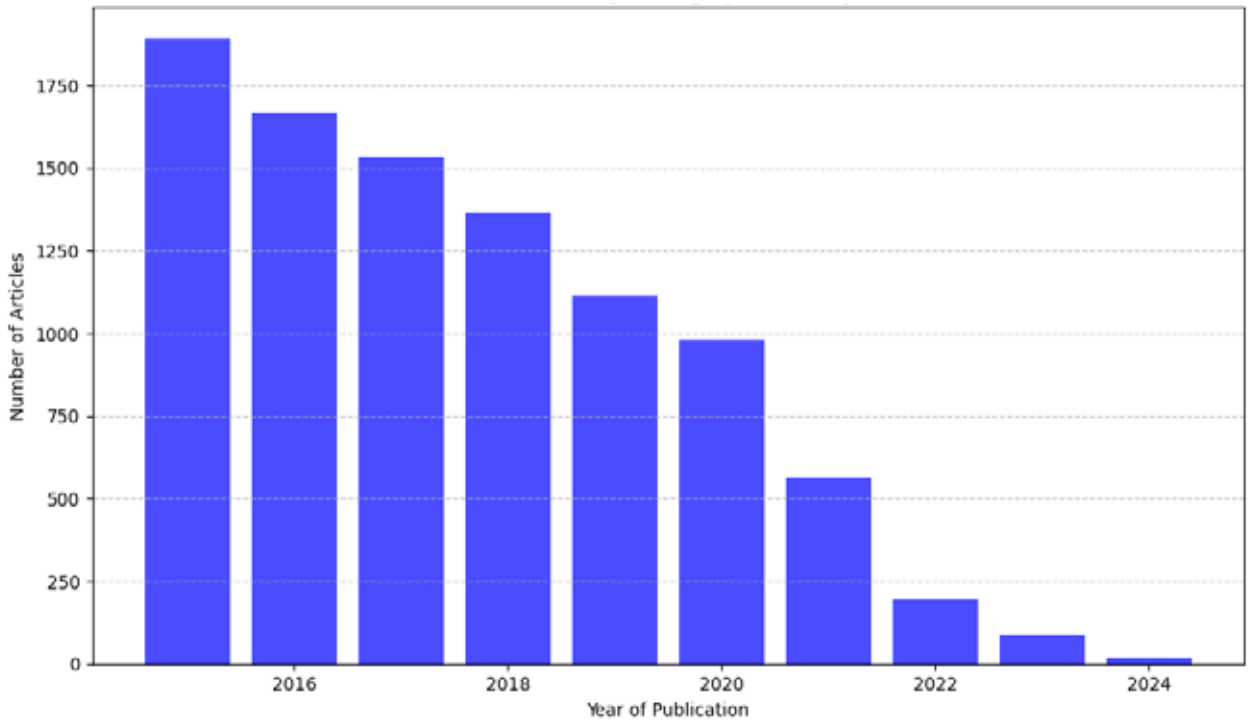

Figure 2. Distribution of Publications with High Citation Levels by Year

Table 4. Distribution of Document Types in the High Citation Category

Document Type	Percentage
Article	75.29
Review	21.81
Chapter	1.04
Material	0.87
Paper	0.8
Book	0.12
Access	0.03
Publication	0.03
Letter	0.01

Table 5. Distribution of High-Category Documents by Citation Count Subcategories

TC_Subcategory	Percentage
Moderate	52.5
Low High	46.21
High	1.06
Very High	0.23

- The largest number of publications falls under the "Unknown" category (5,745 records), indicating a lack of open access information for these records.
- Among publications with known access types, the most common are:
  - Green Accepted (687 records),
  - Green Published, hybrid (425 records),
  - Green Submitted (411 records),
  - Green Published (358 records).
- Combined categories, such as "Green Published, hybrid" and "Green Accepted, Green Published, hybrid," are less frequent but provide valuable insights for analyzing publication accessibility.

Before testing the hypotheses, an assessment of the normality of key metrics was conducted using the Shapiro-Wilk and Kolmogorov-Smirnov tests. The results of both tests indicated a significant deviation from a normal distribution ($p < 0.05$), justifying the use of nonparametric methods, such as Spearman's correlation and the Kruskal-Wallis test.

Hypothesis 1, regarding the relationship between the number of cited references and the citation level of articles, was tested using Spearman's correlation. The analysis revealed a weak but statistically significant correlation between the number of

Table 6. Distribution of Publications by Open Access Types

OA_Sorted	Count	Percentage
Unknown	5745	60.14
Green Accepted	687	7.19
Green Published, hybrid	425	4.45
Green Submitted	411	4.3
Green Published	358	3.75
Green Published, gold	307	3.21
Bronze	305	3.19
hybrid	223	2.33
gold	171	1.79
Green Accepted, Green Submitted	129	1.35
Bronze, Green Published	120	1.26
Green Accepted, Green Published	85	0.89
Green Submitted, gold	78	0.82
Green Accepted, Green Published, hybrid	71	0.74
Bronze, Green Accepted	62	0.65
Green Published, Green Submitted, gold	54	0.57
Bronze, Green Submitted	46	0.48
Green Published, Green Submitted	42	0.44
Green Accepted, hybrid	37	0.39
Green Published, Green Submitted, hybrid	36	0.38
Green Accepted, Green Published, gold	24	0.25
Green Accepted, Green Published, Green Submitted	21	0.22
Bronze, Green Accepted, Green Submitted	19	0.2
Bronze, Green Published, Green Submitted	17	0.18
Green Submitted, hybrid	16	0.17
Green Accepted, Green Published, Green Submitted, hybrid	13	0.14
Bronze, Green Accepted, Green Published, Green Submitted	11	0.12
Bronze, Green Accepted, Green Published	11	0.12
Green Accepted, Green Published, Green Submitted, gold	9	0.09
Green Accepted, gold	9	0.09
Green Accepted, Green Submitted, gold	7	0.07
Green Accepted, Green Submitted, hybrid	3	0.03

cited references and citation levels (coefficients of 0.1329 for TC and 0.1342 for Z9, $p < 0.05$). These results confirm that the number of cited references is associated with an article's citation level, but the relationship is weak, likely influenced by other factors such as the publication year or journal prestige.

Hypothesis 2 regarding differences in citation levels between open-access articles (OA) and articles with closed-access (Non-OA) was tested using the Kruskal-Wallis test. The analysis revealed statistically significant differences for TC (Kruskal-Stat = 34.7722, $p < 0.05$) and Z9 (Kruskal-Stat = 19.6908, $p < 0.05$), but not for the number of cited references (Kruskal-Stat = 0.6218, $p > 0.05$). A detailed breakdown by publication type showed that open access significantly influences the citation levels of Article and Review formats. For the Other category, no significant differences were observed, likely due to the small sample size.

Hypothesis 3 concerning differences in citation metrics across publication years was confirmed. The Kruskal-Wallis test indicated significant differences for all metrics: TC (Kruskal-Stat = 41.0379), Z9 (Kruskal-Stat = 176.6505), and NR (Kruskal-Stat = 324.5172), all with $p < 0.05$. Additional Dunn post-hoc tests for TC demonstrated that the largest differences were observed between 2021 and the years 2022, 2016, and 2015. These differences highlight the temporal influence on citation level distribution.

The analysis results indicated that the number of cited references has a weak but statistically significant impact on the citation level of articles, as evidenced by Spearman's correlation coefficients. However, this relationship is limited and likely influenced by additional factors such as the publication year or journal prestige.

Open access shows a statistically significant impact on the citation levels of publications,

particularly for articles and reviews, underscoring the importance of accessibility in enhancing the scientific impact of research. However, no differences in the number of cited references were identified between articles with different access statuses.

The publication year was found to be a significant factor influencing citation metrics and the structure of references. This highlights the need to account for temporal aspects when evaluating scientific outputs.

Thus, the study's findings confirm the importance of a comprehensive approach to analyzing citation dynamics, taking into account factors such as the number of cited references, publication accessibility, and temporal characteristics.

