INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY: APPLIED BUSINESS AND EDUCATION RESEARCH

2023, Vol. 4, No. 10, 3736 – 3765
http://dx.doi.org/10.11594/ijmaber.04.10.26

Research Article

A Comprehensive Bibliometric Analysis of School-Based Physical Activity Research

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Article history:
Submission October 2023
Revised October 2023
Accepted October 2023

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ABSTRACT

Physical activity has captured considerable interest from international academic scholars due to its fundamental role in maintaining optimal health. Thus, this study sought to examine the scholarly articles on school-based physical activity, employing a comprehensive bibliometric analysis extracted from the Scopus database spanning 2013 to 2023. A filtering protocol was utilized to guide the selection of articles, and analyses were facilitated solely by Python programming. This research yielded extensive insights encompassing document type, publication rates, citation rates, prevalent keywords, and geographic distribution. The results revealed the prominence of "Articles" as the primary document category. Notably, the year 2020 was observed as the highest publication count, with 2014 being the peak year for citation rates. However, both publication and citation patterns exhibited substantial fluctuations. These analyses collectively identify the United States as the largest contributor among the top ten countries, accompanied by substantial contributions from European nations. The analysis of the top 50 most-cited journal articles indicates a prevalence of articles authored by one to five individuals, with a peak in publications during 2014, followed by a gradual decline. Notably, the keyword "children" prominently emerges across the datasets, underscoring its frequent utilization in the context of school-based physical activity research.

Keywords: *Bibliometric analysis, Physical activity, Python programming*

How to cite:
Dofredo, K. H., Pinlac, J. T., Pineda, K. R., Gatus, L. L., Briñas, N. N. N., Miranda, J. P. P., & Tolentino, J. C. G. (2023). A Comprehensive Bibliometric Analysis of School-Based Physical Activity Research. *International Journal of Multidisciplinary: Applied Business and Education Research*. *4*(10), 3736 – 3765. doi: 10.11594/ijmaber.04.10.26

Introduction

Physical activity (PA) is described as all physical movement that involves the usage of energy and engages the skeletal and muscular systems (World Health Organization [WHO], 2019). The international guidelines for physical activity recommend that adolescents should engage themselves in at least 60 minutes of moderate-intensity to vigorous-intensity physical activity (MVPA) daily (WHO, 2010). Carson et al. (2013) suggested that light-intensity activities can provide a beneficial addition to the current 60 minutes per day of MVPA recommendation. Globally, almost 23% of adults worldwide and 80-81% of adolescents aged between 11 to 17 years fail to meet the global physical activity recommendations of WHO (Guthold et al., 2020; WHO, 2019). As more people realize the importance of PA, government and professional organizations are releasing recommendations and guidelines (Pate & O'Neill, 2012). For young children, it was proposed in the USA by the National Association for Sport and Physical Education (NASPE, 2011) that children of preschool age should participate in several hours of unstructured playtime and at least 60 minutes of structured PA daily. Likewise, the American Heart Association (AHA, 2014) recommends that children ages two and older should engage in a minimum of 60 minutes of moderate-intensity activity daily.

As individuals' awareness of the significance of engaging in physical activity grows in promoting good health and preventing diseases associated with a sedentary lifestyle, such as obesity, there is a growing concern that physical education classes in schools worldwide may not provide enough actual physical activity opportunities for students to engage in (United Nations Educational Scientific Cultural Organization [UNESCO], 2013).

From the Asian perspective, Muller et al. (2013) revealed that only 14 out of 48 countries have published data regarding the physical activity prevalence among Asian school-aged children and adolescents, showing that a significant proportion of Asian children did not meet the recommendations for physical activity. Similarly, Wang et al. (2021) discovered that adolescent females lack physical activities compared to their male counterparts in Bangladesh, India, Myanmar, the Philippines, and Vietnam. Moreover, Satija et al. (2018) stated that males are more culturally and socially accepting of participation in formal, organized sports and group physical activities. Also, Tolentino et al. (2022) found the need to facilitate more PA programs even among visually-impaired learners.

