The effects of interdisciplinary teaching between mathematics and physical education: A Systematic Review

Gli effetti di una didattica interdisciplinare tra matematica ed educazione fisica: Revisione Sistematica

Manuela Valentini
University of Urbino Carlo Bo (Urbino, Italy) – manuela.valentini@uniurb.it
https://orcid.org/0000-0003-2655-1778
Irene Sbarbati
University of Urbino Carlo Bo (Urbino, Italy) – i.sbarbati@campus.uniurb.it
https://orcid.org/0009-0000-4504-016X

DOUBLE BLIND PEER REVIEW

ABSTRACT

Physical activity provides numerous benefits to physical and mental health, even affecting learning. Despite this, one of the main modern problems is represented by sedentariness. Children and adolescents spend most of their time at school. Therefore, a valid teaching methodology to benefit from the positive effects of physical activity and reduce sedentary moments could be interdisciplinary learning, which integrates physical education into various curricular subjects. Specifically, this paper proposes a systematic literature review of some protocols (n = 11) to investigate whether an elementary school's integrated physical education and mathematics curriculum can improve learning in the logic-cognitive domain. From all the studies reviewed, the strong importance of interdisciplinary teaching, linking mathematics to physical education, was confirmed to reduce sedentary moments and enable a better attitude toward this discipline, breaking down the many stereotypes that often paint it as a complex and abstract subject.

L'attività motoria apporta numerosi benefici alla salute fisica e mentale, andando ad influire anche sull'apprendimento. Nonostante questo, uno dei principali problemi moderni è quello della sedentarietà. Il luogo frequentato per la maggior parte delle ore da bambini e adolescenti è la scuola, dunque, una valida metodologia didattica per beneficiare degli effetti positivi dell'attività fisica e per ridurre i momenti di sedentarietà potrebbe essere quella dell'apprendimento interdisciplinare, che integra l'educazione fisica alle varie materie curricolari. Nello specifico, il presente lavoro propone una revisione sistematica della letteratura di alcuni protocolli (n = 11) per indagare gli effetti di un curricolo integrato di educazione fisica e matematica nella Scuola Primaria in ambito logico-cognitivo. Da tutti gli studi presi in esame, è stata confermata la forte importanza di una didattica interdisciplinare, che lega la matematica all'educazione fisica, per ridurre i momenti di sedentarietà e per permettere di conseguire un migliore atteggiamento nei confronti di questa disciplina, abbattendo i numerosi stereotipi che spesso la dipingono come una materia complessa ed astratta.

KEYWORDS
Physical education, Implementation of physical education at school, Mathematics, Body-based learning, Interdisciplinary education
Educazione fisica, Implementazione dell'educazione fisica a scuola, Matematica, Apprendimento basato sul corpo, Didattica interdisciplinare

Citation: Valentini, M. & Sbarbati, I. (2024). The effects of interdisciplinary teaching between mathematics and physical education: A Systematic Review. *Formazione & insegnamento*, 22(1S), 83-93. https://doi.org/10.7346/-feis-XXII-01-24_11

Authorship: Supervision (M. Valentini), Investigation (I. Sbarbati). This article is the product of the joint ideation of the Authors, and responsibility for each section is as follows: Section 1 (M. Valentini, I. Sbarbati); Section 2 (M. Valentini, I. Sbarbati); Section 3 (M. Valentini, I. Sbarbati); Section 4 (M. Valentini, I. Sbarbati); Section 5 (M. Valentini, I. Sbarbati); Section 6 (M. Valentini, I. Sbarbati); Section 7 (I. Sbarbati); Section 8 (I. Sbarbati); Section 8.1 (M. Valentini, I. Sbarbati); Section 9 (M. Valentini, I. Sbarbati).

Conflicts of interest: The Author(s) declare(s) no conflicts of interest.

DOI: https://doi.org/10.7346/-feis-XXII-01-24_11

Submitted: March 5, 2024 • **Accepted**: May 13, 2024 • **Published**: December 2, 2024

Pensa MultiMedia: ISSN 2279-7505 (online)

1. Introduction

This paper explores whether integrating physical education and mathematics in the primary school curriculum can improve learning in the logic-cognitive domain. The paper examines how movement and physical education can enhance cognitive abilities, specifically logical-mathematical skills, through interdisciplinary teaching that integrates the learning of mathematics with physical education.

The paper begins with a comprehensive literature search, major search engines, and experiments reporting positive motor activity results regarding physical and mental health and learning. One of the modern problems of sedentariness is analysed, and the means to reduce it, namely the body and movement, are explored. The paper highlights the decreasing trend of physical activity among young people and how schools can counteract this by increasing physical education time. The Finnish school system is presented as an example of how to apply the educational value of the body effectively.

The paper also focuses on the relationship between exercise, cognitive function, and academic achievement. It presents a neuroendocrinological explanation of what happens in an individual's mind during physical activity. The philosophy of embodied cognition, which emphasizes the close correlation between mind and body, is also discussed.

Through this systematic review, the paper investigates the effects of physical exercise on mathematical skills to determine whether interdisciplinary teaching, integrating physical education and mathematics, can lead to better academic achievement in the logic-cognitive domain among primary school pupils.

2. A modern problem: sedentariness

Regular physical activity is now recognized to positively impact both physical and mental health, including improvements in learning. According to the Centers for Disease Control and Prevention (Benefits of Physical Activity, 2023), physical activity helps maintain brain health, manage weight, prevent diseases, strengthen bones and muscles, and efficiently perform daily activities. The Physical Activity Guidelines for Americans, 2nd edition (2018) states that children aged 6 to 13 years can improve their cognitive abilities, including performance on school achievement tests and neuropsychological tests (involving mental processing speed, memory, and cognitive function), after a moderate to vigorous physical activity session or a period of regular physical activity.

Although the positive effects of exercise are widely recognized, the central issue in modern society is that many young people need to meet the recommended physical activity levels set by the World Health Organization. For individuals aged 5 to 17 years, engaging in at least 60 minutes of moderate-intensity or vigorous-intensity physical activity each day is recommended. For those 18 years and older, a minimum of 150 minutes of moderate-intensity aerobic physical activity each week is recommended. Children and adolescents spend a significant portion of their day in school, which makes it an ideal place to encourage them to engage in physical activity and move their bodies. With the help of trained teachers who understand the importance of movement, students can reduce the amount of time spent sitting, which can have significant health benefits. Many schools need to provide more physical education to meet the daily motor activity recommendations of the World Health Organization. The hours of motor activity are often reduced to make room for other activities deemed more important. Consequently, children spend a lot of time sitting in class, which negatively affects their health.

A study conducted by Mooses and colleagues (2017) in multiple schools in Estonia monitored the physical activity levels of students aged 5 to 14 for one school week between December 2014 to April 2016. The study used an accelerometer to record a total of 6363 lessons and was found that most of the class time in the observed classes was spent being sedentary, especially in classes of older pupils. Sedentary behavior during adolescence can lead to a lack of physical activity in adulthood. Hence, reducing sedentary time across all subjects is essential, especially in higher grade levels.