Discussion

The aim of the study is to evaluate the relationship between the number of cited references and the citation level of scientific publications in the field of sport and physical activity. Additionally, the study seeks to analyze the impact of access mode (open or closed) and publication type on citation metrics.

Our results revealed that the number of cited references has a statistically significant but weak impact on citation levels, indicating the presence of other factors influencing citations. Open access was identified as a significant factor that increases citation levels, particularly for articles and reviews. Additionally, the publication year was found to have a substantial effect on citation metrics, with the most notable differences observed for recent publications.

Our results confirm the presence of a weak but statistically significant correlation between the number of cited references (NR) and article citation levels, as reflected by the TC and Z9 metrics (Spearman's coefficients of 0.1329 and 0.1342, respectively). This indicates that while the number of references influences citation levels, its role is not definitive.

Numerical data from our study indicate that the average value of the NR metric in categories with high citation levels is 69.56, ranging from 21 to 766 (Table 3). At the same time, the highest number of citations (TC = 7027) is observed in an article with 41 references, highlighting that a high citation level is achievable even with a moderate number of cited references.

Comparison with data from other studies confirms the ambiguous impact of the number of references on citation levels. For example, Aksnes et al. [15] and Dougherty et al. [56] suggest that citation metrics are more indicative of an article's scientific impact than its structural characteristics, such as the number of references. Nieminen et al. [57] further note that citation levels depend on factors such as journal prestige, indexing in databases, and article visibility.

Unlike other fields, our data, focused on the topic of sport and physical activity, emphasize the importance of the applied aspect of research, which may increase interest in publications regardless of the number of references. For instance, an analysis of highly cited publications revealed that such articles are most frequently published as original research or reviews, accounting for 75.29% and 21.81%, respectively (Table 4).

Moreover, temporal aspects have a significant impact on citation levels: articles from earlier years, such as 2015, have had more opportunities to accumulate citations (Figure 2), further diminishing the relevance of the number of cited references. Thus, our findings confirm that factors such as article accessibility, journal prestige, and research topic play a more substantial role in shaping citation metrics than the number of references.

Our results confirm that the access mode of an article significantly influences its citation level. Statistically significant differences for the TC and Z9 metrics were identified between open-access (OA) and closed-access (Non-OA) articles, whereas the number of cited references (NR) remains independent of the access mode. This suggests that article accessibility primarily affects its visibility and popularity rather than its structural characteristics.

The share of closed-access publications is 60.14% (Table 6), which limits the scope of analysis for this group. Among the known forms of open access, the most common are "Green Accepted" (7.19%) and "Green Published" (4.45%), which, as shown by our data, contribute to greater visibility of publications.

Comparison with literature data confirms the advantages of open access. For instance, Dorta-González et al. [58] note that hybrid journals (Hybrid Gold OA) exhibit higher citation levels compared to closed-access publications. Yun [59] emphasizes that the citation levels of articles in the Hybrid Gold OA model can double, especially when external funding is available. At the same time, Castillo [60] points out that not all OA models are equally effective in increasing citation levels, as this depends on contextual and thematic factors. This is further supported by the findings of Momeni et al. [61].

Our data align with these findings, showing that hybrid and green forms of open access significantly enhance the visibility of publications. For example, hybrid access ("Green Published, hybrid") accounts for 4.45% of all publications with a known access status, while "Green Submitted" represents 4.3% (Table 6). At the same time, the share of publications with Gold OA remains small (1.79%) and shows mixed results in terms of citation levels.

Thus, our results highlight the importance of open access as a factor increasing citation levels, particularly for articles of the Article and Review types. However, the specific impact of various access models remains complex and requires further

investigation to fully understand their effects.

The data analysis confirmed that different publication types (Article, Review, Other) exhibit significant differences in citation levels. Our results showed that publications in the "Review" format have the highest citation levels, followed by "Article," while publications in the "Other" category do not show significant differences. Articles account for 75.29% of highly cited publications, while reviews represent 21.81% (Table 4). These findings confirm that review articles and original research form the foundation of scientific literature in the field of sport and physical activity.

Most highly cited publications fall into the "Moderate" (52.5%) and "Low High" (46.21%) categories, indicating a wide range of scientific impact among articles (Table 5). This aligns with findings from other studies, such as Weale et al. [62], which emphasize the importance of reviews published in high-impact-factor journals. Due to their systematic approach and in-depth analysis of topics, such articles often serve as key references for subsequent research.

The findings of Kousha and Thelwall [63] confirm that additional factors, such as article length, number of authors, and international collaboration, positively influence citation levels. This is particularly relevant for publications in the Article and Review formats, aligning with our observations.

In the context of sport and physical activity disciplines, unique features emerge due to the applied nature of research. Review articles play a crucial role in knowledge systematization, while original articles in the Article format reflect empirical findings significant for practical applications. Publications in the Other category, which includes less formal or specialized document types, remain minimal (2.9%), limiting their influence within the scientific community.

Thus, our findings emphasize that publication type is a key determinant of citation levels. Review articles play a leading role in shaping scientific discourse, while Article-format publications contribute an applied perspective, advancing science and its practical application. This underscores the need to consider publication types when assessing their scientific impact, particularly in sport and physical activity disciplines.

A comparison of our data with findings from studies such as Abramo et al. [64], Dougherty et al. [56], and Nieminen et al. [57] confirmed that the number of cited references can influence subsequent citation levels. However, unlike these studies, our results demonstrate a weak correlation between these metrics (Spearman's coefficients: 0.1329 for TC and 0.1342 for Z9), suggesting the influence of additional factors such as journal prestige, article accessibility, and publication year.

An analysis of citation dynamics over the years showed that articles published between 2015 and 2020 exhibit the highest citation levels. For instance, in the high-citation category, the maximum number of documents (1,890) corresponds to 2015, while the share of publications decreases significantly in later years (e.g., 564 articles in 2021 and 88 in 2023) (Figure 2). This aligns with the findings of Teplitskiy et al. [65], who emphasize that older publications have more time to accumulate citations.

Our results expand on these observations, clarifying that not only temporal factors but also disciplinary characteristics play a significant role in citation dynamics. For example, in the field of sport and physical activity, the applied nature of research increases interest in articles, which may impact their citation levels regardless of the publication year.

Thus, our findings add specificity to existing data, illustrating how temporal frameworks and disciplinary specificity interact to influence citation metrics. This highlights the necessity of accounting for temporal factors in citation analyses, particularly in rapidly evolving disciplines.

Our results confirm the key findings of previous studies, such as Aksnes et al. [15], Thelwall et al. [66], Lafia et al. [67], and Nightingale et al. [68], which suggest that citation levels reflect the scientific value and impact of an article but are not a universal indicator of its quality. At the same time, our study provides more detailed data that deepen the understanding of the relationships between an article's structural characteristics, accessibility, and citation levels.

One of the key advantages of our findings is the comprehensive approach, which includes analyzing the impact of access mode (OA and Non-OA) and publication types (Article, Review, Other) on citation metrics. For example, our data showed that open-access articles account for 39.86% of all analyzed publications, with the highest citation levels observed for Review articles (21.81%) and Articles (75.29%) (Table 4). This complements the findings of Dardas et al. [69] and Torres [17], demonstrating that the accessibility of publications plays a crucial role, particularly in the Article and Review categories.

Moreover, our study refined the temporal aspects of citation dynamics. The highest citation levels were observed for publications from 2015–2020, consistent with the findings of Teplitskiy et al. [65]. However, our data provide additional insights into the quantitative distribution of publications by year: for instance, articles from 2015 account for 19.99% of the sample and exhibit the highest accumulated citation levels (Figure 2).

Our analysis also considers the disciplinary specifics of sport and physical activity. These characteristics, including the applied nature of research, emphasize the importance of factors such as visibility and accessibility of publications. Unlike

the general conclusions of Abramo et al. [64] and Dougherty et al. [56], our findings highlight that thematic specificity significantly impacts citation metrics.

Thus, our study not only confirms existing findings but also provides new, more detailed data. These insights can be used to further explore the relationship between the structural characteristics of publications, their accessibility, and citation levels, as well as to develop strategies for enhancing the scientific impact of research.