Physical activity is now becoming more significant in the promotion of longevity and health of the public in most established and developing countries worldwide (Danaei et al., 2009). PA is important for the improvement and development of children, and it plays a vital role in promoting their current and future health. Schools have been considered the primary institutions in promoting physical activity for young people to be active (Cale & Harris, 2006; Chow et al., 2015). In the Philippines, almost all Filipino children aged five and older typically spend five hours per day of their weekdays at school, making this an essential setting for the promotion of physical education (Gonzalez-Suarez & Grimmer-Somers, 2009). Carson et al. (2014) stated that various strategies for promoting youth physical activity have been advocated, including multi-faceted and school-based approaches. Furthermore, Dobbins et al. (2013) suggested that continuous evidence implementation of PA interventions in school must be conducted at this moment, considering the positive impacts on behavior and improvement for one's physical health status measurement.

In the study of Malm et al. (2019), it was stated that engaging children in sports and various higher levels of PA has a huge impact on their daily lives. It was also affirmed by Robertson-Wilson et al. (2012) that the current levels of PA among youth are shallow. One approach to encourage children to engage in more PA is school-based programs. One of the reasons is that most schools have many resources, personnel, and facilities required for successful PA promotion that may not be present in the home or community (Carson et al., 2014). Stakeholders admit that the PA will increase the academic achievement, academic performance, and motivation of the students if they participate actively in school (Engin & Ege, 2020).

As reported by the United Nations Children's Fund (UNICEF), around one (1) billion students from all over the world attend school on any given day of the week. Children spend more of their time at school than anywhere else outside their homes, making it a great place to provide them with high-quality physical activity and opportunities for an active school day (WHO, 2022). Students have the right to participate in physical activity and understand how this affects their well-being. Through their demonstrations of the benefits of an active lifestyle, they encourage others to participate in sports, dance, exercise, recreation, and adventurous activities (Stothart, 2011).

The physical education research area and its scope of physical activity have been broadened recently. The physical activity of school pupils was identified as a limited area but had the most attractive attention in academia (Tomanek & Lis, 2020). Moreover, Gill et al. (2013) stated that PA must have a contribution in reaching a quality of life (QoL). PA improves the quality of life, as a result of having a positive cycle, self-reliance, and motivation.

In addition, de Vet et al. (2011) discovered in their studies that several physical activities occur outside of the house, such as commuting, playing outside, and taking sports classes—thus minimizing the influence of the environment at home. Lee et al. (2021) stated that in recent times physical activity publications have increased, as shown in the previous works as well as the descriptive studies dominating the literature but with lesser studies related to interventions and dissemination. Moreover, various interventions in physical activity are probably ready for dissemination, and strategies as the emphasis on disseminating evidence-based physical activity has increased recently (Lewis et al., 2017).

Physical activity can have a direct intellectual impact if children are actively engaged in activities that include cognitive control (Marques et al., 2018). Increasing research studies indicate that physical activity has a positive impact on both academic and cognitive performance (Alvarez-Bueno et al., 2017). Based on prior studies on children and adolescents, students who are active in physical activity perform more successfully in school (Wunsch et al., 2021). The efficacy of physical activity in enhancing cognitive function as well as learning indicates that PA may have an advantageous effect on children's and adolescents' academic performance (Bueno et al., 2021).

Following the findings, a higher level of physical activity has been scientifically connected to being more efficient in executing activities in school (Greco et al., 2023). The intervention program found that having a supportive family setting can help to increase the levels of physical activity with significant improvements in various kinds of psychosocial and physical aspects (Nyberg et al., 2020). There is an alteration in personal preferences for specific situations like individual and group activity, which produce different types of enjoyment that are connected to the effects of physical activity on mental health (Burnet et al., 2019; Teychenne et al., 2020). Furthermore, Vaghetti et al. (2018) stated that other than appropriate settings, perceived enjoyment during PA is regarded as an important factor for childhood PA participation and retention. It indicates that the most often mentioned intrinsic motivator for children to engage in PA is enjoyment (Crane & Temple, 2015). PA can be seen as more enjoyable when children are encouraged to try different kinds of tasks or differentiate familiar exercises (Lakicevic et al., 2020). Most children attend schools with at least two opportunities to promote PA: physical education classes and break time. However, some schools needed to provide more implementation of regulations to increase PA engagement in either setting (Hayes & Van, 2015). On the other hand, Lounsbery et al. (2019) found that limited time is the main barrier to PA in schools, and programs with no particular outcomes are allocated less time. School leaders from various levels should be involved when implementing PA policy and practice. The inclusion of measurable PE outcomes in policies may act as a stimulus for program improvement.