2.1 How can schools take action?

Every child and adolescent spends a significant amount of their day, at least five hours, at school. Therefore, schools must encourage physical activity and promote the importance of movement and physical education. Ideally, each school should provide appropriate environments and resources to support physical activity, including getting students moving whenever possible, offering small active breaks that involve bodily movement between work, scheduling activities in the school's open spaces, and bringing them outside to run around in the fresh air during break or after school.

It is necessary to change schools' current approach and how teaching is done. To promote the importance of physical activity and exercise, every teacher must understand the educational value of the body and movement culture. Following Dewey's learning-by-doing approach, teachers can introduce a teaching method that links theoretical concepts to physical movement or allows students to learn and acquire knowledge through movement. In 2013, the Institute of Medicine (IOM) defined this approach as a "whole-of-school approach to physical activity" that has been embraced by some schools in the United States. It involves giving importance to regular and high-intensity physical activity lessons, providing appropriate resources and environments for structured and unstructured physical activity, and supporting initiatives such as biking or walking to school together. This approach also promotes active learning of various subjects like math, geography, literature, and science with the help of movement and the body. If schools adopt this approach, it will be a significant step towards a healthier and less sedentary learning environment that focuses on protecting children's health through movement.

3. The Finnish example

Physical education is often overlooked in schools, and studies have shown that children and adolescents have high levels of sedentary behaviour. These findings were reported by *OKkio alla Salute* (ISS, 2019) and international studies such as that conducted by Mooses and colleagues (2017). However, Finland serves as a positive example in this regard. Finland's education system has lately gained international recognition for producing the best academic results in the West. According to 2018 PISA (Programme of International Student Assessment) surveys, Finnish students scored the highest in reading, science, and math, consistently ranking above the international average (Schleicher, 2019). They scored 520 in reading (average 487), 507 in math (average 489), and 522 in science (average 489).

It is intriguing to consider Finland's success in education when you compare it to the typical East Asian approach of long hours of memorization. Finnish schools have shorter school days, assign less homework, and prioritize recreational play for children (Shalberg, 2011).

The success of Finnish schools can be attributed to their emphasis on physical education, which has been a compulsory subject since the mid-19th century. It is considered a crucial stage of fundamental education, as it aims to develop an individual's physical, cognitive, and psychosocial abilities. The Finnish system believes that schools provide the only structured opportunity for children to engage in moderate to vigorous physical activity and meet the daily minutes of movement recommended by the World Health Organization. In Finland, physical activity and the value of the body are not only given attention during physical education classes but are included in teaching all disciplines, including mathematics. Mathematics teaching is crucial for developing logical-mathematical thinking, which is essential for future social activities. As Krzywacki and colleagues (2016) argue, mathematical learning is often abstract and challenging for children to comprehend. Therefore, teaching models and concrete manipulative materials should be used to facilitate the effective teaching of mathematics. Manipulating objects through the hands and body allows for more immediate and simplified learning. For instance, touching flat or solid geometric figures, or performing addition or subtraction operations with the help of marbles can be very helpful. Finnish lessons often involve pair or small group work to promote cooperation skills and peer tutoring.

4. The impact of physical activity and body condition on cognitive performance and academic success

Over the last two decades, studies have shown that exercise can enhance mental function. Specifically, exercising affects cognitive processes called executive functions, which help control behaviour (Collins & Koechlin, 2012). Executive functions refer to three fundamental and interconnected skills: inhibitory control, working memory, and cognitive flexibility. These skills are highly crucial for the healthy development of a child. Higher-order executive functions like reasoning, problem-solving, and planning are built upon these three skills, as Collins and Koechlin (2012) mentioned. Additionally, executive functions are predictive of various health, well-being, and quality of life indicators and are often more significant than IQ or socioeconomic status (Moffitt et al., 2011).

In recent decades, there has been a rise in obesity rates and concerns about children's health. As a result, researchers have conducted many studies to assess the impact of physical activity on cognitive functioning and school performance. Four major large-scale research studies have been dedicated to testing the impact of physical activity on school achievement. These studies are Sibley & Etnier (2003), Sallis et al. (1999), Shephard (1997), and Shephard et al. (1994). An analysis of these studies and careful comparison by Fedewa and Ahn (2011) shows that three of these studies reported significant improvements in students' academic achievement when physical activity was increased. In contrast, the fourth study (Sibley & Etnier, 2003) found no significant differences in students' academic achievement. Additionally, several other studies confirm the positive influence of physical activity on school performance. These studies include Rasberry et al. (2011), Donnelly et al. (2016), and Álvarez-Bueno et al. (2017).

Increasing physical activity at school is essential to reduce sedentary rates and improve academic performance and behaviour.

5. Exercise and Cognitive Function: A Neuroendocrinological Explanation

The literature on the impact of exercise on cognitive function is extensive, and it is now clear that physical activity has a powerful positive effect on cognitive function. However, what happens in the brain during exercise, and how does this impact cognitive function?

Cooper (1973) was the first to explore the impact of exercise on cognitive function by providing a neuroendocrinological explanation. Neuroendocrinology is a branch of medicine that studies the anatomical and functional relationships between the nervous and endocrine systems. According to Cooper, the brain regulates hormonal activity in the body, and there is a connection between the release of catecholamines (adrenaline, norepinephrine, and dopamine) in the blood during exercise and the increased availability of neurotransmitters in the brain. This, in turn, causes changes in cognitive function. Exercise is a stressor that affects the brain's concentrations of catecholamines, serotonin, and cortisol, just like any other stressor. Cooper first proposed this statement in 1973, hypothesizing that exercise could increase norepinephrine and dopamine brain concentrations. However, it is challenging to obtain empirical evidence of this interaction, and although research demonstrates that psychological stress can cause an increase in plasma concentrations of catecholamines, it is impossible to test this directly in humans. Therefore, researchers have relied on animal studies, which show an actual increase in catecholaminergic activity in the brain during physical activity. However, two significant questions remain: 1) Does this also happen in humans? 2) To what extent does this mean an increase in the efficiency of cognitive functioning?

Recent studies by Chmura, Nazar, and Kaciuba-Uscilko (1994) and McMorris et al. (1999) focused on exploring the relationship between exercise, catecholamines, and cognition. However, the results of these studies have not provided any neuroendocrinological explanation. Although the theoretical basis supporting the idea that exercise-induced increases in catecholamines can cause changes in cognitive function seems strong, the empirical evidence does not fully support it. As a result, several unanswered questions still remain, which will hopefully be addressed by future studies.

