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Review Article

The Interplay Between Physical Fitness, Nutritional Status, and Academic Performance in Physical Education: A Systematic Review

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Abstract

Objectives. This review aimed to explore the extent to which physical fitness and nutritional status serve as significant predictors of learning outcomes in physical education (PE) among secondary school students. Given the growing concern about sedentary lifestyles and poor eating habits among teens, understanding these relationships is critical to improving physical and academic performance.

Materials and methods. This study used the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) method to screen and analyse the literature related to assessing various relevant studies in the scope of physical education, physical fitness, and nutritional status through a systematic analysis of appropriate literature. Articles published between 2020 and 2025 were examined to determine how to prepare learners to have better physical fitness. A comprehensive search was conducted using the databases Scopus, Web of Science, Google Scholar, and PubMed, with keywords including "physical fitness", "nutritional status", "academic achievement", and "physical education" through a literature review.

Results. This review revealed a strong correlation between physical fitness components (cardiovascular endurance, muscle strength, body composition) and PE learning outcomes. Nutritional adequacy, especially sufficient micronutrient intake and a balanced diet, has also been shown to influence cognitive function, motor skill acquisition, and classroom engagement. However, the interaction between fitness and nutrition appeared to be synergistic and context-dependent.

Conclusions. The findings emphasize that physical fitness and nutritional status are not only important for health but also for successful learning in PE. Schools and policymakers should promote integrated programs that support both areas simultaneously. Further longitudinal and experimental research is needed to confirm the causal pathway. Therefore, strategies are required to improve students' physical fitness and nutritional status to optimize learning and the development of learning outcomes holistically.

Keywords: physical fitness, nutritional status, physical education, learning success, literature review.

Introduction

Physical fitness and nutritional status have an important role in the success of physical education learning. Studies show that good physical fitness and optimal nutritional status can improve concentration, learning endurance, and academic performance of students (Jariono et al., 2025; Jariono, Nurhidayat, & Indarto, 2024; Jariono, Nurhidayat, Syaukani, et al., 2024). According to (D. Li et al., 2023), there is a positive relationship between physical fitness and academic achievement, especially in subjects that require physical and cognitive activity at the same time such as physical education (Maniaci et al., 2023). In addition, research by Marinković et al., (2024) states that good nutritional status is significantly correlated with the level of student participation and motivation in physical learning. Hansen et al. (2024) Adequate nutrition supports brain

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development and cognitive function that are essential in the learning process. Therefore, this study aims to review the relevant literature on the influence of physical fitness and nutritional status on learning success in physical education, highlighting the importance of synergy between physical health and nutritional fulfilment in supporting overall learning quality (Durau et al., 2022).

Physical education is an integral part of the education system that aims to develop the physical, mental, and social aspects of students through structured physical activities (Rosales-Ricardo & Cáceres-Manzano, 2024). In the context of physical education learning, students' academic success and motor skills are highly dependent on a variety of factors, including physical fitness and nutritional status (Liza et al., 2024). Both play an important role in supporting academic performance as well as active participation in physical education learning (Fernandes et al., 2024).

Physical fitness includes various components, such as cardiovascular endurance, muscle strength, flexibility, and body composition (Martín-Rodríguez et al., 2024). Some studies show that a good level of physical fitness is positively associated with improved cognitive function and academic success (Latino & Tafuri, 2024). Studies conducted by Zang et al. (2024) found that children with higher cardiovascular fitness showed better brain activity, especially in tasks that require attention and cognitive control.

In the context of physical education, students who have better physical fitness tend to be more active in participating in learning activities, have higher endurance, and are able to absorb material better than students with low physical fitness (Avraham et al., 2024). In addition, physical activity that improves physical fitness also contributes to the improvement of students' social and emotional skills, which can ultimately support overall learning success (Wilhite et al., 2023).

Nutritional status is an important factor that affects students' health, physical development, and academic performance (Zhou et al., 2024). Good nutrition supports brain development, improves concentration, and improves memory, which is very influential in the learning process (Neuman et al., 2024). Children with poor nutritional status, such as iron deficiency or other micronutrient deficiencies, often experience cognitive impairment and lack of energy to participate in physical and academic activities (Sharma et al., 2023).

Research by Masilela & Modjadji (2023) shows that children with a balanced diet that includes an intake of protein, carbohydrates, healthy fats, vitamins, and minerals have better academic outcomes than those who are malnourished. In addition, adequate nutrition also contributes to the development of physical and motor capacities that support active involvement in physical education (Alamnia et al., 2023).

Several studies have highlighted the relationship between physical fitness, nutritional status, and learning success in physical education. Zhao et al. (2024) It found that aerobic fitness was positively correlated with improved cognitive skills and academic outcomes in elementary school-age children. Muntaner-Mas et al. (2024) states that regular physical activity contributes to improved attention and executive function, which is very important in the learning process. Obeidat et al. (2024) found that students with better diets had higher academic scores compared to students with poor diets. Mandefro et al. (2024) examined the impact of obesity on academic performance and found that obesity associated with poor diet and lack of physical activity can hinder academic success. Canli et al. (2024) concludes that students with good physical fitness are more likely to have higher motivation and confidence in participating in physical education learning.