The term "physical education" refers to the engagement in some physical activities that can be applied generally over some time. It also says that in history, elementary schools have reshaped physical education several times. In earlier years, physical education in the United

States had no proper guide for providing processes. White et al. (2018) stated that despite any reasons, every student in secondary education is more active and engaged in different types of physical activities. Individuals should promote good health to maintain a physically active lifestyle (Ganaden, 2019). In school-related PA, the effect was mainly seen, but it was often not observed and assessed outside of school.

Throughout the 20th century, promoting activities and physical fitness to American children has also promoted emotional, social, and intellectual development through physical activity. However, the United States is focused on increasing academic achievement and decreasing opportunities for physical activity in schools (Howie & Pate, 2012).

P.E. teachers suggested creating engaging lesson content to make high school students feel that this is something essential and to uplift their engagement in after-school physical activities (Gonzalez-Serrano et al., 2022). The study by Beni et al. (2017) stated that secondary students are focused on participating in physical activities because they have fun interacting with other students. However, only a small percentage of Filipinos engage in regular exercise despite the numerous research studies that have shown the advantages of exercise and physical activity on psychological and physical health (Cagas et al., 2015).

According to Carballo-Fazanes et al. (2020), most university students enrolled in physical education courses enjoy PA, and through engaging in PA, they can also easily find out whether their lifestyle is healthy or unhealthy. Wallhead et al. (2014) revealed that students who enrolled in university put an effort to participate in physical activities, increased their enjoyment, and gained more knowledge. Students also enrolled in physical education classes for various reasons (i.e., general, physical, mental, social, and academic), and it was found that a greater number of females enrolled in fitness classes, whereas a greater proportion of males enrolled in sports courses (Lackman et al., 2015). Additionally, Kim and Cardinal (2017) claimed that college and university students attend physical activity classes primarily to improve their fitness and to exercise regularly. However, Cosic et al. (2018) indicated that females have less engagement in physical activity than males. Romaguera et al. (2011) stated that many social, environmental, and personal factors have significant effects on university students' physical activity practice. Personal factors of people not practicing physical activity are lack of time, and social factors include maternal educational level and physical activity habits.

Bibliometric analysis has been recognized as a useful tool in terms of assessing and analyzing scientists' output (Moral-Muñoz et al., 2020). In 1969, the term "bibliometrics" was first used by Pritchard. It refers to applying mathematical methods to literary works and other forms of communication that use mathematics and statistical techniques to quantify the distribution of productivity (Thirumagal & Mani, 2019). Bibliometrics has developed immediately and been technically excellent, along with the fast development of science. Also, the platforms' information, such as the references, keywords, research titles, and papers, as well as authors and organizations, serve as valuable examples for performing scientific evaluation research using bibliometric methods (Gutiérrez-Salcedo et al., 2018). Particularly, Donthu et al. (2020) stated that the bibliometric methodology has been used to provide annual reviews of articles like the Journal of Business Research, which typically happen in milestone years. Hence, Fu et al. (2013) stated that bibliometric analysis is a useful tool that can be used in numerous published research papers conducted worldwide to offer a potential direction for ongoing and future studies. Bibliometric reviews use quantitative analysis and statistics to explain how articles are distributed within a particular topic, field, institution, and nation and can also provide more thorough analyses to show the development trends or purpose of particular research fields (Zhang et al., 2017). Furthermore, Quintero-Quintero et al. (2021) stated that a bibliometric analysis accumulates and evaluates quantitative bibliographical information collected via published research papers. Fahimnia et al. (2015) stated that bibliometric analysis acts as an analytical measure-