6. Embodied cognition

The philosophy of embodied cognition, which emerged in the late 1980s, emphasizes the importance of the body and its influence on cognition. This contrasts with the traditional Western philosophical view that the body is irrelevant to understanding knowledge and cognition. One example of this view is Cartesian dualism, which separates the mind from the body and has influenced cognitive science. However, embodied cognition argues that the mind is not independent of the body but is inscribed in it, meaning that the body plays a crucial role in shaping thought and behaviour. Therefore, there is a clear distinction between mental representations processed by language, imagery, and memory and those processed by the sense-motor system.

Embodied theory proponents argue that the systems for perceiving, acting, and thinking are interdependent. The human body plays a critical role in mental activity by constraining, regulating, and shaping it. According to the thesis of embodied cognition theory, the body serves at least two distinct but related roles in cognition: as a constraint and a cognitive distributor.

The proponents of embodied cognition argue that the mind cannot be understood independently of the body. According to them, the mind is deeply rooted in the body's interactions with the world. The biological brains are, first and foremost, control systems of biological bodies that move and act in a reality-rich environment. Therefore, cognitive processes must be understood in the context of the body's interactions with the world. This position implies six assertions, as identified by Wilson (2002): 1) cognition is situated, 2) cognition is under time pressure, 3) we offload cognitive work onto the environment, 4) the environment is part of the cognitive system, 5) cognition is for action, 6) offline cognition is body-based.

The most relevant statement for the current argument is the sixth, which states that offline cognition is body-based. A good example of this is the gesture of finger counting. Most children worldwide initially learn number concepts by counting their fingers through spontaneous practice, parental observation, or direct instruction. Finger counting has a long cultural tradition and is still widely used today as a manifest behaviour and a cognitive representation (Göbel et al., 2011). The complete form of counting involves finger movements that clearly indicate each finger as a counter. However, this can also be done subtly, where the finger positions are different enough to allow the counter to keep track. Using this type of mental activity to aid with tasks such as counting opens up a new realm of cognitive strategies. Many cognitive activities that seem abstract, like counting, can use sensory-motor functions. To say that offline cognition is body-based means that mental structures that initially evolved for perception or action appear to be repurposed and function offline, separated from the physical inputs and outputs they originally intended for (Wilson, 2002).

It is clear from the finger-counting example that even abstract conceptual systems like mathematics are embodied in our bodies, language, and cognition (Nuñez, 2006).

7. Primary school interdisciplinary teaching integrating math and physical education: A systematic review

The initial section of this paper emphasized the significance of physical activity and its impact on cognitive function and academic performance. To this end, a comprehensive literature analysis was carried out to examine the influence of interdisciplinary teaching, which combines mathematics and physical education in primary school, on the logical-cognitive domain.

The research question for this systematic review is whether an integrated physical education and mathematics curriculum in primary school can enhance learning in the logic-cognitive domain.

7.1. Literature research

The protocols were searched on five electronic databases: ERIC, PsycArticles, PsycINFO, PubMed, and SPORTDiscus. The search was carried out around four main topics, which were physical education (using keywords such as physical activity, physical education, physical active lesson, implementation of PE in school, activity-based learning, and body-based learning), mathematics learning (using keywords such as mathematics, math, and problem-solving), interdisciplinary learning (using keywords such as activity-based learning, body-based learning, integrated learning systems, and interdisciplinary education), and population (using keywords such as children and school). All protocols were manually analyzed to identify potentially eligible studies based on the inclusion criteria.

7.2 Inclusion and exclusion criteria

The following criteria were used to select studies for review: studies that combine mathematics learning with physical education in an elementary school setting and use a randomized controlled trial (RCT) or quasi-experimental design. The studies must involve children aged 6-12 years, an experimental group that receives an interdisciplinary lesson combining math and physical education, and a control group. The studies must also compare a baseline and final situation following the integration of physical education and math. Only studies with protocols available in English or Spanish were included. Studies that did not present a control group and an experimental group, those that did not meet the age range (6-12 years), and those that did not present the results obtained in mathematics following the implementation of motor activity were excluded.

7.3 Data extraction

A table was utilized to extract data such as authors, year, number of participants, age, setting, type of activity, duration of the study, and results.

7.4 Assessment of the risk of bias

Bias risk assessment is a process to identify the features of each study that may affect our confidence in the overall estimation of the effect of a particular intervention, such as concealment of assignment or blinding. In physical education interventions, it is impossible to blind children participating in group assignments. However, the presence of data collected before and after the interventions can be considered objective, and therefore, the quality of the evidence is not downgraded. Studies reporting unfavourable results regarding the hypothesis of this systematic review were also selected to reduce the risk of bias.