Empirical studies are increasingly highlighting the strong link between physical fitness, nutritional status, and academic performance. Cardiorespiratory endurance, muscle strength, and healthy body composition are positively correlated with better cognitive function, attention span, and school engagement (Ingham-Hill et al., 2024). Likewise, adequate nutritional intake especially those involving micronutrients such as iron and omega-3 fatty acids supports brain development and motor coordination (Burnett et al., 2024). However, research examining how these two domains interact in influencing learning outcomes, especially in the context of physical education, remains fragmented.

Given the increasing complexity of adolescent health challenges, there is a need to better understand the interaction between physical fitness and nutritional status as a dual predictor of learning success in physical education. Therefore, this systematic review aims to synthesize the latest empirical findings to (1) analysed the relationship between physical fitness and PE academic performance, (2) examine the effects of nutritional status on PE-related learning, and (3) explore how these two factors together contribute to student outcomes

Materials and Methods

Database and Search Profile

Electronic searches on the Web of Science, Scopus, and PubMed were used to conduct this systematic review. "Physical fitness," "nutritional status," "physical education," and "learning success." through the PRISMA Process which consists of four main stages: identification, screening, eligibility, and inclusion can be elaborated: first stage Identification: A total of 350 articles related to physical fitness, nutritional status, physical education, and learning success, or mixed, were identified from various databases. After removing duplication, as many as 150 articles remain for further screening; The second stage is Screening: Out of 200 articles, 100 articles are filtered by abstract and title. Only 100 articles relevant to the topic; The third stage is Eligibility: Out of 100 articles, 20 articles meet the eligibility criteria after an in-depth evaluation of the methodology and research results; and the fourth stage, namely Inclusion: After a rigorous selection process, as many as 20 articles were included in the final study that met the notability criteria based on the PEDro scale, available for free online (https://www.pedro.org.au/english/downloads/pedro-scale/) and have been translated into seven languages in figure 1.

As shown in the flowchart (Figure 1), a total sample of 20 articles was obtained from a total of 350 articles by adhering to the PRISMA guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) (Page et al., 2021) during the identification, screening, suitability, and inclusion phases. The following variables are taken into

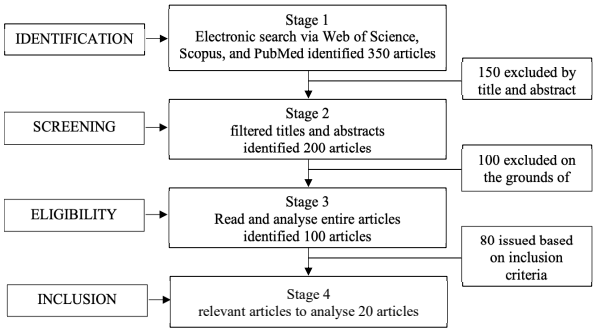

Fig. 1. Diagram of the search process flow

account in the bibliometric analysis: (a) Annual trends of articles published between 2020 and 2025; (b) distribution of publications at the institution of the first author; (c) the number of authors; (d) subject area (physical fitness," "nutritional status," "physical education," and "learning success, or a mixture); (e) type of research (experimental, descriptive, correlational, other); and (f) the average number of citations per article. Further elaborated the inclusion and exclusion criteria are shown in Table 1.

Inclusion criteria, including population, intervention, comparison, outcomes, and study design, are detailed in Table 1. The main focus of the inclusion and exclusion criteria is structured to ensure that only relevant and quality studies are analysed. The study examination includes scientific articles that have gone through a peer-reviewed process, written in English, and published in the period of 2020 to 2025. Studies that are only opinion, editorial, or not available in full-text form are excluded from the review.

The targeted population is school-age children and adolescents (6–18 years old) who are participating in physical education learning in formal institutions. Studies that focused on adults, the elderly, or individuals with clinical conditions that are not relevant to the school's physical education context were excluded. The selected intervention is a program that aims to improve the physical fitness and/or nutritional status of students, either through the school curriculum, additional sports programs, or nutritional interventions. In contrast, studies that did not include elements of fitness or nutrition in their interventions, or only emphasized the academic aspects without a physical approach, were excluded.

In terms of comparison, studies that include control groups or comparison groups with different treatments are prioritized. Studies without a comparison group or only descriptive in nature were not considered. The results of the study analysed included the effect of interventions on academic performance (such as grades or cognitive ability), physical fitness level (e.g. VO_2 max, muscle strength), and nutritional status (including body mass index or nutrient intake). Studies that did not report such results were not included in the analysis. Finally, the accepted research designs include relevant experimental, quasi-experimental, longitudinal, correlational, and mixed approach quantitative designs. Purely qualitative studies without numerical data linking fitness, nutrition, and academic achievement are not included in the scope of this study.

