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Original article

Impact of physical exercise on the cardiovascular and respiratory systems: a systematic review in the educational context

Impacto del ejercicio físico en los sistemas cardiovascular y respiratorio: revisión sistemática en el contexto educativo

Impacto do exercício físico nos sistemas cardiovascular e respiratório: revisão sistemática no contexto educacional

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ABSTRACT

The positive impact of physical exercise on the prevention of cardiopulmonary diseases and overall well-being is widely documented in the literature. However, its integration into educational contexts is a topic that has received little attention. Therefore, the objective of this article was to analyze the impact of physical exercise on the cardiovascular and respiratory systems from a pedagogical

Translated from the original in Spanish

perspective. To this end, a systematic review was conducted in the Scopus database, following the Preferred Reporting Items for Systematic Review (PRISMA) guidelines. Studies were selected using the Population, Intervention, Comparison, and Outcomes (PICO) criteria and analyzed with bibliometric and thematic tools. The results showed how physical exercise improves cardiorespiratory function, especially in clinical populations. Technopedagogical, biomedical, and contextual trends were identified. In all of these, a disconnect between biomedical and pedagogical disciplines was evident. In this way, physical exercise was a valuable tool for teaching physiological processes and its impact on reducing cardiopulmonary symptoms was remarkable.

Keywords: physical exercise; health education; biomedical metrics; pedagogy; systematic review.

RESUMEN

El impacto positivo del ejercicio físico en la prevención de enfermedades cardiopulmonares y bienestar general es ampliamente documentado en la literatura. Sin embargo, su integración en contextos educativos es un tema poco abordado. Es por ello que, el objetivo de este artículo fue analizar el impacto que tiene el ejercicio físico en los sistemas cardiovascular y respiratorio, desde una perspectiva pedagógica. Para ello, se realizó una revisión sistemática en la base de datos de Scopus, de acuerdo a la normativa Preferred Reporting Items for Systematic Review (PRISMA). Se seleccionaron estudios mediante criterios Population, Intervention, Comparison and Outcomes (PICO) y se analizaron con herramientas bibliométricas y temáticas. Como resultado, se evidenció cómo el ejercicio físico mejora la función cardiorrespiratoria, especialmente en poblaciones clínicas. Se identificaron tendencias tecnopedagógicas, biomédicas y contextuales. En todas ellas, se evidenció una desintegración hasta el momento entre las disciplinas biomédicas y pedagógicas. De esta forma, el ejercicio físico fue una herramienta valiosa para enseñar procesos fisiológicos y su impacto en la reducción de síntomas cardiopulmonares, a su vez, fue notable.

Palabras clave: ejercicio físico; educación en salud; métricas biomédicas; pedagogía; revisión sistemática.

RESUMO

O impacto positivo do exercício físico na prevenção de doenças cardiopulmonares e na promoção do bem-estar geral é amplamente documentado na literatura científica. No entanto, sua integração em contextos educacionais permanece pouco explorada. Este estudo teve como objetivo analisar os efeitos do exercício físico sobre os sistemas cardiovascular e respiratório sob uma perspectiva pedagógica. Foi realizada uma revisão sistemática na base de dados Scopus (20202024), seguindo as diretrizes do Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Quinze estudos foram selecionados com base nos critérios Population, Intervention, Comparison and Outcomes (PICO) e analisados por meio de ferramentas bibliométricas e temáticas. Os resultados evidenciaram que o exercício físico melhora significativamente a função cardiorrespiratória, especialmente em populações clínicas. Foram identificadas tendências tecno-pedagógicas, biomédicas e contextuais. Em todas as dimensões, observou-se uma desarticulação persistente entre as disciplinas biomédicas e pedagógicas. Dessa forma, o exercício físico revelou-se uma ferramenta pedagógica valiosa para o ensino de processos fisiológicos, com impacto notável na redução de sintomas cardiopulmonares.

Palavras-chave: exercício físico; educação em saúde; métricas biomédicas; pedagogia; revisão sistemática.

INTRODUCTION

Physical exercise contributes to the prevention of chronic diseases and to overall well-being, with solid evidence in the medical literature (Ciolac *et al.,* 2020; Samuel *et al.,* 2020). According to Rhodes *et al.* (2020), its application in educational settings for teaching the cardiovascular and respiratory systems has received less attention, despite its didactic potential.

Therefore, physical activity allows for the direct observation of physiological responses, such as changes in heart rate or ventilation, which facilitates the link between theory and practice (Bouvière et al., 2021). This approach aligns with pedagogical models that prioritize sensory experience for knowledge retention (Quinn *et al.,* 2021; Moyers & Hagger, 2023).