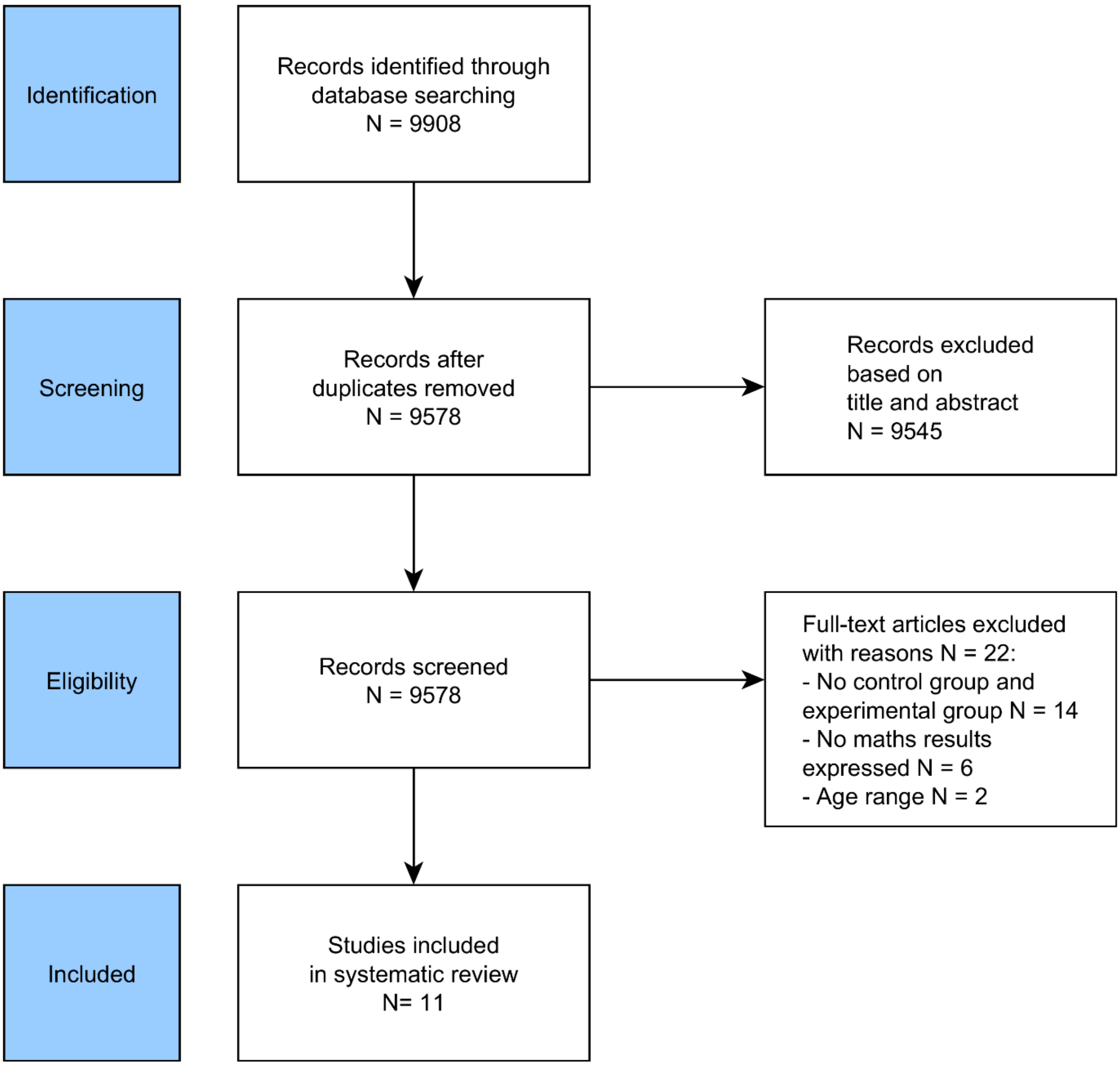

Figure 1. Flow chart for identification, screening, eligibility, and inclusion of studies

7.5 Results

During the preliminary search of electronic databases, we identified 9,908 potentially relevant protocols; *Figure 1* shows the distribution of these protocols across different databases. Out of these, 343 were identified in Eric, 194 in PsycArticles, 4,780 in PsycInfo, 294 in PubMed, and 4,297 in SportDiscus. After removing duplicates, 9,578 relevant articles remained. We conducted a preliminary review of titles and abstracts and excluded 9,545 protocols, leaving only 33 relevant articles. Each of these protocols underwent careful evaluation, and 22 were excluded. The reasons for exclusion were that 14 protocols did not have a control group and an experimental group, six protocols did not have results related to the mathematical domain, and two protocols had ineligible age groups. Ultimately, we included 11 studies in this systematic review, and their characteristics are summarized in *Table 1*.

Source	*Database*	*No. and Age of participating children*	*Setting*	*Duration*	*Activity*	*Results*
Reed et al. (2010)	PsycINFO	*n* = 155; Age: 7–8 y.o.	Classroom	4mo	The experimental group incorporated physical activity (running, jumping, and walking) into their core subjects, including language, math, social science, and science.	The experimental and control groups did not show any significant differences in the mathematical domain results.
Bala et al. (2015)	SPORTDiscus	*n* = 306; Age: 5–9 y.o.	Classroom, gym	One lesson	The experimental groups either took a basic math test before or after exercising (for 30, 40, or 60 minutes). The control group took the same test without exercising.	According to the results, the computational performance of the children in the experimental groups showed significant improvement.
Mullender-Wijnsma (2016)	PubMed	*n* = 499; Age: 8 y.o.	Classroom, gym	2y (22w/year)	The intervention group participated in interdisciplinary classes between curricular subjects and physical education. The control group participated in regular curricular classes.	Children in the intervention group achieved significantly higher scores on both the speed test and general mathematics test.
Beck et al. (2016)	PubMed	*n* = 165; Age: 7–8 y.o.	Classroom	6w	Three groups were included: a control group that received conventional math instruction, a fine-motor math group and a coarse-motor group.	All groups showed improvement in math, but gross-motor group improved significantly more.
Snyder et al. (2017)	Eric	*n* = 155; Age: 8–9 y.o.	Classroom, gym	One teaching unit	The experimental group incorporated physical activity during math lessons. The control group followed typical teaching strategies.	It was observed that there were no notable distinctions between the two groups.
Griffo et al. (2018)	SPORTDiscus	*n* = 55; Age: 8–12 y.o.	Classroom, gym	2w	During the first week of the study, the students were asked to use pedometers to record the level of their body movement during physical education classes. In the second week of the study, the students participated in "math fitness", which is a combination of physical activity with math concepts, using KIA-style lessons (Hodges, 2015). They also wore pedometers to record their steps, but this time only during the fitness segment of the lesson.	According to the results, there was an improvement in the students' learning in math and fitness segments.
Vetter et al. (2018)	SPORTDiscus	*n* = 85; Age: 9–10 y.o.	Classroom, gym, playground	6w	The intervention group engaged in moderate to vigorous physical activity while learning a multiplication table, while the control group learned the same material while sitting.	It was found that there was no significant difference in the improvement of mathematics between the two groups.
Boz and Kiremitci, 2020	SPORTDiscus	*n* = 45; Age: 9–10 y.o.	Classroom, gym	8w	The intervention group participated in six educational game sessions with mathematical exercises. Students in the control group participated in similar educational games, but without the math part.	Scores from the intervention group in the Raven Standard Progressive Matrices Test (RSPM) showed a statistically significant increase.
Cecchini and Carriedo (2020)	SPORTDiscus	*n* = 46; Age: 6 y.o.	Classroom, gym	4w	The control group had separate physical education and mathematics classes according to the core curriculum. The intervention group experienced an interdisciplinary approach that integrated physical education and mathematics.	Students in the intervention group scored higher on light and moderate-vigorous physical activity, and spent less time in sedentary activities. In addition, students in the intervention group scored higher in learning subtraction.

Fakri and Hashim (2020)	SPORTDiscus	*n* = 56; Age: 10 y.o.	Classroom	7w	The intervention group engaged in physical activity such as jumping, running, and walking during math classes, while the control group received regular lessons.	The results show no significant difference between groups. However, the control group achieved a higher percentage increase in math test score.
Otero et al. (2022)	SPORTDiscus	*n* = 72; Age: 11–12 y.o.	Classroom, gym	4 lessons	In the intervention group, mathematical concepts are integrated into physical education. In the control group, only physical education content is taught.	After the intervention, the success rate was found to increase the most in the topics of geometry, probability, and statistics.

Table 1. Descriptive features of included studies

8. Analysis of the results

Eleven studies met the criteria for inclusion in this analysis. These studies can be divided into three categories based on their findings. The first category includes seven studies that showed positive effects on mathematics as a result of interdisciplinary teaching between mathematics and physical education. The second category includes three studies that found no statistically significant effects on mathematics as a result of interdisciplinary teaching between mathematics and physical education. The third and final category includes one study that showed negative effects on mathematics as a result of interdisciplinary teaching between mathematics and physical education. The studies in each category will be analyzed in chronological order.