Table 1. Inclusion criteria and exclusion the interplay between physical fitness, nutritional status, and academic performance in physical education: a systematic review

Component	Inclusion Criteria	Exclusion Criteria
Study Examination	Primary research articles published in accredited scientific journals (peer-reviewed), available in English, and published between 2020–2025.	Non-empirical articles (editorials, opinions, comments), articles are not available in full-text form, or articles in languages other than English and Indonesian.
Population	School-age children and adolescents (6–18 years old) who participate in physical education learning in public schools or other formal educational institutions.	Studies that focus on adult populations, the elderly, or individuals with specific medical conditions that are not relevant to physical education in schools.
Intervention	Programs or activities that aim to improve the physical fitness and/or nutritional status of participants, either based on the physical education curriculum or additional interventions such as extracurricular sports or school nutrition programs.	Interventions that only relate to cognitive aspects without a fitness or nutritional component, or that are not applied in the context of physical education.
Comparison	A control or comparator group that did not receive fitness or nutrition interventions, or that followed a standard physical education curriculum without modification.	Studies that did not have a comparison group or only conducted descriptive observations without comparing different conditions or treatments.
Research Results	The effect of interventions on academic performance (study scores, concentration, learning achievement), physical fitness (VO2 max, muscle strength, agility), and nutritional status (BMI, nutritional intake, micronutrient deficiencies).	Studies that do not quantitatively or qualitatively measure or report academic outcomes, physical fitness, or nutritional status.
Research Design	Quantitative experimental studies (RCTs, quasi-experimental), longitudinal, correlational studies, or mixed methods that are relevant to the topic.	A purely qualitative study with no numerical data that supports the relationship between fitness, nutrition, and academic performance.

Methodological Quality Assessment

The quality of the articles studied was evaluated using 11 PEDro (Physiotherapy Evidence Database criteria) and have been assessed for methodological quality. Quality articles are essential to assist users in overcoming obstacles such as lack of time and critical thinking skills as well as making it easier to integrate high-quality clinical research into clinical practice. Clinical practice guidelines and systematic reviews are not evaluated Moseley et al. (2020), articles with scores of eight to eleven were rated as having high methodological quality, articles with scores of four to seven as moderate, and articles with scores of four to less (Moseley et al., 2020).

Results

Number of Results Reviewed

On electronic search through the Web of Science, Scopus, and PubMed, through the PRISMA Process. Table 2 below shows the main themes and synthesis results of the publications over the selected time period. Year of publication. These articles include research on the interplay between physical fitness, nutritional status, and academic performance in physical education: a systematic review (table 3).

Recent research shows that physical fitness, particularly the cardiorespiratory component and muscle strength, has a strong relationship with improved cognitive function and academic achievement of students in physical education (PE) subjects. Study by (Zarazaga-pel et al., 2024) and (Brien et al., 2024) revealed that children with good fitness levels showed higher concentration, working memory, and motor coordination abilities, which directly impacted improved learning outcomes.

In addition to physical fitness, nutritional status plays an important role in supporting students' cognitive and physical performance. Research by (O'Connor et al., 2025) and (Moyle, 2025) states that deficiencies in micronutrients such as iron, iodine, and omega-3s can interfere with brain development and cause decreased memory, fatigue, and difficulty focusing during learning. This has direct implications for student performance in physical and theoretical learning activities at school.

Furthermore, a number of studies suggest that there is a synergistic relationship between physical fitness and nutritional status on educational attainment. The combination of structured physical activity interventions and dietary improvements has been shown to have a dual positive effect on students' cognitive development, learning motivation, and motor skills (D. Li et al., 2023; B. Li et al., 2023). This kind of intervention can be a strategic approach in improving the quality of physical education that is not only oriented to the physical, but also to the overall learning capacity of the students.

However, the strength of the relationship between fitness, nutrition, and learning achievement is also strongly influenced by contextual factors. Factors such as socioeconomic status, sleep quality, family support, and school climate are critical to the success of nutrition and fitness improvement programs (WHO, 2020a) there has been a steady change in trends of delivery patterns worldwide. The overall increase in Caesarean section rates with the decline of vaginal deliveries also raises many growing concerns. Caesarean deliveries have proven to increase the risk of maternal and infant morbidity. 1 Similarly, Organisation for Economic Cooperation and Development (OECD. Therefore, a community-based and comprehensive approach is highly recommended in the implementation of education policies that target students' health and learning outcomes. Table 3 outlines the characteristics of the research studied in the literature review.

Based on a review of various recent studies, it was found that most studies have the same focus, which is to examine the relationship between physical activity, nutritional status, and outcomes such as body composition, physical fitness, cognitive function, and academic achievement.