Scientific evidence confirms that physical activity improves both cardiovascular health and certain cognitive functions related to learning (Athanasiou *et al.,* 2022; Ibeas *et al., 2021).* However, most existing reviews focus on medical or sports applications, without exploring its integration into educational contexts (Aygün & Çakýr-Atabek, 2021). This omission hinders the development of practical methodologies that link physiological benefits with school dynamics.

According to Kania *et al.* (2024), Lee (2023) Bracho-Fuenmayor *According to et al.* (2024), the integration of biomedical technologies into educational settings is progressing slowly. Devices such as portable spirometers or cardiac monitors, common in laboratories, are rarely incorporated into classrooms or teacher training (Harris & Kazdaðlý, 2024). The COVID-19 pandemic exposed deficiencies in practical health education, even in established educational systems (Avendaño-Porras). *et al.,* 2022; Díaz-Téllez *et al.,* 2022; Pacheco-Velazquez *et al.,* 2023). This lag is concerning given the increase in sedentary behavior among children and its association with respiratory and metabolic disorders (Barabás & Germán-Salló, 2022; Love *et al.,* 2022; Webster, 2020). This study analyzes the integration of physiological data from exercise into educational strategies. Existing literature prioritizes health indicators but omits their pedagogical application. Therefore, this article aims to analyze the impact of physical exercise on the cardiovascular and respiratory systems from a pedagogical perspective.

MATERIALS AND METHODS

A quantitative research paradigm was adopted, with a systematic review design, in accordance with the Preferred Reporting Items for Systematic Review (PRISMA) guidelines. Under this approach, the aim was to analyze the impact of physical exercise on cardiovascular and respiratory systems from a pedagogical perspective.

Selection of studies

Inclusion and exclusion criteria

The criteria for fit and relevance to the research were framed within the PICO guidelines. This was selected due to its educational research approach and the possibility of quantitative synthesis of the results (Table 1).

Table 1. Inclusion and exclusion criteria according to PICO

PICO criteria	Determinants
Population	Studies addressing the topic in populations of students, teachers, or curricular programs were selected
Intervention	Research that designs or implements pedagogical strategies based on physical exercise
Comparison	Studies that synthesize the advantages of traditional and innovative methods in teaching physical exercise
Outcomes	Research presenting results related to improvements in learning, adherence, or physiological awareness

Source: Own elaboration

The literature search was conducted in the SCOPUS database. This platform was selected for two reasons documented in the literature: its broad academic coverage and its focus on peer-reviewed studies, which ensures rigor and quality. The following search formula was used: [TITLE-ABS-KEY (physical AND exercise) AND TITLE-ABS-KEY (cardiovascular AND system) AND TITLE-ABS-KEY (respiratory AND system) AND TITLE-ABS-KEY (health AND education)].

The texts were filtered within a time range spanning 2020 to 2024 to ensure that the data studied were recent and relevant. Furthermore, priority was given to texts published in English and with the structure of an original article.

Selection procedure

The research selection process was carried out according to the flowchart recommended by the PRISMA guidelines, as shown in Figure 1. This selection was made using pre-established inclusion and exclusion criteria. A comprehensive search was performed in the selected database (Scopus). In this initial search, 224 studies were identified, and 21 studies were excluded based on the previously established inclusion and exclusion criteria for bibliometric analysis. Finally, 203 studies were selected for bibliometric analysis after reviewing the titles and abstracts of the other 203 studies. Subsequently, based on the analysis of the most cited publications, 20 studies were selected for

analysis in the map of relevant publications. At the end of this phase, after removing five studies due to their theoretical relevance, 15 studies were returned to the map of relevant research (Figure 1).