Our study confirmed that the citation levels of scientific publications are influenced by multiple factors, including the number of cited references, access mode, and publication type. Despite the weak correlation between the number of cited references and article citation levels, significant effects were observed for open access (particularly hybrid and green formats) and publication types (Article and Review) on citation metrics. These findings underscore the importance of considering context and disciplinary specificity when analyzing scientific publications.

Our study confirmed that the citation levels of scientific publications are shaped by multiple factors, including the number of cited references, access mode, and publication type. Despite the weak correlation between the number of cited references and citation levels, significant impacts were observed for open access (particularly hybrid and green formats) and publication types (Article and Review) on citation metrics. These findings highlight the importance of considering context and disciplinary specificity when analyzing scientific publications.

However, the study has several limitations. First, the dataset covers publications from 2015 to 2024, which may not fully capture long-term citation trends, particularly for recent publications (e.g., articles from 2023–2024 account for less than 2% of the sample). Second, the study is limited to the discipline of sport and physical activity, restricting the generalizability of the results to other scientific fields. Additionally, the applied nature of research in this discipline may reduce the influence of traditional factors, such as the number of cited references, compared to other fields.

For future research, the following recommendations are proposed:

1. Expand the time frame of analysis to include publications with a longer citation history.
2. Conduct comparative analyses across other disciplines to better understand the impact of disciplinary specificity on citation levels.
3. Incorporate additional metrics, such as audience engagement indices and alternative citation indicators (altmetrics), for a more comprehensive analysis.

These steps will deepen the understanding of citation formation mechanisms and enable the development of more precise approaches to evaluating citations, accounting for interdisciplinary differences and temporal aspects.

Conclusions

The study results confirmed that the citation levels of scientific publications depend on several factors, including the number of cited references, access mode, and publication type. The main findings can be summarized as follows:

1. Despite the weak correlation between the number of cited references and citation levels, this metric holds auxiliary importance and may influence citation levels in combination with other factors, such as journal prestige and publication year.
2. Open access, particularly in hybrid and green forms, has a significant impact on citation levels. This highlights the importance of accessibility in increasing the visibility and influence of scientific articles.
3. Publications in Review and Article formats demonstrate the highest citation levels, underscoring their pivotal role in shaping scientific discourse and advancing research in sport and physical activity.
4. High citation levels are characteristic of publications from 2015–2020, confirming the influence of time on citation accumulation. However, a trend of declining citation levels is observed for articles published in more recent years.
5. In the field of sport and physical activity, the applied nature of research enhances the importance of factors such as publication accessibility and visibility while reducing the influence of structural characteristics, such as the number of references.

The study revealed significant patterns that can be used to develop recommendations for authors and journal editors aimed at enhancing the scientific impact of publications. At the same time, the findings highlight the need for further research that considers temporal and disciplinary aspects and employs a broader set of metrics for analysis.

Conflict of Interest

One of the authors (Sergii Iermakov) serves as the Editor-in-Chief and Publisher of this journal. To ensure an objective review process, the manuscript was handled by an independent editorial board member, and the peer review was conducted by external reviewers who had no affiliations with the authors. The Editor-in-Chief did not participate in the review or editorial decision-making process regarding this manuscript. The other co-author (Georgiy Korobeynikov) declare no conflict of interest related to this publication.

References

1. *Concise Guide to APA Style*. 7th Edition. American Psychological Association; 2019.
2. Elsevier. *Guidelines for authors*. [Internet]. Elsevier; 2024 [updated 2024 Jun; cited 2024 Sep 28]. Available from: https://static.elsevier.es/norm_orga/035normas_eng.pdf
3. Wiley. Author Guidelines. [Internet]. Wiley; 2024 [updated 2024 Jun; cited 2024 Sep 28]. Available from: https://onlinelibrary.wiley.com/page/journal/2688268x/homepage/author-guidelines
4. Springer. *References*. [Internet]. Springer; 2024 [updated 2024 Jun; cited 2024 Sep 28]. Available from: https://www.springer.com/gp/authors-editors/authorandreviewertutorials/howtopeerreview/references/10286412?srsltid=AfmBOop_ZdFQJBVDHY9kbJDwxDpvs5V-bj7NAHQLI6yM20y5b79TtO7H
5. Iermakov S, Yermakova T, Wnorowski K, Bensbaa A. Beach volleyball athlete training trends of Russian-language scientific resources: a systematic review. *Physical Education of Students*, 2021;25(5): 319–338. https://doi.org/10.15561/20755279.2021.0508
6. Iermakov S, Podrigalo L, Podrihalo O, Yermakova T, Jagiello W. Means and methods of physical activity in the context of prevention and treatment of Alzheimer's disease (analysis of Russian-language scientific resources) and the perspective of implementing the unique achievements of the "Polish School of Safe Falling". *Archives of Budo,* 2022;18:121–143.
7. Tykhonkova I. References are the important indicator of articles` quality. How to escape an extra work. In: *Ukrainian Science in the Global Information Space*, 2015. P. 100–106. https://doi.org/10.13140/RG.2.1.4176.5842
8. Peh WCG, Ng KH. Preparing the references. *Singapore Medical Journal*. 2009;50(7): 659–661.
9. Blicq RS, Moretto LA. *Writing Reports to Get Results: Quick, Effective Results Using the Pyramid Method*. 1st ed. Wiley; 2015. https://doi.org/10.1002/9781119134626
10. Staiman Avi. *The Bibliography - Formal Requirement or Essential Ingredient*?; [Internet]; 2017. [cited 2023 Nov 15]. Available from: https://www.researchgate.net/publication/323279708_The_Bibliography_-_Formal_Requirement_or_Essential_Ingredient
11. Jawaid SA, Jawaid M. How to write introduction and discussion. *Saudi Journal of Anaesthesia*, 2019;13(Suppl 1): S18.
12. Fox CW, Paine CT, Sauterey B. Citations increase with manuscript length, author number, and references cited in ecology journals. *Ecology and Evolution,* 2016;6:7717–7726.
13. Leydesdorff L, Wouters P, Bornmann L. Professionaland citizen bibliometrics: Complementarities and ambiva-lences in the development and use of indicators - A state-of-the-art report. *Scientometrics*, 2016; 109: 2129–2150.
14. Baumgartner SE, Leydesdorff L. Group-BasedTrajectory Modeling (GBTM) of citations in scholarly litera-ture: Dynamic qualities of "transient" and "sticky knowledgeclaims." *Journal of the Association for Information Scienceand Technology*, 2014;65: 797-811. https://doi.org/10.1002/asi.23009
15. Aksnes DW, Langfeldt L, Wouters P. Citations, Citation Indicators, and Research Quality: An Overview of Basic Concepts and Theories. *SAGE Open*, 2019;9(1): 215824401982957. https://doi.org/10.1177/2158244019829575
16. Hui A, Rains LS, Todd A, Boaz A, Johnson S. The accuracy and accessibility of cited evidence: a study examining mental health policy documents. *Social Psychiatry and Psychiatric Epidemiology*, 2020;55(1): 111–121. https://doi.org/10.1007/s00127-019-01786-8
17. Torres Á. *Quality of the references* [Internet]; 2016 Oct 23 [cited 2023 Nov 15]. Available from: https://doi.org/10.3916/school-of-authors-021
18. Santini A. The Importance of Referencing. *Journal of Critical Care Medicine (Universitatea De Medicina Si Farmacie Din Targu-Mures)*, 2018;4(1): 3–4. https://doi.org/10.1515/jccm-2018-0002
19. Kumar A. Quality of references reveal the merit of the research. *Journal of Indian Society of Periodontology*, 2022;26(6): 519–520. https://doi.org/10.4103/jisp.jisp_410_22
20. Sanchez-Ramos L, Lin L, Romero R. Beware of references when using ChatGPT as a 356source of information to write scientific articles. *American Journal of Obstetrics and Gynecology*,2023;229(3):356–357. https://doi.org/10.1016/j.ajog.2023.04.004
21. McGowan A, Gui Y, Dobbs M, Shuster S, Cotter M, Selloni A, et al. ChatGPT and Bard exhibit spontaneous citation fabrication during psychiatry literature search. *Psychiatry Research*, 2023;326: 115334. https://doi.org/10.1016/j.psychres.2023.115334
22. Walters WH, Wilder EI. Fabrication and errors in the bibliographic citations generated by ChatGPT. *Scientific Reports*, 2023;13(1): 14045. https://doi.org/10.1038/s41598-023-41032-5
23. Hueber AJ, Kleyer A. Quality of citation data using the natural language processing tool ChatGPT in rheumatology: creation of false references. *RMD Open*, 2023;9(2): e003248. https://doi.org/10.1136/rmdopen-2023-003248
24. Comeau DC, Wei CH, Islamaj Doğan R, Lu Z. *PMC text mining subset in BioC: about 3 million full text articles and growing*. Bioinformatics; 2019.
25. Food Technology and Biotechnology. *Guidelines for Writing References*. [Internet]. 2023 [updated 2023 Jun; cited 2024 Sep 12]. Available from: https://hrcak.srce.hr/upute/upute_reference_Food_Technology_and_Biotechnology.pdf
26. Anger J. Should there be a recommended limit to the number of references in a scientific article? *Sao Paulo Medical Journal*, 1999;117(1): 42–43. https://doi.org/10.1590/S1516-31801999000100010
27. Elsevier. *Article Types* [Internet]. 2023 [updated 2023 Jun; cited 2024 Sep 02]. Available from: https://legacyfileshare.elsevier.com/promis_misc/jnrt-article-types.pdf