Tabel 2. Summary of the main literature

Key References (2023–2025)	Main Themes	Synthesis Results
(Fernandes et al., 2024) ; (Canli et al., 2024); PANIC Study (Laamanen et al., 2024)	Physical Fitness and Academic Performance	Cardiovascular fitness (CRF) and muscle fitness have been shown to be positive for executive function, focus, and academic achievement. Cross-sectional tests in adolescents show higher VO_2 peak correlates with better school scores(Fernandes et al., 2024).
Nutrition & Cognition (Ahmed et al., 2024) & (Elechi et al., 2024) ; Cross-sectional studies (Samigullin et al., 2025); Micronutrient review (2022)	Nutritional Status and Cognitive Function	The intake of macronutrients and micronutrients, especially iron and omega-3, plays a major role in cognitive function, attention, short-term memory, as shown in school-age children.
Stub Meta analysis (Moore et al., 2023); PA+ Review(Janssen & Voelcker-rehage, 2023); Network meta-analysis Exercises (Edwards et al., 2023)	Synergistic Relationships	School-based interventions that mix physical activity and curriculum education simultaneously showed significant improvements in academics, especially mathematics.
EPA obesity study (Smorenburg et al., 2025); PA acute effects review (2024) (James et al., 2023); IoT effect on EF (Peng et al., 2025)	Contextual Factors	The positive effect of physical activity on academics is stronger in obese/at-risk children and depends on frequency, intensity, duration (FITT). Abdominal obesity is associated with changes in the hippocampus and amygdala that can interfere with learning function.

Tabel 3. Characteristics of the research examined in the literature review

Author and Year	Population and Sample	Data Collection Techniques	Synthesis Results
(Bernard et al., 2025)	25 community intervention studies involved elderly adults with low incomes and/or living in rural areas. Of the 2,954 initial citations, 25 articles met the inclusion criteria; Only 2 studies involved rural populations specifically.	Systematic search on 4 databases through July 2024, using Arksey & O'Malley's scoping methodology; classification of intervention types based on the Michie Behaviour Change Wheel	All interventions showed positive outcomes: increased fruit & vegetable consumption, physical activity levels, functional fitness, and nutritional knowledge. There is a shortage of studies specific to rural populations, only two indicating the need to expand research in rural contexts.
(Cabral et al., 2025)	41 studies in children totalling 7 316 participants; include acute and chronic interventions.	Meta-analysis of studies related to cognitive and/or aerobic physical activity, comparing with sedentary controls, regular aerobic exercise, or PJOK classes; Calculate the pre-post and post-test effects.	Acute (short activity): Small to large effects in pre-post, significant only on working memory accuracy when compared to rest.
(Ferozi et al., 2024)	100 youth ages 12–15 in Delhi (India)	Lifestyle questionnaire; height, weight, BMI, body fat%; battery FITNESSGRAM, * PAQ-A; 2×24-hour meal recall	19 % overweight, 6 % obese; 74% are physically passive; negative correlation of physical activity vs multiple nutritional indices; positive grip strength with BMI; Low nutrition & fitness need intervention.
(Pinto-Escalona et al., 2024)	Children aged 7–8 years (grade 2 of primary school) from 20 schools in 5 European countries; a total of 721 children (344 females, 377 males); 388 intervened and 333 controls	Academic: The average grade point average of the semester (scale of 010) is determined by the teacher and standardized by country; Psychosocial: Strengths and Difficulties Questionnaire (SDQ) version of parents; and Physical fitness: shuttle run test (aerobics), Y Balance Test (balance), frontal split test (flexibility)	A one-year school-based karate program is effective: improving academic achievement, physical fitness (aerobics & balance), and reducing conduct problems in 7–8-year-olds. These findings support the integration of karate in the PJ curriculum to improve students' physical and cognitive outcomes
(Zang et al., 2024b)	2,655 healthy children (women & boys), 1,308 in the intervention group and 1,347 in the control group	Literature search from 10 databases (e.g. PubMed, Scopus, CNKI) to November 2023 8 RCTs were selected based on inclusion criteria (healthy children, AE >50 weeks for academics); Tools: Cochrane RoB2 for bias, funnel plot & Egger's test for publication bias, combined effects analysis via R (fixed/random model)	Inhibitory control was significantly improved in the aerobic group (SMD = 0.29; 95% CI [0.05, 0.54]; p = 0.018); increased working memory (SMD = 0.25; 95 % CI [0.07, 0.42]; p = 0.005); Increased cognitive flexibility (SMD = 0.36; 95 % CI [0.17, 0.54]; p < 0.001); Academic achievement only significantly improved if the aerobic duration > 50 weeks (SMD = 1.19; 95% CI [0.34, 2.04]; p = 0.006) Publication bias was not significant (p > 0.1) and the quality of the evidence was low.
(Vaquero-sol et al., 2024)	1166 junior high school students in Extremadura, Spain; 642 males (mean age 13.16 ± 0.91 years) and 524 females (13.08 ± 0.85 years)	Physical activity: PAQA (Physical Activity Questionnaire for Adolescents)- Body composition: measurement of weight and height → BMI- Cardiovascular fitness: CourseNavette test- Body dissatisfaction: a scale of body dissatisfaction (expressed in the Study, although the details of the instrument are not mentioned)	Increased physical activity was significantly correlated with improvements in BMI, cardiopulmonary fitness, and reduced body dissatisfaction, especially in male students. Interventions in PJOK subjects are very important to promote a healthy lifestyle and support adolescents' physical health and body image.