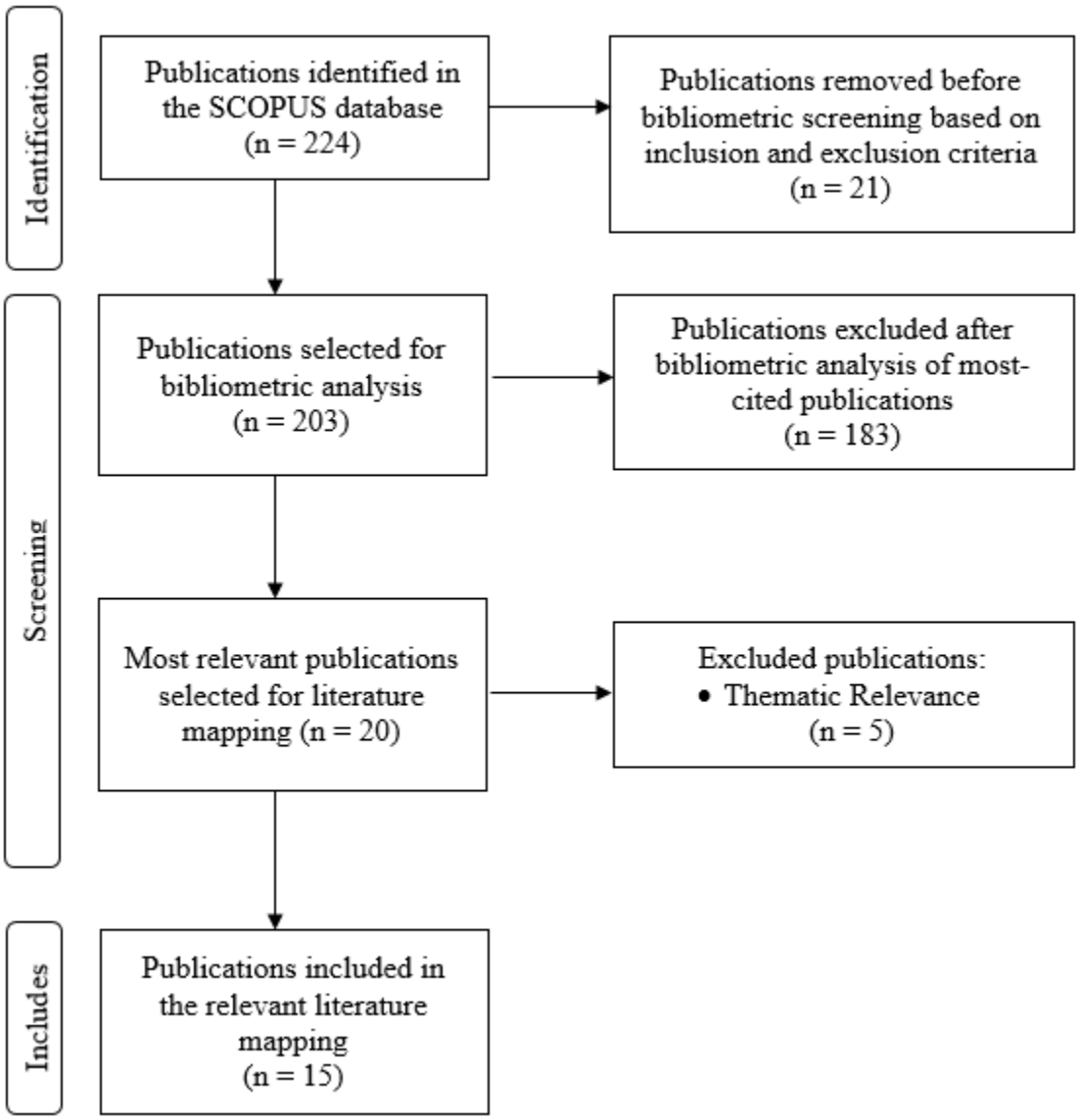

Figure 1. Flowchart for study selection

Source: Authors' elaboration based on the recommendations of Page *et al.* (2021)

Data extraction and analysis

The bibliometric analysis of the studies was conducted using the Bibliometrix and VOSviewer tools. Both proved to be essential for carrying out quantitative analyses of scientific literature, as highlighted by Moral-Muños *et al.* (2020). Data on institutions, countries, and collaborative networks were collected from a health education and educational policy perspective. Finally, for the thematic analysis of the research, an extraction matrix with three dimensions of analysis was designed.

RESULTS

Bibliometric analysis

Temporal frequency of publications

The data showed a fluctuating trend in annual documentary production on the study topic, as shown below in Figure 2. The year 2021 recorded the highest number of publications (47 documents), with a significant peak that exceeded the base year 2020 (33 documents) by 42% (Figure 2).