28. Liang Z, Mao J, Lu K, Li G. Finding citations for PubMed: a large-scale comparison between five freely available bibliographic data sources. *Scientometrics*, 2021;126(12): 9519–9542. https://doi.org/10.1007/s11192-021-04191-8
29. Rahayu NI, Suherman A, Muktiarni. A Bibliometric Analysis Of Physical Activity Research Using Vosviewer. *Journal of Engineering Science and Technology*, 2023;18: 206–216.
30. Chen L, Ren T, Tan Y, Li H. Global trends of research on depression in breast cancer: A bibliometric study based on VOSviewer. *Frontiers in Psychology*, 2022;13: 969679. https://doi.org/10.3389/fpsyg.2022.969679
31. Rahayu N indri, Bachari A dutha, Muktiarni M, Maryanti RINA. Information and communication technology (ict) intervention targeting physical activity and diet behaviors in people with disabilities: Vosviewer mapping analysis. *Journal of Engineering Science and Technology*, 2023;18: 164–175.
32. Kulczycki E, Holowiecki M, Taskin Z, Krawczyk F. Citation patterns between impact-factor and questionable journals. *Scientometrics*, 2021;126(10): 8541–8560. https://doi.org/10.1007/s11192-021-04121-8
33. Nalbant A. Does altmetric score affect the impact factor of anatomy journals? *European Journal of Anatomy*, 2022;26(3): 263–272. https://doi.org/10.52083/UXMV4266
34. Lyne J, Doherty AM, Hallahan B. Impact factor and future directions for the Irish Journal of Psychological Medicine. *Irish Journal of Psychological Medicine*, 2023;40(3): 321–322. https://doi.org/10.1017/ipm.2023.42
35. Gazendam A, Cohen D, Morgan S, Ekhtiari S, Ghert M. Quotation Errors in High-Impact-Factor Orthopaedic and Sports Medicine Journals. *JBJS Open Access*, 2021;6(3): e2100019. https://doi.org/10.2106/JBJS.OA.21.00019
36. Lugaz N. *Space Weather* Bibliometrics for 2022: Going Beyond Impact Factor. *Space Weather-the International Journal of Research and Applications*, 2022;20(9): e2022SW003276. https://doi.org/10.1029/2022SW003276
37. Ho YS, Giordano V, Mauffrey C, V. Giannoudis P. Trends of impact factor contributors to the *Injury Journal:* A bibliometric analysis. *Injury-International Journal of the Care of the Injured*, 2024;55(3): 111255. https://doi.org/10.1016/j.injury.2023.111255
38. Silva D de O, Taborda B, Pazzinatto MF, Ardern CL, Barton CJ. The Altmetric Score Has a Stronger Relationship With Article Citations Than Journal Impact Factor and Open Access Status: A Cross-sectional Analysis of 4022 Sport Sciences Articles. *Journal of Orthopaedic & Sports Physical Therapy*, 2021;51(11): 536–542. https://doi.org/10.2519/jospt.2021.10598
39. Ariza-Guerrero AM, Blazquez JS. Evolution of number of citations per article in Materials Science: possible causes and effect on the impact factor of journals. *Scientometrics*, 2023;128(12): 6589–6609. https://doi.org/10.1007/s11192-023-04863-7
40. Martin RL, Davenport TE, Fraser JJ, Sawdon-Bea J, Carcia CR, Carroll LA, et al. Ankle Stability and Movement Coordination Impairments: Lateral Ankle Ligament Sprains Revision 2021. *Journal of Orthopaedic & Sports Physical Therapy*, 2021;51(4): CPG1–CPG80. https://doi.org/10.2519/jospt.2021.0302
41. Wut TM, Xu J, Wong S mun. Crisis management research (1985?2020) in the hospitality and tourism industry: A review and research agenda. *Tourism Management*, 2021;85: 104307. https://doi.org/10.1016/j.tourman.2021.104307
42. Guest NS, VanDusseldorp TA, Nelson MT, Grgic J, Schoenfeld BJ, Jenkins NDM, et al. International society of sports nutrition position stand: caffeine and exercise performance. *Journal of the International Society of Sports Nutrition*, 2021;18(1): 1. https://doi.org/10.1186/s12970-020-00383-4
43. Pranckutė R. Web of Science (WoS) and Scopus: The Titans of Bibliographic Information in Today's Academic World. *Publications*, 2021;9(1): 12. https://doi.org/10.3390/publications9010012
44. Powell KR, Peterson SR. Coverage and quality: A comparison of Web of Science and Scopus databases for reporting faculty nursing publication metrics. *Nursing Outlook*, 2017;65(5): 572–578. https://doi.org/10.1016/j.outlook.2017.03.004
45. Martín-Martín A, Orduna-Malea E, Thelwall M, Delgado López-Cózar E. Google Scholar, Web of Science, and Scopus: A systematic comparison of citations in 252 subject categories. *Journal of Informetrics*, 2018;12(4): 1160–1177. https://doi.org/10.1016/j.joi.2018.09.002
46. Stahlschmidt S, Stephen D. *Comparison of Web of Science, Scopus and Dimensions databases*. KB Forschungspoolprojekt; 2020.
47.Web of Science [Internet]; 2023 Oct 23 [cited 2023 Nov 15]. Available from: https://access.clarivate.com/login?app=wos
48. Yang S, Han R. Breadth and depth of citation distribution. *Information Processing & Management*, 2015;51(2): 130–140. https://doi.org/10.1016/j.ipm.2014.12.003
49. Lin Z, Wang Y, Li H. *Depth and Breadth of Research Area Coverage and Its Impact on Publication Citation: An Analysis of Bibliometric Papers*. 2023. https://doi.org/10.48550/ARXIV.2311.06785
50. Stern DI, Tol RSJ. Depth and breadth relevance in citation metrics. *Economic Inquiry*, 2021;59(3): 961–977. https://doi.org/10.1111/ecin.12994
51. Wang SQ, Wang JX, Zhang C, Sun FH, Xie YJ, Jiang W, et al. What You Should Know About Osteoarthritis Rehabilitation: A Bibliometric Analysis of the 50 Most-Cited Articles. *Geriatric Orthopaedic Surgery & Rehabilitation*, 2020;11: 2151459320973196. https://doi.org/10.1177/2151459320973196
52. ELsinghorst ThAM. Analysis of the 96 most often cited articles published in veterinary journals in 2002 and 2003. *Veterinary Quarterly*, 2005;27(4): 183–189. https://doi.org/10.1080/01652176.2002.9695199
53. Gan Y, He Q, Li C, Alsharafi BLM, Zhou H, Long Z. A bibliometric study of the top 100