Table 3 (continued)

Author and Year	Population and Sample	Data Collection Techniques	Synthesis Results
(Pelc et al., 2024)	55 active individuals aged 16–61 years; 28 people with disabilities (Frame Running) and 27 nondisabilities, adjusted by age, gender, and physical activity level	FFQ6 (food frequency questionnaire)- Bioimpedance analyser (Tanita) for body composition (fat, muscle, bone mass)- Stadiometer for height	Subjects with active disabilities had a different body composition and higher body fat, but consumption of vegetables and animal fats was dominant. Diet has a significant effect on body composition, so balanced nutritional interventions and a healthy lifestyle are recommended, especially for people with disabilities
(Mateo-orcajada & Vaquero-crist, 2024)	Adolescents aged 12–16 years; the review included 12 systematic reviews (273 articles total), with 22 intervention studies using mobile apps exclusively in this age group. In separate RCTs: active versus inactive adolescents; sample details were not mentioned.	- Search of literature on Web of Science, PubMed, Scopus, Google Scholar. - Selection of reviews based on criteria (age, duration of ≥ 8 weeks, pre-post measurement). - Quality assessment with external AMSTAR2 and validity analysis. On RCTs: measurements of kinaanthropometry, body composition, and fitness.	Mobile apps alone have not been effective in increasing physical activity or body/fitness variables in adolescents 12–16 years old. It is emphasized that subsequent interventions need stronger designs, larger samples, and more solid methods to produce more convincing evidence
(Shao & Zhou, 2023)	Youth aged 10–19 years, various countries; Total primary studies filtered from 5 databases as of August 14, 2022	Literature exploration on EBSCOhost (ERIC), Psychology & Behavioural Science Collection, PubMed, Scopus, Web of Science; Selection of studies on physical, cognitive, social & lifestyle factors	Adolescents' physical activity habits are influenced by many biological, psychological, environmental, and lifestyle dimensions that should be targeted by comprehensive interventions
(Wu et al., 2023)	3,258 13-year-olds from the general population cohort Generation R in Rotterdam, Netherlands	Self-report questionnaire for daily physical activity and screen time; Body composition measurement: BMI, DXA (fat mass & lean body mass), MRI (subcutaneous & visceral fat)	Higher physical activity and lower screen time were seen as effective in lowering general and visceral adiposity in adolescents.
(Eglseer et al., 2023)	4,957 participants (aged 55–70 years, overweight/obese) from 66 RCTs with a total inclusion of 92 main studies for review	Systematic collection of data from four databases up to July 2022; RCT analysis with network meta-analysis, random effects, pooled mean differences, SMD, CI 95%, subgroup & sensitivity analysis	a combination of a low-energy, exercise and high-protein diet is the optimal intervention to improve the body composition of adults approaching retirement; Diet alone can lead to sarcopenic obesity.
(Jylänki et al., 2022)	2,472 children aged 3–7 years from 35 primary studies (7 databases as of April 2020)	A systematic review of 35 studies in children aged 3–7 years (n = 2,472), using PRISMA methodological standards and EPHPP assessments.	Interventions that combine fundamental motor skills and physical activity significantly improve cognitive and academic abilities, especially memory, executive, language, and numeracy. A combination of skill practice is more effective than general physical activity; The motor skill approach is better than activity alone.
(Zukowska et al., 2022)	The study covers the general population, not limited to specific age groups or demographics	The literature review used six databases, resulting in 17 studies that were analysed with classification and quality assessment.	A comprehensive transportation policy combines the most effective physical, educational, and public support elements in encouraging the physical activities of the wider community.

Table 3 (continued)