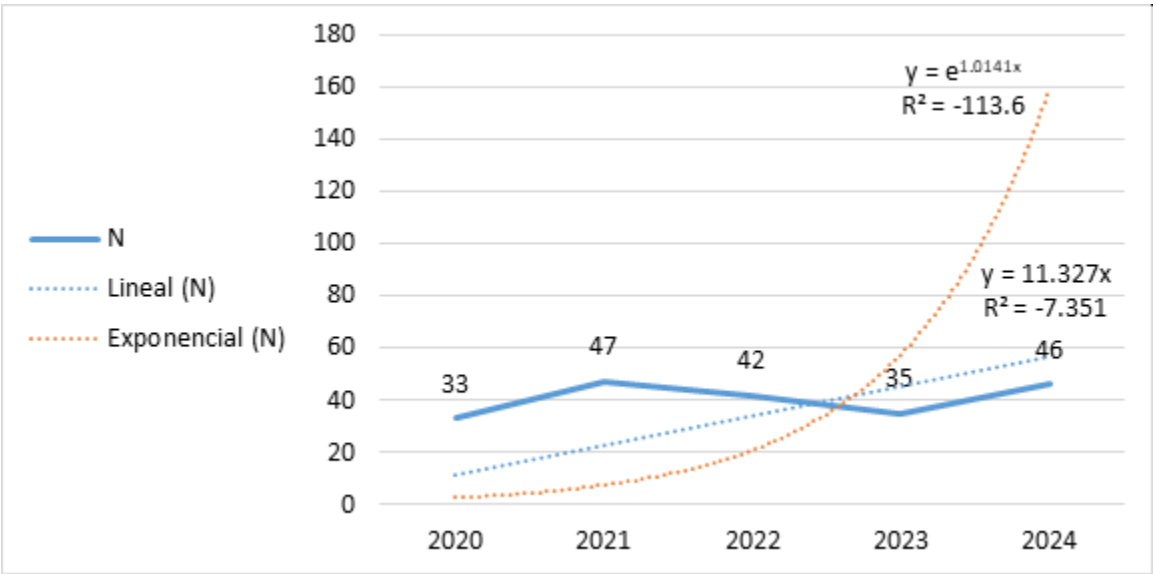

Figure 2. Temporal distribution of publications
Source: Own elaboration

However, this growth was not sustained in subsequent years, as a progressive decline was observed in 2022 (42 documents, -11%) and 2023 (35 documents, -17% compared to 2022). These data, viewed from a temporal and analytical/evolutionary perspective, suggested a possible temporary saturation in this area of study. In 2024, however, a notable recovery (46 documents) in academic interest in this particular topic was observed.

The analysis of trend models showed that the exponential equation ($y = e1.0141x$) and the linear equation ($y = 11.327x$) were statistically invalid, with negative R^2 values (-113.6 and -7.351, respectively). These data supported the argument that publications did not follow a uniform growth pattern, suggesting they may be responding to more complex dynamics that influence scientific output.

Collaboration networks by country

Figure 3 presents the collaboration networks among the leading countries in scientific production on the topic. For further understanding, the ten most productive countries are presented in Figure 4, to facilitate their analysis (Figure 3).

Figure 3. Mapping of collaborations between countries
Source: Authors' elaboration based on VOSviewer data

The presence of consolidated networks was observed in English-speaking countries, with the United States leading in scientific production, with 25 documents and a collaboration intensity of 35. The United Kingdom came in second, with 23 documents and a collaboration intensity of 32. (Figure 4)

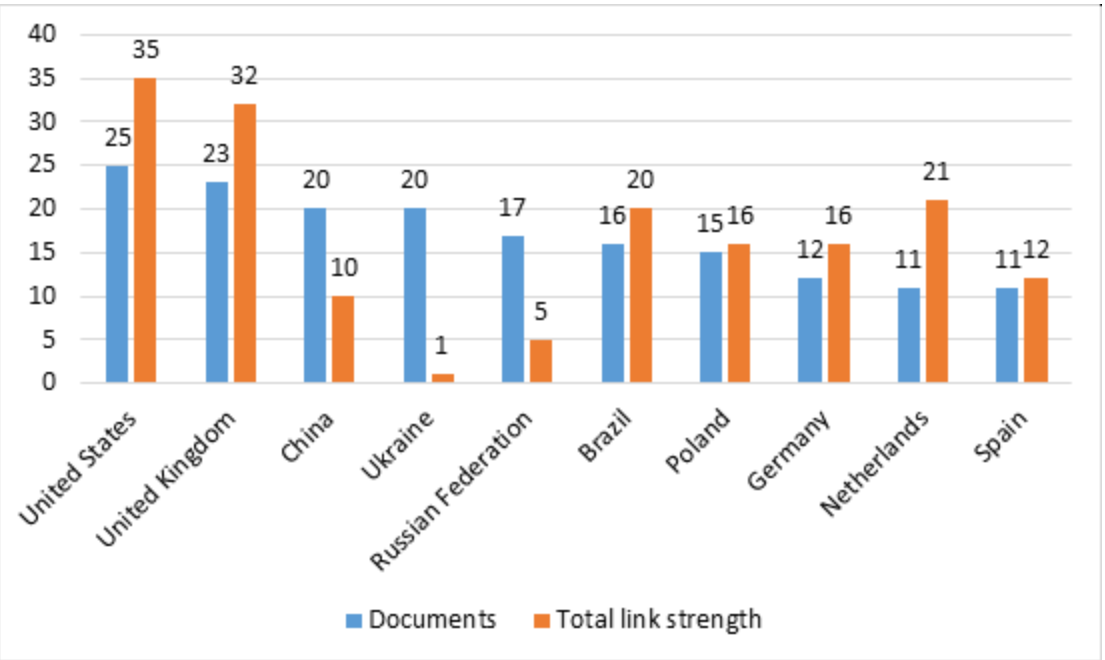

Figure 4. Distribution of documents and intensity of collaborations by country
Source: Own elaboration

Based on these data, three main collaboration clusters were identified (Figure 5). These were organized around collaborations between countries and also the themes that these geographical groups addressed in relation to the object of our research.