most-cited papers in neuroendocrine prostate cancer. *Frontiers in Oncology*, 2023;13: 1146515. https://doi.org/10.3389/fonc.2023.1146515
54. Zhang Z, Van Poucke S, Goyal H, Rowley DD, Zhong M, Liu N. The top 2,000 cited articles in critical care medicine: a bibliometric analysis. *Journal of Thoracic Disease*, 2018;10(4): 2437–2447. https://doi.org/10.21037/jtd.2018.03.178
55. Liu Z, Ning W, Liang J, Zhang T, Yang Q, Zhang J, et al. Top 100 cited articles in the thromboangiitis obliterans: a bibliometric analysis and visualized study. *European Journal of Medical Research*, 2023;28(1): 551. https://doi.org/10.1186/s40001-023-01540-6
56. Dougherty MR, Horne Z. Citation counts and journal impact factors do not capture some indicators of research quality in the behavioural and brain sciences. *Royal Society Open Science*, 2022;9(8): 220334. https://doi.org/10.1098/rsos.220334
57. Nieminen P, Carpenter J, Rucker G, Schumacher M. The relationship between quality of research and citation frequency. *BMC Medical Research Methodology*, 2006;6(1): 42. https://doi.org/10.1186/1471-2288-6-42
58. Dorta-González P, Dorta-González MI. Citation differences across research funding and access modalities. *The Journal of Academic Librarianship*, 2023;49(4): 102734. https://doi.org/10.1016/j.acalib.2023.102734
59. Yun JJ, Liu Z, Jeong E, Kim S, Kim K. The Difference in Open Innovation between Open Access and Closed Access, According to the Change of Collective Intelligence and Knowledge Amount. *Sustainability*, 2022;14(5): 2574. https://doi.org/10.3390/su14052574
60. Castillo M. Citations and Open Access: Questionable Benefits: Fig 1. *American Journal of Neuroradiology*, 2009;30(2): 215–216. https://doi.org/10.3174/ajnr.A1325
61. Momeni F, Fraser N, Peters I, Mayr P. *From closed to open access: A case study of flipped journals*. 2019. https://doi.org/10.48550/ARXIV.1903.11682
62. Weale AR, Bailey M, Lear PA. The level of non-citation of articles within a journal as a measure of quality: a comparison to the impact factor. *BMC Medical Research Methodology*, 2004;4(1): 14. https://doi.org/10.1186/1471-2288-4-14
63. Kousha K, Thelwall M. Factors associating with or predicting more cited or higher quality journal articles: An Annual Review of Information Science and Technology (ARIST) paper. *Journal of the Association for Information Science and Technology*, 2024;75(3): 215–244. https://doi.org/10.1002/asi.24810
64. Abramo G, D'Angelo CA. Evaluating research: from informed peer review to bibliometrics. *Scientometrics*, 2011;87(3): 499–514. https://doi.org/10.1007/s11192-011-0352-7
65. Teplitskiy M, Duede E, Menietti M, Lakhani KR. How status of research papers affects the way they are read and cited. *Research Policy*, 2022;51(4): 104484. https://doi.org/10.1016/j.respol.2022.104484
66. Thelwall M, Kousha K, Stuart E, Makita M, Abdoli M, Wilson P, et al. In which fields are citations indicators of research quality? *Journal of the Association for Information Science and Technology*, 2023;74(8): 941–953. https://doi.org/10.1002/asi.24767
67. Lafia S, Thomer A, Moss E, Bleckley D, Hemphill L. How and Why Do Researchers Reference Data? A Study of Rhetorical Features and Functions of Data References in Academic Articles. *Data Science Journal*, 2023;22: 10. https://doi.org/10.5334/dsj-2023-010
68. Nightingale JM, Marshall G. Citation analysis as a measure of article quality, journal influence and individual researcher performance. *Radiography*, 2012;18(2): 60–67. https://doi.org/10.1016/j.radi.2011.10.044
69. Dardas LA, Sallam M, Woodward A, Sweis N, Sweis N, Sawair FA. Evaluating Research Impact Based on Semantic Scholar Highly Influential Citations, Total Citations, and Altmetric Attention Scores: The Quest for Refined Measures Remains Illusive. *Publications*, 2023;11(1): 5. https://doi.org/10.3390/publications11010005

Information about the authors:

Sergii Iermakov; (Corresponding Author); https://orcid.org/0000-0002-5039-4517; sportart@gmail.com; Department of Methodologies of Cross-Cultural Practices, Kharkiv State Academy of Design and Arts; Kharkiv, Ukraine.

Georgiy Korobeynikov; https://orcid.org/0000-0002-1097-4787; k.george.65.w@gmail.com; Department of Theory and Methodology of International Wrestling, Uzbek State University of Physical Education and Sports (Tashkent region, Chirchik, Uzbekistan); Institute of Psychology, German Sport University Cologne (Cologne , Germany).

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REVIEW ARTICLE

The effect of physical fitness on academic achievement through self-confidence in adolescents aged 16 – 18 years: a scoping review

Trisnar Adi Prabowo[ABCDE], Asyidika Vito Indarto[AB], Achmad Zakaria[BC], Febriansyah Dwi Cahyo[DE], Mar'atul Afifah [AE]

Physical Education Study, Universitas Muhammadiyah Brebes, Indonesia

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim: Although the relationship between physical fitness and academic achievement has been widely studied, the mechanisms that explain this relationship still need to be explored further. One possible mechanism that may serve as a mediator is self-confidence. This study aims to conduct a scoping review of the literature that discusses the effects of physical fitness on academic achievement through self-confidence.

Material and Methods: This study is a scoping review that analyzes the relationship between physical fitness, self-confidence, and academic achievement in adolescents aged 16–18 years. The literature review was conducted systematically using the PubMed, Scopus, and Web of Science databases for articles published in English between 2015 and 2024. Article selection was based on predefined inclusion and exclusion criteria and followed the PRISMA procedure.

Results: The analysis identified 9 articles demonstrating a positive relationship between physical fitness, self-confidence, and academic achievement in adolescents. Most studies found that better physical fitness levels, especially cardiorespiratory fitness, were correlated with higher academic achievement. In addition, self-confidence was shown to act as a mediator that strengthens the relationship between physical fitness and academic achievement. However, several studies also reported variations in results, such as students with high fitness but low academic achievement. In general, these findings confirm the important role of physical activity and self-confidence in supporting adolescents' academic success.

Conclusions: Physical fitness plays an important role in supporting academic achievement through self-confidence in adolescents. The positive relationship between physical fitness, self-confidence, and academic achievement emphasizes the importance of integrating physical fitness programs into the school environment as part of a holistic effort to improve the quality of education. Although this study has several limitations, future research is expected to employ stronger designs and broader scopes to provide more applicable recommendations for improving the quality of education and children's health.

Keywords: physical activity, psychology, adolescents, mental health

Introduction

Education is one of the main pillars in the development of quality human resources. One indicator of educational success is academic achievement in students [1]. Various factors have been identified as contributing to academic achievement, including both internal and external factors. One factor that is currently receiving increasing attention is the physical fitness of students [2, 3]. Physical fitness not only influences physical health but is also thought to have a close relationship with academic performance [4].

Engaging in regular physical activity helps improve physical fitness, which in turn enhances blood and oxygen circulation to the brain, thereby supporting better cognitive function [4]. This optimal cognitive function is very important in helping students understand subject matter and complete academic tasks more effectively [5]. In addition, physical activity is also known to reduce stress and anxiety levels, as well as improve mood [6, 7], thereby enhancing students' mental condition and enabling them to become more focused and motivated in learning. Furthermore, regular involvement in physical activities can also foster positive traits such as discipline, responsibility, and effective time management, all of which greatly contribute to academic success [3]. Numerous empirical studies indicate that students who possess higher levels of physical fitness generally achieve higher academic scores than those who are less physically active [2, 4].