Author and Year	Population and Sample	Data Collection Techniques	Synthesis Results
(Bogataj et al., 2021)	48 adolescent girls were overweight (mean age = 15.6 ± 0.7 years); divided: 24 in the intervention group (EXP) and 24 in the control group (CON)	Body composition through measurements of body fat, BMI, and body fat Physical fitness: countermovement jump (CMJ), medicine ball throw, hand-grip strength, and Yo-Yo Intermittent Recovery Test Level 1 (YYIRT1 HIIT intervention for 8 weeks (3×/week), as well as nutrition education sessions 2×/week	Significant interactions (group × time) for body weight ($p = 0.008$), BMI ($p = 0.020$), body fat kg ($p < 0.001$), and body fat % ($p < 0.001$Significant improvements in medicine ball throw ($p < 0.001$) and YYIRT1 ($p = 0.024$Significant time effects for hand-grip ($p = 0.004$) and CMJ ($p = 0.001$) Conclusions: An 8-week school-based HIIT program, plus nutritional interventions, Effective in improving body composition and muscle and aerobic fitness in overweight adolescent girls
(Wang & Boros, 2021)	Healthy general population, literature review from Jan 2010–Jun 2018, total of 14 quantitative studies	Systematic search of PubMed & Scopus; A selection of studies that compared the intensity of physical activity (light, moderate, severe) to sleep quality	Moderate-intensity physical activity is more effective in improving sleep quality than strenuous activity. These findings are consistent across different age groups
(Ruhland & Lange, 2021)	School-age children (7–16 years), a total of 6,032 students from 20 studies	Prospective reviews (RCTs and non-RCTs) using large databases according to PRISMA; Study Quality Assessment with Standard Checklist	Generally, active breaks in the classroom (light to moderate mobility) increase focus and task time. Measurements were carried out through d2 tests, TEACh, and behavioural observations
(Farooq et al., 2020)	52 longitudinal studies, totalling 22,091 children and adolescents aged 3–18 years (8,857 boys, 13,234 girls) from different countries	Physical activity measurement using an accelerometer (MVPA in minutes per day) was followed for at least 1 year. Search through December 2018 in 10 databases	MVPA decreases significantly with age, faster in women, with a critical period in the transition period from primary to secondary school. Designing interventions targeting 9–12-year-olds, particularly women, is critical.
(Haverkamp et al., 2020)	Healthy adolescents & young adults aged 12–30 years; acute intervention: n = 44 studies; Chronic: n = 27	Systematic searches on Embase, ERIC, MEDLINE, PsycINFO, Web of Science. Only controlled studies (controls/experiments)	Physical activity interventions, both brief (acute) and sustained (chronic), significantly improve various aspects of cognitive function (processing speed, attention, inhibitory control, working memory, cognitive flexibility) and language skills in adolescents and young adults
(Sember et al., 2020)	The study included 44 experimental interventions (>6 weeks) in children/adolescents aged 6–19 years in a school setting	Randomized meta-analysis with validity generalization; Grouping of subgroups based on the qualifications of the program implementer	Positive effects on academic/cognitive ($r = 0.181$), Interventions guided by competent personnel produced greater effects ($r = 0.22$), and Many studies did not report activity intensity, which was a critical factor.
(Gelius et al., 2020)	A review of 57 reviews covering 53 types of policies promoting physical activity, a variety of settings (schools, transport, environment), without a direct human population	The review-review study, filtering 57 primary sources related to physical activity promotion policies, was systematically analysed using the EPPI-Reviewer tool	Policies in the context of schools (more and more quality physical education lessons) and public infrastructure policies (green spaces, walking/cycling paths) have proven effective. Fiscal policy (subsidies, taxes) still needs stronger evidence

The majority of studies used a quantitative approach, with longitudinal, experimental, and meta-analysis designs, and involved children and adolescents as the main population. Almost all interventions, whether physical, nutritional, or a combination of both, showed positive results on participants' physical and cognitive health. Nevertheless, there were striking differences in duration, intervention methods, and output focus. Some studies emphasize on improving brain function (such as memory and cognitive control), while others focus on improving body composition, self-image, or behavioural changes. In addition, most research was conducted in school and urban settings, with few studies specifically targeting rural communities or older groups. Therefore, it is recommended that future interventions be multimodal, adaptive to local contexts, and include more diverse populations, especially vulnerable groups in rural areas as well as non-productive ages.

Discussion

The results of this study reveal that physical fitness and nutritional status play an important role in supporting students' academic achievement, especially in physical education. The balance between physical condition and optimal nutritional intake has been proven to be able to increase concentration, motivation, and learning outcomes. These findings confirm the need for a holistic approach in education, which includes aspects of physical health and nutrition as support for academic success.

Furthermore, physical fitness and nutritional status have a very important role in supporting learning success, especially in the context of physical education. Physical fitness and nutritional status play a very important role in supporting learning success, especially in the context of physical education. Physical fitness reflects a person's physical capacity to perform daily activities efficiently without experiencing excessive fatigue and still having energy reserves for other activities (Redondo-Flórez et al., 2022). Meanwhile, a good nutritional status contributes to optimal cognitive development, endurance, and motor skills for students (WHO, 2020b). Studies have shown that students with good physical fitness and balanced nutritional status tend to have higher academic performance compared to students who are deficient in both aspects (Garciá-Hermoso et al., 2021).

In physical education, physical fitness is a key factor that affects student involvement in physical activity. According to research conducted by Ma et al. (2020), students with higher levels of physical fitness show better motor skills, more active participation in physical activities, and have better endurance in taking lessons. Good physical fitness is also associated with more stable mental health, so students tend to have lower stress levels as well as higher motivation to learn (Jariono, Nurhidayat, & Indarto, 2024). Therefore, students who have optimal physical fitness are better able to absorb learning materials well and have superior academic performance.