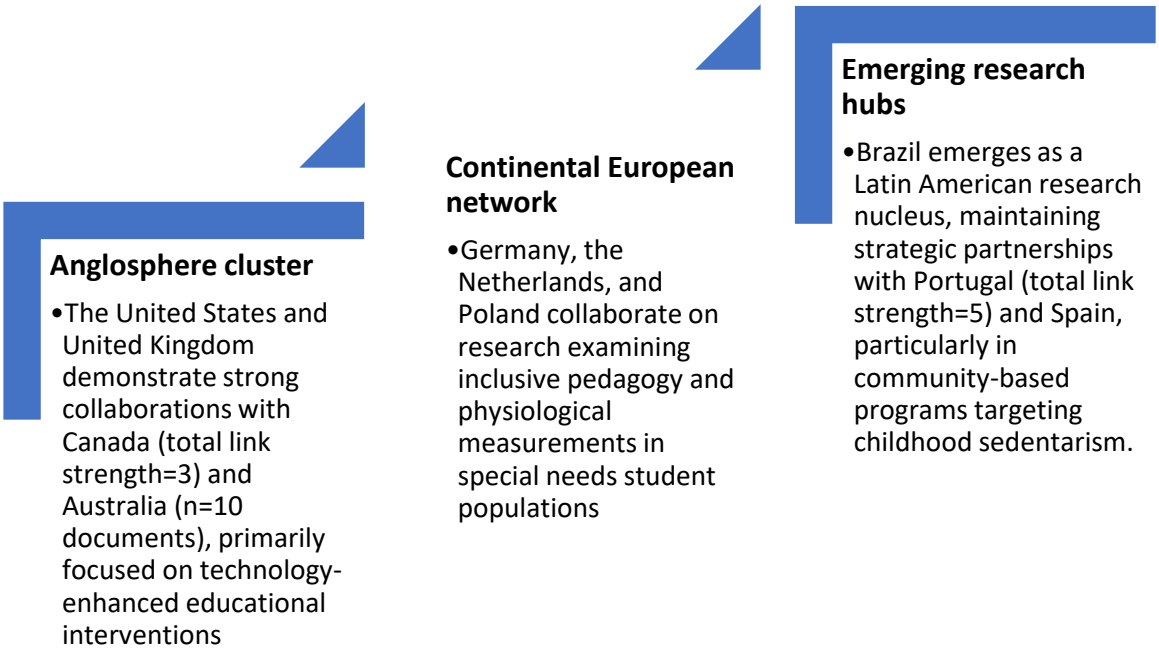

Figure 5. Main collaboration clusters

Source: Own elaboration

The cases of China and Ukraine revealed an interesting pattern; these nations, with 20 documents each, showed a low index (10) of collaborative intensity, or rather, focused on local research without global integration. On the other hand, the Netherlands had only 11 documents yet demonstrated a higher collaborative intensity (21) than leading countries like Brazil or Germany.

Citation patterns

Of the total documents analyzed, only 154 accumulated citations (see Figure 6). Based on this data, 2113 citations were observed, with an h-index of 19. In 2020, 41 citations were recorded, a figure that tripled in 2021 (133 citations) and increased sixfold in 2022 (257 citations). This upward trend intensified significantly in 2023 (493 citations) and reached its peak in 2024 (797 citations).