ment of the key authors who have been published in a particular journal, the number of citations of specific papers and other publications, the most important topic, and it can also include an analysis of co-citations. Additionally, the significance of bibliometric analysis lies in its ability to enable researchers to analyze the citation trend, which allows them to recognize relationships between the area of interest and other research disciplines (Ratten et al., 2020). Bibliometric analysis is a widespread tool that has a huge impact in terms of doing research (Ellegaard & Wallin, 2015). Further, Linnenluecke et al. (2019) stated that bibliometric analysis can be potentially used in research, and through bibliographic mapping tools, researchers are influenced to map informative publications about the field of research. In the study of Zhou et al. (2007), the bibliometric analysis serves as a procedure for the researchers to easily look for the common authors by applying the Scopus database. In the study of Farrukh et al. (2020), bibliometric analysis serves as a procedure by providing a holistic view to analyze titles, journals, and authors from the Scopus database. Tomanek and Lis (2020) employed bibliometric analysis to assess the scientific production trends and to recognize the most important contributors to the research field of physical education. Similarly, Pérez-Gutiérrez et al. (2021) used bibliometric analysis to provide a comprehensive perspective that focused on topics and collaboration, productivity, and review articles associated with physical education. However, in mapping physical education research, bibliometric analysis has been utilized to provide a summary of the types of topics that can be selected related to adaptive physical education (Umar et al., 2022). Meanwhile, Memon et al. (2020) used bibliometrics to analyze and examine papers related to physical activity through the Scopus database. It covers the volume publication and distribution of citations, top authors, average authors for each paper, visualization of network for co-authorship, international collaboration, author keywords co-occurrence, top countries, leading journals, and highly cited papers. Similarly, Liu et al. (2023) utilized bibliometric analysis in analyzing and summarizing the core research associated with the physical activity of children and teenagers to understand the countries' cooperation relationship and the authors, as well as to identify the key authors, journals, and the pieces of literature along with the important topics in the field of PA. Moreover, in analyzing the literature on physical activity, bibliometrics was used to acquire publications such as the origin of publication per country, year of publication, type of publication, region, and the income of the country (Wattanapisit et al., 2022).

While the importance of citation rate has been subject to discussion, it remains the main factor utilized to assess the influence of published literature. Several studies have been carried out utilizing various data sources to examine the top 50 most frequently cited journal articles (Chu et al., 2022; Seriwala et al., 2015; Zhai & Xu, 2023; Zhang et al., 2022). Chu et al. (2022) reviewed the top 50 highly cited papers on artificial intelligence (AI) in higher education using a technology-based learning model in the Web of Science database. Meanwhile, Zhai & Xu (2023) analyzed the 50 most-cited journal articles using bibliometric analysis to summarize the current research trends in the relationship between physical activity between depression. Seriwala et al. (2015) extracted data from the Scopus database to analyze the top 50 cited respiratory articles. Additionally, Zhang et al. (2022) described the research landscape and hotspots of COVID-19 and physical activity by reviewing the top 50 most influential articles over the past two years through bibliometric citation analysis.

Scopus is the outcome of Elsevier's collaboration for more than two years with researchers and librarians around the world. It is the largest single latest all-science abstract and index (A&I) database (Baas et al., 2020; Schotten et al., 2017). In the year 2004, Scopus was launched by Elsevier as a discovery tool (Schotten et al., 2017). It was also considered one of the largest abstract and database citations that include a wide coverage of regional and global scientific journals, proceedings conferences, and books (Baas et al., 2020). Further, Scopus also contains different elements of scientific publications, such as author, keywords, publication title, abstract, affiliations linked, and references (Berkvens, 2012).