Then, the results of previous studies showed that students with good levels of physical fitness tend to have more optimal concentration, memory, and cognitive abilities, which can support higher academic achievement [8, 9]. In addition, physical

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fitness is also related to psychological aspects, one of which is self-confidence [10, 11]. Self-confidence is an individual's belief in their own ability to complete certain tasks, including in the context of learning [12, 13, 14]. Students who have high self-confidence are usually more motivated, willing to take on challenges, and more persistent in facing learning difficulties.

Although the relationship between physical fitness and academic achievement has been widely studied, the mechanisms that explain this relationship still need to be explored further. One possible mediating mechanism is self-confidence. In other words, increasing physical fitness can enhance self-confidence, which in turn can improve students' academic achievement [15]. Nevertheless, comprehensive research that systematically explores the connections between physical fitness, self-confidence, and academic achievement remains limited, particularly in the form of scoping reviews that can offer an in-depth overview of this subject.

Based on this background, this study aims to conduct a scoping review of the literature that discusses the effects of physical fitness on academic achievement through self-confidence, in order to provide a deeper understanding of the relationship among the three variables and serve as a basis for further research and intervention in the fields of education and children's health.

Materials and Methods

Study Organization

This research is a scoping review, which is a literature review method that aims to map the main concepts, evidence, and existing research gaps related to a particular topic [16]. The scoping review method was chosen because it allows researchers to identify, analyze, and synthesize various studies, specifically in this study to analyze the relationship between physical fitness, academic achievement, and self-confidence comprehensively.

Data source

Empirical studies published between 2015 and 2024 were identified through searches in three leading international databases: PubMed, Scopus, and Web of Science. The search was restricted to peer-reviewed articles written in English. Identification, screening, eligibility, and inclusion of available research were the steps used to implement this method. Researchers examined articles relevant to the research questions. Each step was carried out in a structured and systematic manner by following predetermined stages.

Inclusion and Exclusion Criteria

After comprehensive keyword definitions, inclusion and exclusion criteria were outlined and applied through database filters. The inclusion criteria were: (a) research published between 2015 and 2024 related to the impact of physical fitness on self-confidence and academic achievement in students aged 16–18 years; (b) research involving specific physical activities (e.g., structured exercise, daily physical activity, or physical fitness programs) that were relevant to their impact on self-confidence and academic achievement using standardized indicators.

The exclusion criteria were: (a) research measuring the impact of physical fitness on self-confidence and academic achievement in students under 16 years of age; (b) studies published before 2015; and (c) publications with different contexts such as medication, non-empirical studies, non-English language, or irrelevant populations.

Based on the inclusion and exclusion criteria, 4,110 studies were identified. The researcher then conducted re-screening through step-by-step selection of the material contained in each article. The final selection was carried out according to the procedures specified in PRISMA 2020 [17] (Fig. 1).

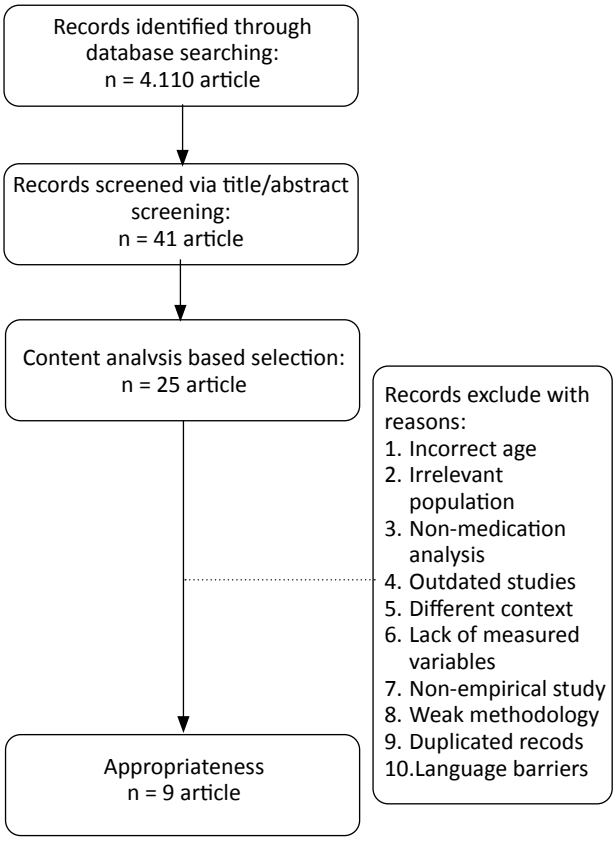

Figure 1. PRISMA flowchart of the article selection process

After the analysis was completed, 25 articles met the requirements. Among these, 9 articles were deemed worthy of in-depth examination and analysis because they are relevant to the research theme and aligned with the research objectives. The following is a chart illustrating the stages carried out by the researchers in conducting this Systematic Literature Review (SLR) using Publish or Perish (PoP).

Results

The findings presented in this literature review consist of analyses and summaries of articles examining the effects of physical fitness on self-confidence and academic achievement (Tabl. 1). A total of nine relevant studies were selected for review to assess how physical fitness influences adolescents' self-confidence and academic performance, as detailed in the table below.

Table 1. Review of Research Results

Author	Study Design	Subject	Result	Findings	Source
Fatima (2015)	This study uses a comparative descriptive design. It can also be considered a cross-sectional study, with data collected at one point in time from different samples.	The study involved 1,000 adolescents aged 17 to 19 years, consisting of 361 males and 639 females, with 671 living in urban areas and 329 in rural areas.	A positive correlation was found between self-confidence and academic achievement. This suggests that increased self-confidence is associated with improved academic performance in adolescents.	The findings indicate that adolescents' self-confidence increases along with academic achievement. However, this relationship is considered very small and unpredictable. This suggests that self-confidence may serve as a mediating variable affecting adolescent academic achievement.	[18]
Sardinha et al. (2016)	This longitudinal study allowed researchers to evaluate the long-term relationship between physical fitness and academic achievement among students.	The study involved 1,286 students from 14 schools, aged between 11 and 14 years.	The study found that students with good levels of cardiovascular fitness tended to achieve better academic outcomes. Students who were categorized as «unfit» at the start but improved their fitness during the follow-up period demonstrated academic improvement compared to those who remained «unfit.»	Students who improved from an unfit to a fit status also showed better academic performance. This indicates that not only is consistent physical fitness important, but improvements in fitness can positively influence academic achievement.	[19]
Han (2018)	The research used a correlational design.	The sample consisted of 236 students aged 13–15, randomly selected from three high schools in the city of D, South Korea.	Pearson's correlation test revealed a significant negative relationship between PAPS scores and final exam scores, indicating that students with higher levels of physical fitness tended to achieve better academic outcomes.	There was a significant correlation between students' physical fitness and their academic achievement. The results showed that healthier students tended to score better on final exams, particularly in core subjects such as math, English, and science.	[20]
Gil-Espinosa et al. (2020)	This study employed a data collection method conducted during the first semester of the 2015/2016 school year.	The sample was a convenience sample consisting of 403 adolescents (53.6% male) with an average age of 13.7 ± 1.2 years from a secondary school in Andalusia, Spain.	The research demonstrated a positive association between components of physical fitness, especially cardiovascular fitness, and academic achievement. Adolescents with higher levels of physical fitness tended to perform better academically.	The study found a positive correlation between general intelligence and cardiovascular fitness in adolescents. This indicates a relationship between higher fitness levels and better cognitive performance as measured by intelligence tests. Teenagers who are physically fit are more likely to achieve academic success. Regular physical activity can improve fitness and, in turn, positively impact both intelligence and academic performance.	[21]