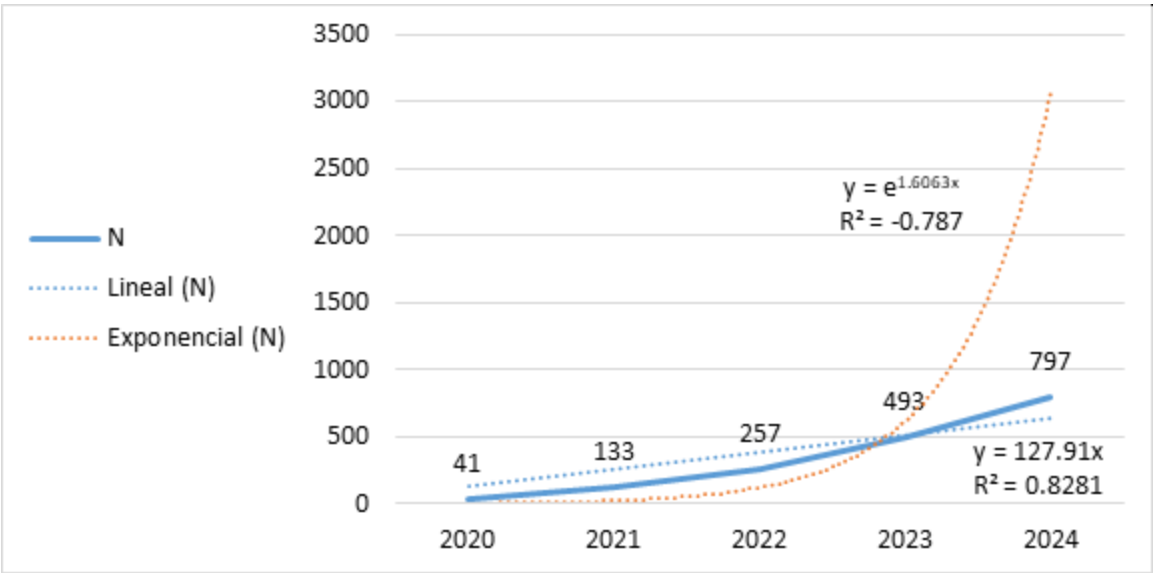

Figure 6. Annual distribution of citation patterns
Source: Own elaboration

Additionally, the linear equation (y = 127.91x) showed a high degree of fit (R^2 = 0.8281), indicating that growth follows an approximately linear trend with an average increase of approximately 128 citations per year. This model adequately explained 82.81% of the observed variability. On the other hand, the exponential equation (y = e1.6063x) showed a poor fit (R^2 = -0.787), implying that this model was not suitable for describing the trend, despite the apparent exponential growth of the raw data. This indicated that the behavior of citations over the years was better suited to a linear growth pattern than an exponential one.

Co-occurrence of keywords and trends in literature

The keyword co-occurrence analysis identified three thematic areas specifically linked to physiology and medicine. These areas: *exercise* (111 occurrences), *physical activity* (95), and *cardiorespiratory fitness* (31), had a combined link strength exceeding 2,500. Furthermore, the centrality of these three thematic areas was related to the quantification of organic effects associated with these variables, as evidenced by the categories of *blood pressure* (27) and *oxygen consumption* (45).

On the other hand, although this research was focused on the educational applications of physical exercise, it was observed that *education* (4), *health education* (3) and *physical education* (9)

presented marginal occurrences, with link strengths lower than 100. This indicated, in the authors' inference, that the physiological data of physical education were poorly contextualized in the pedagogical curricula.

Factor analysis corroborated the data on the co-occurrence of keywords, primarily in clinical and adult populations (see Figure 7), thus confirming the scarcity of research in educational contexts identified in the previous analysis. The terms described in this analysis grouped into a single cluster. However, the distribution across the factor dimensions allowed for the identification of two dimensions within the conceptual network (Figure 7).

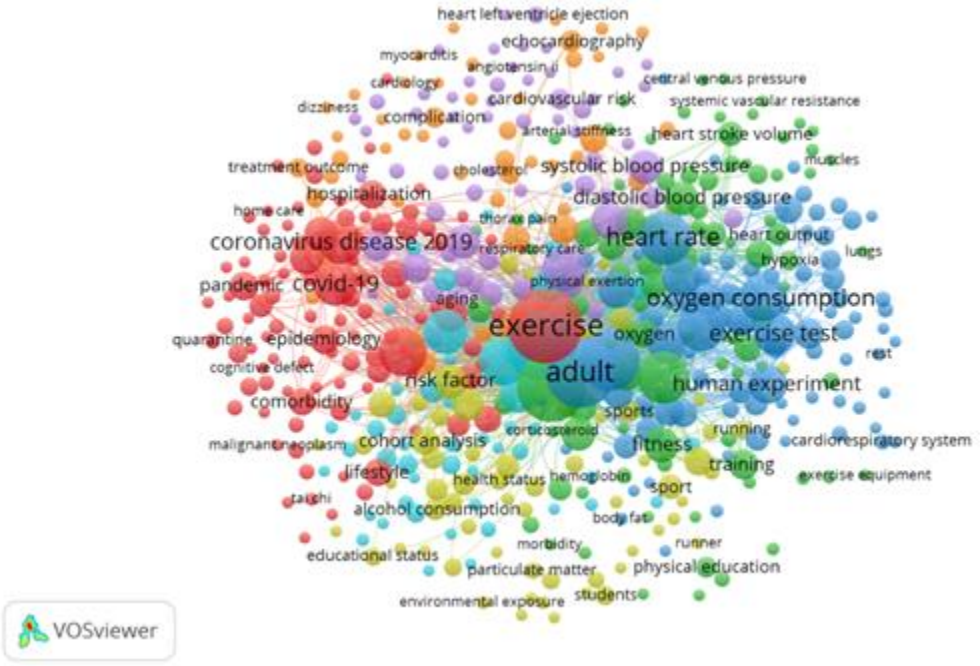

Figure 7. Keyword co-occurrence network
Source: Authors' elaboration based on VOSviewer data

Included studies

To analyze the effect of physical exercise on the cardiovascular and respiratory systems from a pedagogical perspective, a filtering process was carried out to identify the 15 most cited documents in the literature, which were then evaluated by experts for inclusion in this research. Based on these

data, an analysis of the results of each study was performed, using the thematic analysis matrix presented in table 2.