A study published in 2015 by Bala and colleagues named "The Effects of Acute physical exercise training on mathematical computation in Children" showed statistically positive results. The study aimed to determine whether acute physical exercise could enhance the ability of children to solve basic math problems quickly. The participants were from Kindergarten, primary school, and a special needs school in several cities in Serbia. Some participants were asked to take a basic math test before and after doing physical exercise for 30, 45 or 60 minutes (experimental group), while others took the same test without exercising (control group).

According to the results, the math performance of children showed significant improvement in the experimental groups that underwent 30, 45, or 60 minutes of physical activity. The p-value for each group was 0.01, indicating that the intervention was positive. A result is considered statistically significant if the p-value is less than 0.05. On the other hand, classes that did not participate in physical activity did not show significant improvement in math test results.

In 2016, Mullender-Wijnsma and her colleagues conducted a study to examine the effects of a physically active school program on the academic achievement of children. The study was conducted in the northern region of the Netherlands and involved a total of twelve elementary schools. Only second and third grades were included in the study, and they were randomly assigned to either the control group ($n = 250$) or intervention group ($n = 249$) in each school. The study's results were statistically significant and showed that physically active math and language lessons improved the children's academic achievement. The mathematical test analysis results indicate that children in the intervention group did not show significant improvement after one year of intervention ($t = 2.44$, $p = .02$; ES = 0.20, 95% CI 0.04 to 0.37). However, after the second year, they showed significantly more significant improvement than the control group ($t = 5.44$; $p < 0.001$; ES = 0.51, 95% CI 0.32 to 0.69) (Mullender-Wijnsma, 2016). This means that after two years of intervention, they gained more than four months of learning gains compared to the control group.

In 2016, Beck et al. conducted a study investigating whether adding fine or gross motor activities to math lessons could improve children's math performance. The study included 165 first-grade children from three different public schools in Denmark, and they were divided into three groups: the mathematical gross motor group (GMM), the mathematical fine motor group (FMM), and the control group (CON). The three groups had different teaching methods. The pupils were tested for mathematical achievement, cognitive function, and motor skills at three different times - before (T0), during (T1), and eight weeks (T2) after the intervention. The duration of the intervention was six continuous weeks.

The test results indicate that all groups showcased an improvement in their mathematical skills from T0 to T1 and T2. Furthermore, a significant group-time interaction was observed from T0 to T1 ($p = 0.03$). The mean mathematical performance changes were considerably higher in the coarse motor mathematics (GMM) group than the fine motor mathematics (FMM) group from T0 to T1 ($p = 0.02$). This suggests that the coarse motor mathematical group showed a temporary improvement in their mathematical abilities compared to the fine motor mathematical group. A larger sample size would have strengthened the effects of the intervention.

In 2018 Griffo et al. conducted a study titled "Becoming One in the Fitness Segment: Physical Education and Mathematics." The study aimed to determine if mathematical concepts could be integrated into primary school physical activity lessons without reducing the amount of movement performed, and if combining the two fields would increase students' uptake of mathematical knowledge. The study included 55 pupils from a primary school consisting of two third and one fourth grade. Physical education teachers used the Knowledge In Action (KIA) model (Hodges, 2015) to incorporate mathematical concepts into the motor education segment. The results obtained were statistically significant. In the first week of the study, students took a pre-test and utilized pedometers to record their steps during physical education classes only. In the second week, they participated in mathematical fitness lessons that followed the KIA model

(Hodges, 2015) and used pedometers to record their steps during the fitness segment of the lessons. During the mathematical fitness classes, a 'Jackpot Fitness' activity was conducted where they worked in pairs to complete a variety of exercises. The pre-test and post-test for maths consisted of 32 questions that covered the topics taught during the intervention, such as addition, subtraction, multiplication, division, decimal numbers, and counting jumping jacks. The difference in scores between the pre-test and post-test was evaluated. The t-test showed significant data, indicating that the mean of the pre-test scores was 24.05, while the mean of the post-test was 25.94, with a p-value less than 0.01.

One limitation of this study was the absence of a comparison group, as the students were also engaging in mathematics inside the classroom, not just during physical education time. However, both students and teachers reported better knowledge outcomes due to KIA's mathematical fitness classes. This supports the credibility and reliability of the results.

In 2020, Boz and Kiremitci conducted a study to investigate the impact of educational games that combine physical education and maths exercises on cognitive ability. The study used a quasi-experimental model, with a pre-test/post-test design and both experimental and control groups. A total of 45 students, aged 9-10 years, participated in the study and were randomly assigned to either the experimental group ($n = 21$) or the control group ($n = 24$). The study yielded positive results. It was used Raven's Standard Progressive Matrices Test (RSPM) (Raven et al., 1998) to measure the cognitive abilities of individuals. The test was administered both before and after the eight-week intervention. A day after the intervention ended, all participants took the post-test using the same measurement instrument. The analysis of the results indicates that there was no significant difference in the RSPM scores between the control group (scoring 12.43±3.87) and the experimental group (scoring 14.67±5.23) at the beginning of the intervention. However, the results of the independent post-test, conducted to evaluate the differences between the two groups at the end of the intervention, showed a statistically significant difference ($p<0.01$) between the RSPM scores of the control group (scoring 13.19±3.66) and the experimental group (scoring 17.19±4.38). In summary, the analysis of the results indicates that the use of mathematics exercises, combined with didactic games and the interdisciplinary teaching model, has a positive impact on the development of general mental abilities.

One of the studies examined in this systematic review was conducted in 2020 by Cecchini and Carriedo. The study investigated the "effects of an interdisciplinary approach that integrated Mathematics and Physical Education on both mathematical learning and physical activity levels" (Cecchini&Carriedo, 2020). The study involved forty-six students who participated in the experiment for a period of three weeks. They were randomly divided into two groups; a control group ($n = 23$) that followed traditional curricular lessons, and an experimental group ($n = 23$) that followed an interdisciplinary teaching unit. In the study, a pre-test and post-test mathematical knowledge test was administered to assess the learning of multiplication. Additionally, pedometers were used to measure the physical activity levels of the pupils during each Maths and PE lesson. The analysis of the results indicates that both the experimental and control groups have significantly improved their ability to perform subtraction operations. However, it has been found that the students in the experimental group ($p < 0.001$) scored higher than those in the control group ($p < 0.004$). It is important to note that this research has some limitations, such as a small sample size, the intervention focusing only on the learning of one mathematical skill (subtraction), and a limited duration of the intervention. Consequently, the long-term effects of the intervention still need to be discovered.

In 2022, Otero and Lafuente-Fernández conducted a study to evaluate the motivation, learning and challenges involved in integrating mathematical concepts with physical education in primary education. The study included 72 pupils aged 11-12 years from a Spanish primary school who were divided into two groups: experimental and control. The intervention took place in four sessions where the experimental group implemented mathematical concepts during PE hours while the control group performed similar exercises during PE hours but without any mathematical work involved. After analyzing the post-test data for both groups, it is evident that the students in the experimental group scored higher compared to the pre-test. However, the scores remained similar for the students in the control group. Overall, the experimental group showed significant improvement in their success rate across all the mathematical contents proposed.