Table 1. Continued

Author	Study Design	Subject	Result	Findings	Source
Batez et al. (2021)	Using a longitudinal design, the study observed students over a three-year period.	The sample consisted of 1,286 students between the ages of 11 and 14 years.	Children's academic achievement was generally found to be positively related to physical fitness and motor competence. The study also noted that weight status (BMI) was negatively correlated with GPA, suggesting that children with higher BMIs tended to have lower academic achievement.	The findings indicate a positive correlation between physical fitness levels and academic achievement. Specifically, children with better fitness test results tended to have higher GPAs. This suggests that physical exercise may support learning. Cognitive processing, overall health, and motivation may mediate this relationship. In other words, the connection between physical fitness and academic achievement is positive, significant, and complex.	[22]
Vist Hagen et al. (2022)	This cross-sectional study collected data from a representative sample at a single point in time.	The sample consisted of high school students aged 13–16 years; participants were selected from various schools.	The research showed that physical fitness had a greater influence on academic achievement in physical education (PE) compared to motor competence.	In physical education, a significant relationship exists between fitness and academic achievement. Students who are fitter tend to have better PE scores than those who are less fit. This study emphasizes the importance of physical fitness as a factor that can affect academic achievement and suggests that physical education teachers consider individual fitness levels when assessing and instructing students.	[23]
Yuda et al. (2022)	This study employed a correlational method.	The sample consisted of 90 students in grades 7 to 9 at Ibtidaiyah Junior High School.	A significant positive correlation was found between self-confidence, academic stress, coping strategies, and academic achievement. Regression analysis showed that coping strategies had the greatest influence on academic achievement, followed by self-confidence and academic stress.	During the COVID-19 pandemic, self-confidence was identified as an important predictor of students' academic achievement in physical education classes. Students with higher confidence tended to perform better academically. Academic stress also influenced outcomes, as it could motivate some students, while excessive stress hindered performance.	[24]
Li et al. (2023)	The study used a cross-sectional design, observing a group of participants at a single point in time.	A total of 304 eighth-grade students aged 13–14 from seven public schools in Tekirdağ, Turkey, were recruited. Schools were selected based on similar socioeconomic backgrounds.	The study found significant differences in VO_2max scores across academic achievement groups, with the low-performing group showing higher VO_2max scores than both the average and high-performing groups (47.1 vs. 42.6 and 42.4, respectively).	The findings suggest that students with poor academic performance may engage more in physical activity, potentially at the expense of their studies. These results challenge conventional assumptions about the relationship between physical fitness and academic success.	[25]

Table 1. Continued

Author	Study Design	Subject	Result	Findings	Source
Ortega-Gómez et al. (2023)	Although the study was designed to be longitudinal, the analysis presented here focuses on cross-sectional baseline data collected between February and May 2015.	The sample consisted of 268 high school students aged 14 years, including 138 males and 130 females.	The study found a positive association between physical activity levels, especially moderate to vigorous physical activity, and physical fitness components (such as lower-body muscle strength and cardiovascular fitness), as well as confidence and interpersonal relationships in adolescents.	The findings indicated that physical fitness elements, including muscle strength, speed-agility, and cardiorespiratory fitness, were positively correlated with higher levels of self-confidence in adolescents.	[15]

Discussion

The main purpose of this literature review is to evaluate the influence of physical fitness and self-confidence on academic achievement in adolescents. Several studies have shown that physical fitness positively impacts students' academic achievement. Sardinha et al. [19] reported that physical fitness influences both academic and health outcomes in adolescents. Another study by Gil-Espinosa et al. [21] found a positive relationship between cardiorespiratory fitness and flexibility and academic achievement, while muscular strength did not show a significant relationship with performance in certain subjects.

Engaging in regular physical activity not only enhances physical fitness but also significantly contributes to the improvement of cognitive abilities, including students' focus and memory. As a result, students who are more physically active generally demonstrate stronger concentration and memory skills. Xiong et al. [26] showed that students who are physically active generally achieve higher academic grades compared to those who are less active. In addition, children who exercise regularly tend to have better health conditions and higher school attendance rates. Further evidence from Zhang et al. [27] showed that an 11-week aerobic exercise intervention significantly improved children's executive functions, including inhibitory control, working memory, reaction time, and cognitive flexibility. Erickson et al. [28] also emphasized that physical activity can stimulate the release of hormones that support cognitive function and increase blood flow to the brain, which in turn improves sleep quality and enhances memory and learning ability.

The relationship between physical fitness and academic achievement is increasingly being discussed, particularly in relation to self-confidence. In general, fitness and self-confidence are interrelated and can influence each other [15]. Improving physical fitness can be a positive step toward building self-confidence, and conversely, high self-confidence can motivate individuals to be more active in maintaining their fitness. Through regular and active participation in physical activity, students' self-confidence can increase, and they tend to feel more positive about their appearance [24]. This may be because engagement in physical activity often involves social interaction, which can help strengthen self-confidence.

High self-confidence is generally positively associated with academic achievement. Students who are confident tend to approach difficult tasks more courageously and are more active in class discussions and extracurricular activities [7]. Self-confidence also helps students manage academic stress more effectively. Therefore, by promoting physical activity, schools not only help students maintain physical health but also support their academic performance. Research by Fatima [18] demonstrated that students with high levels of self-confidence are typically more motivated in their learning and academic participation. Self-confidence enables students to face academic challenges and increases their resilience to stress and pressure. Positive outcomes of physical fitness, such as improved mood and reduced anxiety, can in turn enhance self-confidence [29]. Thus, when students feel better emotionally and are able to cope with stress, they tend to have a more positive view of themselves and their abilities, which makes them more likely to achieve strong academic results.

This study has several limitations, including the review of literature limited to sources in Indonesian and English and within a specific time span, which may have resulted in the omission of relevant research. Additionally, the diversity of designs and methods among the reviewed studies

may lead to heterogeneous results, limiting the generalizability of the findings. Nevertheless, the results of this study offer important implications for the field of education, particularly by emphasizing the importance of integrating physical fitness programs to support academic achievement and the development of student self-confidence. These findings can serve as a basis for more holistic educational policies and interventions. In the future, it is recommended that research be conducted using stronger designs, such as longitudinal or experimental studies, involving more diverse populations and standardized measurement instruments, to provide more robust evidence and applicable recommendations for the advancement of children's education and health.

Conclusions

Based on the results of the scoping review, it can be concluded that physical fitness plays an important role in supporting academic achievement through self-confidence in adolescents. The positive relationship among physical fitness, self-confidence, and academic achievement highlights the importance of integrating physical fitness programs into the school environment as part of a holistic effort to improve educational quality. Although this study has several limitations, such as language constraints and variation in study designs, the findings still provide a strong foundation for the development of more comprehensive educational policies and interventions. Future research is expected to adopt stronger designs and broader scopes to reinforce the evidence on the relationship between physical fitness, self-confidence, and academic achievement, thereby offering more applicable recommendations for improving the quality of education and children's health.

Conflict of Interest

The authors declare no conflict of interest.