Table 2. Classification of the most cited documents according to PICO criteria

Code	Population	Intervention	Comparison	Results
E1	502,490 adults from the UK Biobank	Consumption of different types and quantities of alcohol	Comparison between safe and unsafe doses	U-shaped relationship with mortality and CVD; inverse association with CKD
E2	60 pregnant women in the first/second trimester	Exercise combined with cognitive-behavioral therapy	Standard prenatal education	Anxiety reduction, improvement in physical and psychological quality of life
E3	35 women aged 21-35	Barre-fitness training	Fitness dance classes	Improvement in morphofunctional parameters (except hip circumference and blood pressure)
E4	419 patients with COPD	8-week home pulmonary rehabilitation program	Presence/absence of comorbidities	Improvement in exercise capacity and quality of life sustained for one year
E5	Patients with multiple chronic diseases	Personalized 6-month MultiPill-Exercise Program	Not applicable (pilot without control group)	Increased weekly exercise time, improved VO2 max and leg strength
E6	22 female university students (19-21 years old)	Aerobic exercise program	Traditional physical education program	Improvement in cardiorespiratory function measured with specific tests

E7	Patients with non-communicable diseases	Social media-based interventions	Not applicable (systematic review)	Significant improvements in exercise behavior in four out of five RCTs
E8	University students	Literature review on physical exercise	Not applicable (narrative review)	Proposals to improve exercise promotion policies
E9	200 patients with congenital heart disease (13-25 years old)	Transition education program	Group without intervention	Protocol for evaluating health-related quality of life
E10	190 patients with post-pulmonary embolism syndrome	Eight-week pulmonary rehabilitation program	Standard medical care	Protocol to assess physical capacity, dyspnea and quality of life
E11	91 patients with COPD	24-week Tai Chi program	Group hike and standard service	Greater improvement in the walking test and quality of life parameters
E12	Young adults from the Moscow region	Regular physical activity	Not applicable (observational study)	Increased lung capacity and fitness levels
E13	87 male university students	Physical education based on football	Traditional methods of physical education	Improvement in somatic health and emotional state in the experimental group
E14	Students with special medical needs	Methodological framework for heterogeneous physical education classes	Not applicable (methodological study)	Proposed structure for inclusive physical education

E15	34 female university students (17-19 years old)	Adapted method of physical education	Comparison between subgroups	Significant improvements in endurance, coordination, and cardiovascular function

Source: Own elaboration

Technopedagogical trends

Up to this point, it was observed that a high frequency of the selected texts alluded to integrating technological advantages into pedagogical methodologies to enhance the benefits of physical exercise (see Table 2); this was the case with E2. These authors demonstrated that combining physical exercise with cognitive behavioral therapy (CBT), especially during pregnancy, significantly reduced anxiety and improved quality of life. They also highlighted the importance of psychological strategies in physical activity programs.

E7, for its part, emphasized that interventions carried out through social media were effective in promoting exercise among patients with non-communicable diseases. However, they acknowledged the limited impact of these interventions on dietary adherence. This, in the opinion of the authors of this study, indicated that digital environments as pedagogical tools for promoting healthy habits warranted more comprehensive approaches.

In parallel, E9 and E10 emphasized the importance of transitional education programs and pulmonary rehabilitation (respectively). For these two groups of authors, therapeutic education offered advantages by improving autonomy and clinical outcomes, especially in populations with congenital heart disease or post-pulmonary embolism syndrome (Table 3).

Table 3. Techno-pedagogical trends identified

Techno-pedagogical trends	Improvement strategies
Hybrid interventions: psychopedagogy and movement	**E2:** Psychological strategies amplified the physiological effects of exercise by addressing emotional barriers (e.g., fear of movement in pregnant women). **E4:** CBT-based pedagogy could be adapted to other populations to improve adherence and self-efficacy.
Digital environments as pedagogical spaces	**E7:** Social media platforms function as virtual classrooms for health education, but they require a multidimensional design. **E7:** The digital divide and information overload demanded more structured digital curricula, potentially incorporating artificial intelligence (AI) for content personalization.
Transitional and self-management education programs	**E9-10:** Mobile applications for monitoring physiological parameters (e.g., heart rate), linked to educational workshops on respiratory/cardiovascular anatomy. **E9-10:** Virtual simulators that teach patients to recognize warning signs during exercise, reinforcing their autonomy.
Limitations and opportunities	**E7:** The technological gap may exclude older adults or low-income populations. **E11:** Overly individualistic approach; collaborative models need to be explored (e.g., group virtual classrooms for rehabilitation, as suggested by the Tai Chi program in E11).