The field of physical education is well-established with a long history in research. During the 2010s, it received an increase in attention from academia that resulted in significant growth of publications indexed in Scopus (Tomanek & Lis, 2020). Scopus database was used in a comprehensive search of the literature to locate relevant publications to determine randomized controlled trials, identify systematic reviews and meta-analysis, and select a research sample in the study of physical activity as the source of bibliometric data (Biddle et al., 2019; Gibson et al., 2017; Lee et al., 2021; Ortenburger & Tsos, 2021; & Ranasinghe et al., 2013). It is also used as a bibliometric analysis to retrieve and obtain related data in the field of PE (Chen et al., 2022; Muhtar et al., 2021) and in reviewing articles and examining reference lists related to the effectiveness and interventions of PE lesson time (Lonsdale et al., 2013).

To meet the global recommendation of physical activity participation, many students acquire their engagement within the school premises, making it the best place to be active. The aforementioned studies have revealed that PA in school has a lot of benefits. However, there is still a need for more exploration to determine emerging trends of the existing studies. The main objective of this study is to examine and assess the current status of trends in physical activity research by analyzing the literature on physical activity in schools. Furthermore, the analysis provided by this study might assist researchers in acquiring evidence and realization of the changes in the pattern of publications concerning the utilization of physical activity in schools.

Statement of the Problem

The study aimed to examine the research on school-based physical activity using a comprehensive bibliometric analysis of the Scopus database.

Specifically, the following objectives were addressed:

1. Describe the general state of the scholarly works on school-based physical activity in terms of:
   1.1. document;
   1.2. publication and citation analysis;
   1.3. keywords; and
   1.4. geographical distribution
2. Identify the top 50 most-cited articles in terms of:
   2.1. authors;
   2.2. publication and citation analysis;
   2.3. keywords; and
   2.4. countries
3. Compare the relevant keywords used by the top 50 most-cited articles and the rest of the dataset.

Methods

Research Design

Bibliometric analysis was used as the strategy of inquiry. The initial bibliometric analysis captured basic information about authors, journals, titles, and keywords (Guo et al., 2019), which helped in analyzing bibliographic data and publication growth, keywords, authors, affiliation, and citation patterns (Alajmi & Alhaji, 2018). Bibliometric analysis was also utilized to measure the impact and statistically evaluate published scientific literature on the scientific world (Aria & Cuccurullo, 2017). Bibliometric analysis is a tool that can showcase the evolution and connections between ideas within a particular subject or journal (Wang et al., 2021). Moreover, Denche-Zamorano et al. (2022) utilized bibliometric analysis to review existing scientific publications, journals with the most cited articles, and most co-authored countries to provide a summary of the present status of scientific literature related to physical activity. Thus, utilizing bibliometric analysis was found suitable in this study as it was an advantageous approach for assessing the literature on physical activity in schools. It served as an effective way to highlight significant research topics and emerging directions about physical activity in schools (Fernandez et al., 2022; Miranda & Tolentino, 2023).

Source of Data

Scopus is one of the most widely used databases for bibliometric analyses (Singh et al., 2021) and the most comprehensive database of the world's scientific research production (dela-Fuente-Robles et al., 2022). Scopus has a broader journal range coverage that can be used in analyzing citations, quick searching

keywords such as an author search, basic and advanced search, and search of sources. As compared to PubMed and Web of Science, Scopus has more expanded spectrum journals the analysis of citations is faster, and it has a larger number of articles than the Web of Science (Falagas et al., 2008). For this reason, it was considered that this database would be the most suitable for conducting searches related to physical activity (de-la-Fuente-Robles et al., 2022).

Search Strategy

The researchers conducted their data collection from the Scopus database on March 28, 2023, and the process of extracting journal articles was completed in a single day. They obtained the data electronically from Scopus and only selected papers published between 2013 and 2023. Through the Scopus database, the keywords "physical activity in school" or "school-based physical activity" were encoded and yielded a total of 3,423 initial articles. Figure 1 presents the flow of how the researchers filtered their data that reached the total number of 1,184 articles included in the study. The researchers only included articles that had been published from 2013 to 2023. Additionally, the type of document was also considered during the filtration of data, such as journal articles, book chapters, and conference papers. After exporting the data from Scopus, which was exactly 2,017 articles, the researchers manually analyzed the articles by reading their abstracts and titles to confirm if all articles were school-based physical activity research. Studies such as literature and systematic studies were excluded. Moreover, checking for duplication was also done by the researchers. Consequently, 1,184 research articles were included in the study after the thorough process of filtration of the dataset.