To summarize, after analyzing the results of these seven studies, it was found out that integrating motor activity and mathematics significantly improved school achievement in math, despite some limitations in the studies. All of the interventions used in the seven studies can be implemented by any teacher in the classroom, and they can help reduce sedentary time while improving mathematical skills.

Three of the studies analyzed in this systematic review differ from the results mentioned earlier. After the interventions, they found no significant differences between the control and experimental groups. One such study is by Reed et al. (2010) titled "Examining the Impact of Integrating Physical Activity on Fluid Intelligence and Academic Performance in an Elementary School Setting: A Preliminary Investigation". The study involved 155 third-grade students from six different classes. Three classes, comprising 80 students, were randomly selected as the experimental group, while the other three classes, comprising 75 students, were selected as the control group. The experimental group integrated physical activity like running, jumping, and walking into the core curriculum (language, mathematics, social studies) for 30 minutes a day, three days a week, for four months. To ensure the fidelity of the intervention, random checks were conducted by direct observation. During the last day of the intervention, the Palmetto Achievement Challenge Tests (PACT) were administered to measure academic achievement. PACT evaluates achievement in four core areas: English, mathematics, science, and social studies. In South Carolina, PACT tests are not given before the third grade, so the researchers could not make pre-test comparisons. The analysis of the PACT scores showed that there were no significant differences between the control and experimental groups (t-test = 1.107, p = 0.09). However, in the experimental group, a higher percentage of children received a designation of 'proficient' and 'advanced' than in the control group.

A study conducted by Snyder and colleagues in 2017 aimed to test the effects of integrating physical activity into a mathematics teaching unit. The study, "Purposeful Movement: The Integration of Physical Activity into a Mathematics Unit," reported no significant differences between the control and experimental groups. It was conducted at a primary school in the United States, with two third-grade classes participating. One class was assigned as the intervention group (n = 11), where "movement was integrated into mathematics instruction. The other class (n = 13) was assigned as the comparison group where the teacher was asked to teach using typical teaching strategies" (Snyder et al., 2017). The intervention took place during school hours and lasted for an entire mathematics unit. The study collected pre and post data on physical activity levels, measured by accelerometer; behavior during the task, measured by direct observation; and academic achievement, measured by unit tests. After the final data collection, students' perceptions were measured through a writing and drawing activity. The objective of each lesson was to ensure that the students remained active for at least 50% of the 70-minute class duration.

Before the intervention, there were no statistical differences in the level of mathematical competence between the two classes (p = 0.542). All students received either 'basic' or 'progress' scores except for two students in the comparison class who received 'proficiency' scores. At the follow-up assessment, all students received 'adequate' or 'advanced' level scores on the final test except for one student from the comparison class who received a 'progress' score. Nevertheless, no statistically significant differences were found in mathematics results between the two classes (p = 0.094). The results suggest that incorporating physical activity into the curriculum as a teaching strategy does not hinder academic achievement. This finding could reassure teachers that targeted movement does not prevent satisfactory learning.

In 2018, Vetter and colleagues reported similar results to this study in their work titled "Learning 'Math on the Move': Effectiveness of a Combined Numeracy and Physical Activity Programme for primary school Children". Their study aimed to investigate whether learning important numeracy skills, such as multiplication tables, while participating in an aerobic activity is more effective than a sedentary teaching approach. The study involved 88 fourth grade students from an Australian primary school, who were randomly assigned to either the physical activity group (experimental group) or the classroom group (control group) during the first term. After a six-week break, the groups were reversed. During the second week of the first trimester, a baseline test was conducted to check competencies concerning multiplication tables, which was also carried out at the end of the intervention. The results showed that there were no significant differences in the improvement of mathematical skills between the two groups (p = 0.86).

The findings of three studies suggest that there were no significant differences between the mathematical results of the control and experimental groups after integrating mathematics and physical education. Despite this, the scores indicate that interdisciplinary teaching between mathematics and physical education is not harmful and can benefit students' learning by reducing sedentariness. However, these studies have certain limitations that may have affected the results. For instance, in the study by Reed et al. (2010), no pre-test comparison was carried out. Similarly, in the study by Vetter et al. (2018), the small sample size of participants is a limitation. A larger sample could have produced more reliable results. Although the study by Snyder et al. (2017) did not show any significant effects from the interaction of PE and mathematics, it did demonstrate a positive improvement in attitudes towards this discipline, which is often perceived as challenging. This is an important finding that highlights the significance of PE in fostering a better attitude towards mathematics.

A study conducted by Fakri and Hashim in 2020 showed different results than previous studies. The study focused on "the effects of integrating physical activity into math lessons on math test performance, body mass index and short term memory among 10-year-old children" (Fakri&Hashim, 2020). The study lasted for 7 weeks and involved 56 primary school pupils aged 10 years. The participants were randomly divided into two groups, a control group (n = 28) and an experimental group (n = 28). The researchers measured educational achievement in mathematics using a mathematics test. The analysis of the results presents conflicting data. Surprisingly, the group that did not engage in physical activity recorded a higher percentage increase in their mathematical test score (+23.29%) compared to the group that did (+14.28%). However, this study has a limitation. As Fakri and Hashim (2020) suggested, future studies should consider broader outcome measures encompassing cognitive and psychosocial aspects such as concentration, reaction time, and enjoyment. This will provide a more comprehensive assessment of the effectiveness of integrating physical education and mathematics.

8.1 For interdisciplinary learning: Motor-Math

In summary, the analysis of the studies considered shows that careful motor activity programming integrated with mathematical content, Motor-Math, in addition to being highly motivational and rewarding for young learners, brings benefits at the motor and cognitive levels. Specifically, in the eleven studies reviewed, the motor content combined with mathematical exercises addressed gross and fine motor skills, fundamental motor patterns, lateralization, body schema, and general coordination skills. Exercises that emphasized improving pupils' mathematical performance, highlighting the positive effects of interdisciplinary teaching between mathematics and physical education, were running, jumping, push-ups, jumping jacks, proprioception exercises combined with, for example, numeration and reiteration. In this way, the playful form enhances interest in learning by engaging pupils in physical exercise, varying it from moderate to vigorous, and using materials such as pedometers to record the level of body movement during activities and pedometers to record steps.

This brings one closer to achieving the goal set by the World Health Organization (2019) of spending at least 180 minutes a day in physical activity at any intensity, including at least 60 minutes at moderate to vigorous intensity.