Source: Own elaboration

DISCUSSION

The results of this systematic review are consistent with previous evidence, such as The study by Grainger *et al.* (2020) associated physical exercise with improvements in cardiorespiratory fitness. However, most of the studies analyzed are limited to clinical or sports contexts, without addressing their integration into educational systems (Conaghan *et al.,* 2020; Morgan *et al.,* 2021). A relevant factor is the predominance of physiological variables (VO, max, blood pressure), to the detriment of methodologies that allow these findings to be applied in classrooms (Sánchez *et al.,* 2020).

Jankowski *et al.* (2021) demonstrate that technologies such as mobile spirometry and cardiac monitors have improved the measurement of biomedical parameters in experimental studies. However, bibliometric data reveal that these tools are not systematically incorporated into teacher training or school curricula (Galea *et al.,* 2020; Huang *et al.,* 2020). This disconnect reflects a gap between technological development and educational demands, likely due to limited collaboration between the biomedical and educational fields.

Current literature on exercise interventions in adolescents prioritizes clinical metrics, such as those reported by Yuen *et al.* (2021), but omits educational assessments. Rosales *et al.* (2024) addressed cognitive dimensions; however, none of the reviewed studies integrate tools to measure the transfer of results to educational settings. This gap hinders the development of programs that articulate physiological principles with concrete pedagogical applications.

The literature has extensively documented the benefits of exercise in education. However, in the authors' opinion, gaps remain in its practical application, particularly in the integration of biomedical technologies into school settings and in measuring their cognitive impact. An approach that combines physiological and pedagogical perspectives could optimize its use as a teaching resource.

Additionally, the results of this systematic review demonstrate that physical exercise can be used as an educational tool for teaching physiological processes. Recent studies show that physical activity, beyond its therapeutic benefits, facilitates the understanding of systems such as the cardiovascular and respiratory systems through direct experience (Belanger *et al.,* 2021; Jung *et al.,* 2022). This approach requires adapting physiological data to pedagogical contexts, prioritizing practical interaction over abstract theory (Jean-Gilles *et al.,* 2024; Moreira *et al.,* 2020). Furthermore, approaches such as situated learning reinforce the idea that bodily movement contributes to the assimilation of complex knowledge (Hahad *et al.,* 2021).

Hybrid interventions, such as the integration of physical exercise and cognitive-behavioral therapy, along with digital tools, have shown effectiveness in educational settings (García-Martínez *et al.,* 2021; Samuel *et al.,* 2020). Their implementation depends on contextual adaptations, as studies rule out universal models (Seiser & Portfelt, 2022). Tai Chi improves functional capacity in patients with COPD, but in school settings, it requires methodological adjustments that are appropriate to the psycho-developmental stage of the children (Gilliam *et al.,* 2021; Yang *et al.,* 2023).

The findings of this study highlight the need to integrate physical exercise into education systems. The data show that its impact depends on collaboration among schools, researchers, and policymakers (Alazmi & Alazmi, 2022; Sinnema *et al.,* 2020). A key step is adapting teacher training to include principles of physiology, along with practical teaching materials (Pacheco-Velazquez *et al.,* 2023). Furthermore, it is essential to consider the socioeconomic barriers that limit access to these practices (Quinn *et al.,* 2021; Moyers & Hagger, 2023). This approach could significantly improve health and learning outcomes.

This systematic review confirms that physical exercise improves cardiovascular and respiratory function. Despite this, the analyzed literature includes few references to pedagogical or educational strategies. Technology-based interventions, such as digital platforms, increase treatment adherence, but their use in educational settings is still infrequent. However, our research is not without limitations. This study is restricted to English-language research published between 2020 and 2024, which excludes previous contributions or those in other languages. The low representation of pedagogical studies in the sample reduces the applicability of the results to heterogeneous educational settings. It is recommended to incorporate non-English-language databases and employ mixed-methods approaches that complement bibliometric analysis with qualitative evidence to address the current limitations in integrating exercise into health education.

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Conflict of interest

Authors declare no conflict of interests.

Authors' contribution

The authors participated in the design and writing of the article, in the search and analysis of the information contained in the consulted bibliography.

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