References

1. Fierro-Suero S, Sáenz-López P, Carmona-Márquez J, Almagro BJ. Achievement Emotions, Intention to Be Physically Active, and Academic Achievement in Physical Education: Gender Differences. *Journal of Teaching in Physical Education*, 2022; 1–9. https://doi.org/10.1123/jtpe.2021-0230
2. Haverkamp BF, Oosterlaan J, Königs M, Hartman E. Physical fitness, cognitive functioning and academic achievement in healthy adolescents. *Psychology of Sport and Exercise*, 2021;57: 102060. https://doi.org/10.1016/j.psychsport.2021.102060
3. Park S, Chun H, Etnier JL, Yun D. Exploring the Mediating Role of Executive Function in the Relationship between Aerobic Fitness and Academic Achievement in Adolescents. *Brain Sciences*, 2023;13(4): 614. https://doi.org/10.3390/brainsci13040614
4. Yangüez M, Raine L, Chanal J, Bavelier D, Hillman CH. Aerobic fitness and academic achievement: Disentangling the indirect role of executive functions and intelligence. *Psychology of Sport and Exercise*, 2024;70: 102514. https://doi.org/10.1016/j.psychsport.2023.102514
5. Shi Y, Qu S. The effect of cognitive ability on academic achievement: The mediating role of self-discipline and the moderating role of planning. *Frontiers in Psychology*, 2022;13: 1014655. https://doi.org/10.3389/fpsyg.2022.1014655
6. Li S, Wang Y. The Relationship Between Risk Perception, Physical Activity, and Adolescent Mental Health: A Cross-Lagged Analysis. *Psychology Research and Behavior Management*, 2023;16: 3347–3357. https://doi.org/10.2147/PRBM.S422982
7. PrabowoTA,AfifahM,CahyoFD,etal.Self-EfficacyandMotivation Student in Physical Education Learning: Scoping Review. *Jurnal Porkes*, 2025;8(1): 377–389. https://doi.org/10.29408/porkes.v8i1.29743
8. Alves. Physical activity, physical fitness and cognitive function in adolescents. *TRENDS in Sport Sciences*, 2022;29(3): 91–97. https://doi.org/10.23829/TSS.2022.29.3-2
9. Rahayu A, Sumaryanti S, Arovah NI. Physical Activity Levels and Social Cognitive Processes among Adolescents. *Jurnal Pendidikan Jasmani dan Olahraga*, 2022;7(2): 130–139. https://doi.org/10.17509/jpjo.v7i2.48817
10. Ng KW, Sudeck G, Marques A, Borraccino A, Boberova Z, Vasickova J, et al. Associations Between Physical Activity and Perceived School Performance of Young Adolescents in Health Behavior in School-Aged Children Countries. *Journal of Physical Activity and Health*, 2020;17(7): 698–708. https://doi.org/10.1123/jpah.2019-0522
11. Eighmy KE, Lightner JS, Grimes AR, Miller T. Physical Literacy of Marginalized Middle School Adolescents in Kansas City Public Schools. *Pediatric Exercise Science*, 2022;34(4): 169–174. https://doi.org/10.1123/pes.2021-0075
12. Prabowo TA, Afifah M, Cahyo FD, Zakaria A, Indarto AV. Self-efficacy and motivation student in physical education learning: scoping review. *Jurnal Porkes*. 2025;8(1):377–89. https://doi.org/10.29408/porkes.v8i1.29743
13. Walid Djaba HS, S S, Budiarti R, Fauzi, Sukamti ER, Tomoliyus, Prabowo TA. The Impact of Motivation on Decision-Making of Futsal Goalkeepers in Indonesia: An Analysis of Self-Confidence as Mediator. *Sport Mont*, 2024;22(2): 45–51. https://doi.org/10.26773/smj.240707
14. Halilsoy T. The Importance of Self-Confidence. *Akademik Tarih ve Dusunce Dergisi*, 2024; 11. https://doi.org/10.46868/atdd.2024.803

15. Ortega-Gómez S, Adelantado-Renau M, Carbonell-Baeza A, Moliner-Urdiales D, Jiménez-Pavón D. Role of physical activity and health-related fitness on self-confidence and interpersonal relations in 14-year-old adolescents from secondary school settings: DADOS study. *Scandinavian Journal of Medicine & Science in Sports*, 2023;33(10): 2068–2078. https://doi.org/10.1111/sms.14431
16. Tricco AC, Lillie E, Zarin W, O'Brien K, Colquhoun H, Kastner M, et al. A scoping review on the conduct and reporting of scoping reviews. *BMC Medical Research Methodology*, 2016;16(1): 15. https://doi.org/10.1186/s12874-016-0116-4
17. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*, 2021; n71. https://doi.org/10.1136/bmj.n71
18. Fatma F. A Study of Self-confidence of Adolescents in Relation to Their Gender, Locality, and Academic Achievement. *Int J Appl Res*, 2015;1(12):541–4.
19. Sardinha LB, Marques A, Minderico C, Palmeira A, Martins S, Santos DA, et al. Longitudinal Relationship between Cardiorespiratory Fitness and Academic Achievement. *Medicine & Science in Sports & Exercise*, 2016;48(5): 839–844. https://doi.org/10.1249/MSS.0000000000000830
20. Han GS. The relationship between physical fitness and academic achievement among adolescent in South Korea. *Journal of Physical Therapy Science*, 2018;30(4): 605–608. https://doi.org/10.1589/jpts.30.605
21. Gil-Espinosa FJ, Chillón P, Fernández-García JC, Cadenas-Sanchez C. Association of Physical Fitness with Intelligence and Academic Achievement in Adolescents. *International Journal of Environmental Research and Public Health*, 2020;17(12): 4362. https://doi.org/10.3390/ijerph17124362
22. Batez M, Milošević Ž, Mikulić I, Sporiš G, Mačak D, Trajković N. Relationship between Motor Competence, Physical Fitness, and Academic Achievement in Young School-Aged Children. Wen X (ed.) *BioMed Research International*, 2021;2021(1): 6631365. https://doi.org/10.1155/2021/6631365
23. Vist Hagen R, Lorås H, Sigmundsson H, Haga M. Association Between Motor Competence, Physical Fitness, and Academic Achievement in Physical Education in 13- to 16-Year-Old School Children. *Frontiers in Sports and Active Living*, 2022;3: 774669. https://doi.org/10.3389/fspor.2021.774669
24. Yuda AK, Resita C, Nurwansyah R, Gani RA, Németh Z, Setiawan E. Confidence, Academic Stress, Coping Strategies as Predictors of Student Academic Achievement in Physical Education Classes During Covid-19. *Physical Education Theory and Methodology*, 2022;22(2): 180–187. https://doi.org/10.17309/tmfv.2022.2.05
25. Li C, Taerken AY, Li Q, Selimu A, Wang H. Secular trends in physical fitness of rural Chinese children and adolescents aged 7–18 years from 1985 to 2019. *Scientific Reports*, 2023;13(1): 4229. https://doi.org/10.1038/s41598-023-31190-x
26. Xiong X, Cui Y, Zhang W, Zhao C, Wu J, Li H, et al. Association between Sleep Duration and Physical Fitness in Children Aged 3–6 Years: A Cross-Sectional Study from China. *International Journal of Environmental Research and Public Health*, 2022;19(11): 6902. https://doi.org/10.3390/ijerph19116902
27. Zhang M, Garnier H, Qian G, Li S. Effect of 11 Weeks of Physical Exercise on Physical Fitness and Executive Functions in Children. *Children*, 2023;10(3): 485. https://doi.org/10.3390/children10030485
28. Erickson KI, Hillman C, Stillman CM, Ballard RM, Bloodgood B, Conroy DE, et al. Physical Activity, Cognition, and Brain Outcomes: A Review of the 2018 Physical Activity Guidelines. *Medicine & Science in Sports & Exercise*, 2019;51(6): 1242–1251. https://doi.org/10.1249/MSS.0000000000001936
29. Saputra MW, Nopembri S, Yuliarto H, Hartanto A. The influence of physical fitness on self-confidence and its impact on physical education academic achievement. A study on grade V school students. *Fizjoterapia Polska*, 2024;24(3): 393–399. https://doi.org/10.56984/8ZG020A1JC

Information about the authors:

Trisnar Adi Prabowo; (Corresponding Author); https://orcid.org/0000-0001-6977-0503; trisnar.prabowo@umbs.ac.id; Phyiscal Education Study, Universitas Muhammadiyah Brebes; Jawa Tengah, Indonesia.

Asyidika Vito Indarto; https://orcid.org/0009-0005-3210-8379; asyidika.vito@umbs.ac.id; Phyiscal Education Study, Universitas Muhammadiyah Brebes; Jawa Tengah, Indonesia.

Achmad Zakaria; https://orcid.org/0009-0006-6184-1112; achmadzakaria@umbs.ac.id; Phyiscal Education Study, Universitas Muhammadiyah Brebes; Jawa Tengah, Indonesia.

Febriansyah Dwi Cahyo; https://orcid.org/0009-0006-6845-9602; riancahyoqwerty@gmail.com; Phyiscal Education Study, Universitas Muhammadiyah Brebes; Jawa Tengah, Indonesia.

Mar'atul Afifah; https://orcid.org/0009-0004-2849-6543; maratul.afifah@umbs.ac.id; Phyiscal Education Study, Universitas Muhammadiyah Brebes; Jawa Tengah, Indonesia.

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CONTACT INFORMATION
box 11135, Kharkiv-68, 61068, Ukraine
sportart@gmail.com

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