As is also evident from the study by Sneck et al. (2019), there is no clear evidence indicating which types of physical activity are most effective for improving math performance. According to the study by Álvarez-Bueno et al. (2017), curricular physical education classes are the most effective activity for improving children's academic achievement. In the systematic review by Sneck et al. (2019), they report considerations by Howie and colleagues (2015) on the importance of PA breaks, "those of 5 minutes may be too short to affect math performance, whereas if they last 10 or 20 minutes, they may contribute to better results" (Howie et al., 2015). In an article by Capio and colleagues (2024), a variety of activities are proposed for achieving different mathematical goals, such as "pushing and rolling a rubber wheel while walking/running (to learn the oval and circle shapes), throwing with one hand (to learn spatial positions), taking side steps (to learn numbering from 1 to 5)" (Capio et al., 2024).

To summarize, according to the results of the present systematic review and the data from the studies by Sneck et al. (2019) and Álvarez-Bueno and colleagues (2017), ideally, we would be able to incorporate exercises such as those described by Capio et al. (2024), aimed at achieving various mathematical goals, within curricular physical education lessons, taking 10 or 20 minute breaks. In this way, through interdisciplinary work, significant improvements in academic achievement in mathematics would be achieved.

One certainty remains: play and movement, combined with mathematical concepts (Motor-Math), are optimal both against sedentariness and for approaching this dreaded discipline. This reinforces the notion that a change in school habits, involving and entertaining, will produce better results in pupils' learning.

9. Conclusions and perspective

Despite analysing eleven protocols, the original question of this systematic review cannot be answered due to the presence of contradictory results. However, if we consider the limitations of this study that have already been described, we can infer that interdisciplinary work favors functional learning and the overall development of students, improving their understanding of content practically. Additionally, a discrete number of studies have shown positive outcomes in the mathematical domain of integrating mathematics and physical education. Therefore, it is safe to say that interdisciplinary work positively impacts students' involvement and motivation (Camps, 2016).

Based on the analysis of 11 studies, it has been found that interdisciplinary teaching between mathematics and physical education can help reduce sedentary activity levels, increase cardiorespiratory fitness levels, and improve attitudes toward mathematics. This conclusion was consistent even in studies that reported contradictory or non-statistically significant results. The study conducted by Snyder et al. in 2017 specifically highlights that physical education programs alone are insufficient to increase physical activity levels in children. Instead, integrating physical education with other curricular disciplines is necessary to achieve this goal. Given the results of this systematic review, it is recommended that further research be conducted to understand better the benefits of interdisciplinary teaching between mathematics and physical education. Interventions should be conducted on different age groups to gain a broader perspective. In addition, qualitative methods, such as evaluating the opinions of both students and teachers and observing the planning and implementation process of the intervention, should also be included in the research process.

References

Álvarez-Bueno, C., Pesce, C., Cavero-Redondo, I., Sánchez-López, M., Garrido-Miguel, M., & Martínez-Vizcaíno, V. (2017). Academic Achievement and Physical Activity: A Meta-analysis. *Pediatrics*, *140*(6), e20171498. https://doi.org/10.1542/peds.2017-1498

Bala, G., Adamovi , T., Madi , D., & Popovi , B. (2015). Effects of Acute Physical Exercise on Mathematical Computation Depending on the Parts of the Training in Young Children. *Collegium Antropologicum*, *39 Suppl 1*, 29–34.

Beck, M. M., Lind, R. R., Geertsen, S. S., Ritz, C., Lundbye-Jensen, J., & Wienecke, J. (2016). Motor-Enriched Learning Activities Can Improve Mathematical Performance in Preadolescent Children. *Frontiers in Human Neuroscience*, *10*. https://doi.org/10.3389/fnhum.2016.00645

Benefits of Physical Activity. (2023, August 1). [Institutional website]. *Centers for Disease Control and Prevention*. https://www.cdc.gov/physicalactivity/basics/pa-health/index.htm

Boz, B., & Kiremitci, O. (2020). Effect of maths-integrated PE games on cognitive ability. *South African Journal for Research in Sport, Physical Education and Recreation*, *42*(2), 1–14. https://www.ajol.info/index.php/sajrs/article/view/200104

Capio, C. M., Cheung, S. K., Fung, S. S. W., & Hu, X. (2024). Integrating Fundamental Movement Skills and Mathematics in Early Childhood: A Pilot Study. *Children*, *11*(4), 457. https://doi.org/10.3390/children11040457

Cecchini, J. A., & Carriedo, A. (2020). Effects of an Interdisciplinary Approach Integrating Mathematics and Physical Education on Mathematical Learning and Physical Activity Levels. *Journal of Teaching in Physical Education*, *39*(1), 121–125. https://doi.org/10.1123/jtpe.2018-0274

Chmura, J., Nazar, K., & Kaciuba-U cilko, H. (1994). Choice Reaction Time During Graded Exercise in Relation to Blood Lactate and Plasma Catecholamine Thresholds. *International Journal of Sports Medicine*, *15*(04), 172–176. https://doi.org/10.1055/s-2007-1021042

Collins, A., & Koechlin, E. (2012). Reasoning, Learning, and Creativity: Frontal Lobe Function and Human Decision-Making. *PLoS Biology*, *10*(3), e1001293. https://doi.org/10.1371/journal.pbio.1001293

Cooper, C. J. (1973). Anatomical and Physiological Mechanisms of Arousal, with Special Reference to the Effects of Exercise. *Ergonomics*, *16*(5), 601–609. https://doi.org/10.1080/00140137308924551

Donnelly, J. E., Hillman, C. H., Castelli, D., Etnier, J. L., Lee, S., Tomporowski, P., Lambourne, K., & Szabo-Reed, A. N. (2016). Physical Activity, Fitness, Cognitive Function, and Academic Achievement in Children: A Systematic Review. *Medicine & Science in Sports & Exercise*, *48*(6), 1197–1222. https://doi.org/10.1249/MSS.0000000000000901

Fakri, N. F. N., & Hashim, H. A. (2020). The effects of integrating physical activity into mathematic lessons on mathematic test performance, body mass index and short term memory among 10 year old children. *Journal of Physical Education and Sport*, *20*(1), 425–429. https://doi.org/10.7752/jpes.2020.s1061

Fedewa, A. L., & Ahn, S. (2011). The Effects of Physical Activity and Physical Fitness on Children's Achievement and Cognitive Outcomes: A Meta-Analysis. *Research Quarterly for Exercise and Sport*, *82*(3), 521–535. https://doi.org/10.1080/02701367.2011.10599785

Göbel, S. M., Shaki, S., & Fischer, M. H. (2011). The Cultural Number Line: A Review of Cultural and Linguistic Influences on the Development of Number Processing. *Journal of Cross-Cultural Psychology*, *42*(4), 543–565. https://doi.org/10.1177/0022022111406251

Griffo, J. M., Kulinna, P., Hicks, L., & Pangrazi, C. (2018). Becoming One in the Fitness Segment: Physical Education and Mathematics. *The Physical Educator*, *75*(4), 647–660. https://doi.org/10.18666/TPE-2018-V75-I4-8199