On the other hand, nutritional status is also an important predictor of learning success. Adequate and balanced nutrition affects brain development, memory, and focus on learning. Research conducted by Taras (2005) suggests that students with nutritional deficiencies, such as iron deficiency or certain vitamin deficiencies, tend to have difficulty concentrating and have lower problem-solving abilities. In addition, a study by Edimo Dikobo et al. (2023) found that students who were malnourished tended to have lower attendance rates in school, which directly impacted their academic achievement.

Further, the relationship between physical fitness, nutritional status, and academic performance has been extensively researched. A longitudinal study by Hermassi et al. (2021) in the United States found that students with higher levels of physical fitness performed better in subjects such as math and language compared to students with lower levels of physical fitness. In addition, research by Alvarez-Bueno et al. (2017) has also shown that regular physical activity can improve cognitive function and academic achievement, especially in terms of working memory and information processing speed.

In the context of physical education, teachers have an important role to play in ensuring that students get the optimal benefits from the physical activities carried out in school. An effective physical education program not only aims to improve physical fitness but also educates students about the importance of good nutrition to support their health and academic achievement. A study by Yasin Akinci & Sadettin Kirazci (2022) emphasizes that schools need to integrate a physical activity-based approach with nutrition education to create a healthier learning environment and support better academic achievement.

To improve the physical fitness and nutritional status of students, several recommendations can be implemented in the education system. First, schools need to provide adequate sports facilities as well as attractive and varied physical education programs to increase student participation in physical activities. Second, schools need to pay attention to the availability of healthy food in the canteen and provide nutrition education regularly to students so that they understand the importance of a balanced diet. Third, parental involvement in supporting their children's healthy eating and physical activity habits is also an important factor in ensuring the success of this strategy.

Physical Fitness and Nutritional Status as Predictors of Learning Success in Physical Education: Physical fitness and nutritional status play crucial roles in determining students' academic performance, particularly in physical education. Numerous studies have demonstrated that students with higher physical fitness levels tend to perform better academically due to improved cognitive functions, concentration, and overall well-being (Álvarez-Bueno et al., 2017). Similarly, proper nutritional intake is essential for cognitive development and learning efficiency, as it directly impacts energy levels, memory, and motivation (Burrows et al., 2017). This discussion explores the relationship between physical fitness, nutritional status, and learning success in physical education, supported by previous research findings.

Physical Fitness and Academic Performance in Physical Education: Physical fitness encompasses various components such as cardiovascular endurance, muscular strength, flexibility, and body composition, all of which contribute to overall health and functional capabilities (Raul Roscamp de Oliveira et al., 2023). A well-rounded fitness level allows students to actively participate in physical education classes, enhancing their skill acquisition, motor coordination,

and overall engagement in learning activities. Research by (Chaddock-Heyman et al., 2014) found that students with higher aerobic fitness exhibited better executive function and cognitive flexibility, which are essential for both academic and physical performance.

Moreover, physical activity has been linked to improved brain function through increased blood flow and neurogenesis, fostering better memory retention and learning efficiency (Donnelly et al., 2016). In the context of physical education, students who regularly engage in exercise demonstrate better skill development, higher motivation, and increased confidence in physical tasks, all of which contribute to their learning success (Gerber et al., 2025). A study by (Haapala et al., 2014) emphasized that students with better motor skills and physical endurance were more likely to excel in physical education assessments, indicating a strong correlation between fitness and learning outcomes.

Nutritional Status and Learning Success: Nutrition plays an equally significant role in academic achievement, as it directly influences cognitive function and physical performance. Proper nutrition ensures adequate energy levels for participation in physical activities and supports muscle recovery and growth. Deficiencies in essential nutrients such as iron, vitamin B12, and omega-3 fatty acids have been linked to decreased cognitive function, reduced attention span, and lower academic performance (Nyaradi et al., 2013).

A study conducted by Florence et al. (2008) found that students who consumed a balanced diet, including sufficient fruits, vegetables, and protein, performed better in physical education and general academic subjects. Similarly, Burrows et al. (2017) noted that malnutrition, whether undernutrition or overnutrition (obesity), negatively affected students' ability to focus, participate in physical activities, and engage in learning. Overweight students often experience reduced physical capacity, lower self-esteem, and decreased motivation to participate in sports and physical education tasks, further hindering their learning success.

Additionally, proper hydration and meal timing significantly impact students' physical performance. Research by Guzek et al. (2022) indicated that students who had a nutritious breakfast demonstrated better endurance and focus in physical education classes compared to those who skipped meals. This aligns with findings by Adolphus et al. (2013), which suggests that a well-balanced diet enhances memory, attention, and learning efficiency, further reinforcing the importance of nutrition in education.

The Combined Impact of Physical Fitness and Nutrition on Learning Outcomes: Both physical fitness and proper nutrition contribute synergistically to academic success, particularly in subjects like physical education that demand active participation and motor skill development. Students who maintain a physically active lifestyle and consume a nutritious diet are more likely to develop resilience, discipline, and a positive attitude toward learning (Tomporowski et al., 2011). A longitudinal study by Esteban-Cornejo et al. (2017) found that students with a combination of high fitness levels and good nutritional status performed significantly better in physical education and other subjects compared to those who lacked either component. This supports the argument that an integrated approach, combining structured physical education programs with proper nutritional guidance, is essential for maximizing student learning outcomes.

Implications for Education Policy and Practice: Given the substantial impact of physical fitness and nutrition on learning success, schools should prioritize comprehensive programs that promote active lifestyles and healthy eating habits. Implementing structured physical education curricula that emphasize cardiovascular endurance, strength training, and flexibility exercises can enhance students' overall fitness levels. Additionally, integrating nutritional education into school programs can help students make informed dietary choices, leading to better academic performance (Story et al., 2009). Teachers and school administrators should also collaborate with parents to ensure students receive adequate physical activity and nutrition outside of school. Encouraging participation in extracurricular sports, providing healthy meal options in school cafeterias, and conducting regular health assessments can further support students' academic and physical well-being.

Overall, physical fitness and nutritional status are closely related to learning success in physical education and other academic fields. Previous research has shown that good physical fitness can improve students' motor skills, learning motivation, and mental health, while optimal nutritional status contributes to better cognitive development and endurance. Therefore, the integration of physical fitness and nutrition education in the educational curriculum is a must to support the development of students as a whole, both from a physical and academic perspective.

Conclusions

Based on the literature review, it can be concluded that physical fitness and nutritional status are significant predictors of learning success in physical education. Students who have good physical fitness and optimal nutritional status tend to have better academic performance and superior motor skills. Therefore, an intervention approach that includes improving physical fitness through structured physical activity and dietary improvement is needed to support a more effective learning process in a physical education environment.

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Conflict of interest

The research has no conflict of interest, and the entire process is conducted independently without external intervention.

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Взаємозв'язок між фізичною підготовленістю, нутритивним статусом та академічною успішністю у фізичному вихованні: Систематичний огляд

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 14 с., 3 табл., 1 рис., 70 джерел.

Мета дослідження. Цей огляд мав на меті дослідити, наскільки фізична підготовленість та нутритивний статус є значущими предикторами результатів навчальної діяльності у фізичному вихованні (ФВ) серед учнів середніх шкіл. Враховуючи зростаючу стурбованість щодо малорухливого способу життя та нездорових харчових звичок серед підлітків, розуміння цих взаємозв'язків є критично важливим для поліпшення фізичної та академічної результативності.

Матеріали та методи. У цьому дослідженні використовувався метод пріоритетних елементів звітування для систематичних оглядів та метааналізів (PRISMA) з метою відбору та аналізу літератури, пов'язаної з оцінкою різних релевантних досліджень у галузі фізичного виховання, фізичної підготовленості та нутритивного статусу, що було здійснено шляхом систематичного аналізу відповідної літератури. Для визначення способів підготовки учнів щодо покращення їх фізичної підготовленості було проаналізовано статті, опубліковані у період з 2020 по 2025 рік. За допомогою літературного огляду проведено комплексний пошук із використанням наукометричних баз даних Scopus, Web of Science, Google Scholar та PubMed за наступними ключовими словами: «фізична підготовленість», «нутритивний статус», «академічні досягнення» та «фізичне виховання».

Результати. Представлений огляд встановив сильну кореляцію між складовими фізичної підготовленості (серцево-судинна витривалість, м'язова сила, композиція тіла) та результатами навчання з фізичного виховання. Також було доведено, що повноцінність харчування, особливо достатнє споживання мікроелементів та збалансована дієта, впливає на когнітивні функції, набуття моторних навичок та залученість учнів до навчального процесу. Однак взаємодія між фізичною підготовленістю та харчуванням виявилася синергічною та залежала від контексту.

Висновки. Результати дослідження підкреслюють, що фізична підготовленість та нутритивний статус є важливими не тільки для здоров'я, але й для успішного навчання на уроках фізичного виховання. Школи та політичні діячі мають сприяти впровадженню інтегрованих програм, що передбачають одночасну підтримку обох зазначених галузей. З метою підтвердження причинно-наслідкового зв'язку необхідно провести додаткові лонгітюдні та експериментальні дослідження. Отже, задля комплексної оптимізації навчання та розвитку результативності навчальної діяльності потребуються стратегії, спрямовані на поліпшення фізичної підготовленості та нутритивного статусу учнів.

Ключові слова: фізична підготовленість, нутритивний статус, фізичне виховання, успішність у навчанні, огляд літератури.

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