Howie, E. K., Schatz, J., & Pate, R. R. (2015). Acute Effects of Classroom Exercise Breaks on Executive Function and Math Performance: A Dose–Response Study. *Research Quarterly for Exercise and Sport*, *86*(3), 217–224. https://doi.org/10.1080/02701367.2015.1039892

Indagine nazionale 2019: I dati nazionali. (2020). ISS - Istituto Superiore di Sanità. https://www.epicentro.iss.it/okkioallasalute/indagine-2019-dati

Krzywacki, H., Pehkonen, L., & Laine, A. (2016). Promoting Mathematical Thinking in Finnish Mathematics Education. In H. Niemi, A. Toom, & A. Kallioniemi (Eds.), *Miracle of Education* (pp. 109–123). SensePublishers. https://doi.org/10.1007/978-94-6300-776-4_8

McMorris, T., Myers, S., MacGillivary, W. W., Sexsmith, J. R., Fallowfield, J., Graydon, J., & Forster, D. (1999). Exercise, plasma catecholamine concentrations and decision-making performance of soccer players on a soccer-specific test. *Journal of Sports Sciences*, *17*(8), 667–676. https://doi.org/10.1080/026404199365687

Moffitt, T. E., Arseneault, L., Belsky, D., Dickson, N., Hancox, R. J., Harrington, H., Houts, R., Poulton, R., Roberts, B. W., Ross, S., Sears, M. R., Thomson, W. M., & Caspi, A. (2011). A gradient of childhood self-control predicts health, wealth, and public safety. *Proceedings of the National Academy of Sciences*, *108*(7), 2693–2698. https://doi.org/10.1073/pnas.1010076108

Mooses, K., Mägi, K., Riso, E.-M., Kalma, M., Kaasik, P., & Kull, M. (2017). Objectively measured sedentary behaviour and moderate and vigorous physical activity in different school subjects: A cross-sectional study. *BMC Public Health*, *17*(1), 108. https://doi.org/10.1186/s12889-017-4046-9

Mullender-Wijnsma, M. J., Hartman, E., De Greeff, J. W., Doolaard, S., Bosker, R. J., & Visscher, C. (2016). Physically Active Math and Language Lessons Improve Academic Achievement: A Cluster Randomized Controlled Trial. *Pediatrics*, *137*(3), e20152743. https://doi.org/10.1542/peds.2015-2743

Núñez, R. (2006). Do Real Numbers Really Move? Language, Thought, and Gesture: The Embodied Cognitive Foundations of Mathematics. In R. Hersh (Ed.), *18 Unconventional Essays on the Nature of Mathematics* (pp. 160–181). Springer-Verlag. https://doi.org/10.1007/0-387-29831-2_9

Otero, M. A., & Lafuente Fernández, J. C. (2022). Análisis del trabajo de contenidos matemáticos desde el área de Educación Física en Educación Primaria (Analysis of the work of mathematical contents from the area of Physical Education in Primary Education). *Retos*, *45*, 224–232. https://doi.org/10.47197/retos.v45i0.92365

Rasberry, C. N., Lee, S. M., Robin, L., Laris, B. A., Russell, L. A., Coyle, K. K., & Nihiser, A. J. (2011). The association between school-based physical activity, including physical education, and academic performance: A systematic review of the literature. *Preventive Medicine*, *52 Suppl 1*, S10-20. https://doi.org/10.1016/j.ypmed.2011.01.027

Reed, J. A., Einstein, G., Hahn, E., Hooker, S. P., Gross, V. P., & Kravitz, J. (2010). Examining the Impact of Integrating Physical Activity on Fluid Intelligence and Academic Performance in an Elementary School Setting: A Preliminary Investigation. *Journal of Physical Activity and Health*, *7*(3), 343–351. https://doi.org/10.1123/jpah.7.3.343

Sahlberg, P. (2011). Paradoxes of educational improvement: The Finnish experience. *Scottish Educational Review*, *43*(1), 3–23. https://doi.org/10.1163/27730840-04301002

Sallis, J. F., McKenzie, T. L., Kolody, B., Lewis, M., Marshall, S., & Rosengard, P. (1999). Effects of Health-Related Physical Education on Academic Achievement: Project SPARK. *Research Quarterly for Exercise and Sport*, *70*(2), 127–134. https://doi.org/10.1080/02701367.1999.10608030

Schleicher, A. (2019). *PISA 2018: Insights and Interpretations* (https://www.oecd.org/pisa/PISA%202018%20Insights%20and%20Interpretations%20FINAL%20PDF.pdf). OECD. https://www.oecd.org/pisa/PISA%202018%20Insights%20and%20Interpretations%20FINAL%20PDF.pdf

Shephard, R. J. (1997). Curricular Physical Activity and Academic Performance. *Pediatric Exercise Science*, *9*(2), 113–126. https://doi.org/10.1123/pes.9.2.113

Shephard, R. J., Lavallée, H., Voile, M., LaBarre, R., & Beaucage, C. (1994). Academic Skills and Required Physical Education: The Trios Rivieres Experience. *CAHPER Research Supplement*, *1*, 1–12.

Sibley, B. A., & Etnier, J. L. (2003). The Relationship between Physical Activity and Cognition in Children: A Meta-Analysis. *Pediatric Exercise Science*, *15*(3), 243–256. https://doi.org/10.1123/pes.15.3.243

Sneck, S., Viholainen, H., Syväoja, H., Kankaapää, A., Hakonen, H., Poikkeus, A.-M., & Tammelin, T. (2019). Effects of school-based physical activity on mathematics performance in children: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity*, *16*(1), 109. https://doi.org/10.1186/s12966-019-0866-6

Snyder, K., Dinkel, D. M., Schaffer, C., Hively, S., & Colpitts, A. (2017). Purposeful Movement: The Integration of Physical Activity into a Mathematics Unit. *International Journal of Research in Education and Science*, *3*(1), 75–87. https://digitalcommons.unomaha.edu/hperfacpub/20/

Vetter, M., O'Connor, H., O'Dwyer, N., & Orr, R. (2018). Learning "Math on the Move": Effectiveness of a Combined Numeracy and Physical Activity Program for Primary School Children. *Journal of Physical Activity and Health*, *15*(7), 492–498. https://doi.org/10.1123/jpah.2017-0234

WHO - World Health Organization. (2019). *Guidelines on physical activity, sedentary behaviour and sleep for children under 5 years of age*. World Health Organization. https://iris.who.int/handle/10665/311664

WHO - World Health Organization. (2020). *WHO guidelines on physical activity and sedentary behaviour*. World Health Organization. https://www.who.int/publications/i/item/9789240015128

Wilson, M. (2002). Six views of embodied cognition. *Psychonomic Bulletin & Review*, *9*(4), 625–636. https://doi.org/10.3758/bf03196322