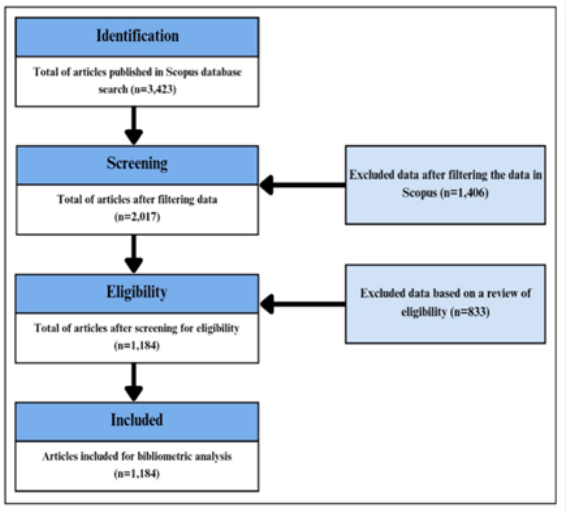

Figure 1. Data Filtering Protocol

The search formula was:
(TITLE (physical AND activity) AND TITLE (school) OR TITLE (school-based)) AND (LIMIT-TO (PUBYEAR, 2023) OR LIMIT-TO (PUBYEAR, 2022) OR LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2015) OR LIMIT-TO (PUBYEAR, 2014) OR LIMIT-TO (PUBYEAR, 2013)) AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "ch") OR LIMIT-TO (DOCTYPE, "cp")) AND (LIMIT-TO (LANGUAGE, "English"))

Data Analysis

Descriptive statistical measures such as frequency counts and percentages to present the current state of research in physical activity in schools were employed. This was done by analyzing various aspects, including the total number of publications, the topmost productive authors, the most influential journals, research

topics, keyword co-occurrence networks, and the top countries and institutions. To conduct a more in-depth analysis of the gathered data, Python Programming was used to report the descriptive statistics of the data collected. Python is a programming language that is adaptable and high-level, with a focus on code readability in its design philosophy. Its purpose is to provide a language that is simple to learn, write, and understand. The syntax of Python is straightforward and uses minimal punctuation, which contributes to its ease of understanding. Python is commonly used as a scripting language, but it is also utilized in a variety of non-scripting contexts. Python's flexibility comes from its extensibility, which allows developers to incorporate other programming languages and tools into their Python code, making it adaptable to various development goals (Van Rossum, 2007).

Results and Discussion

The General State of the Scholarly Works on School-Based Physical Activity

School-based Physical Activity has become an increasingly important topic in the field of research, and there has been a growing interest in understanding the impact of it. The Scopus database was the main source of this undertaking, and 2,017 research articles were initially retrieved in the data collection process. However, only 1,184 journal articles published between 2013-2023 met the researchers' criteria and were included in the study. The excluded data consisted of physical activity research that did not take place in schools, literature reviews, and systematic reviews. This current stage of the research involves analyzing the general state of the scholarly works on physical activity in schools, including its document type, citation and publication analysis, and geographical distribution.

Document Type. Figure 2 shows the document types that were included in this study. The analysis of the data found three (3) types of documents. The article is the leading type of document as it has the highest number of document types among Book Chapter (n = 13) and Conference Paper (n = 4). There were 1,167 (98%) articles identified out of 1,184 documents. It indicates that researchers and scientists published more article types of documents than book chapters and conference papers. By analyzing the aforementioned results, we can infer that the authors of the articles collected predominantly published articles rather than book chapters or conference papers. The higher number of articles indicates that this is the most popular type of choice of document among researchers for sharing their studies. On the other hand, book chapters and conference papers were less commonly employed, which means that they were the less common publication formats for researchers. Yang et al. (2020) conducted a bibliometric analysis, and articles were found to be the most common type of document in their study. Similarly, Chiu and Ho (2007) discovered in their analysis that Articles are also the most utilized document type.

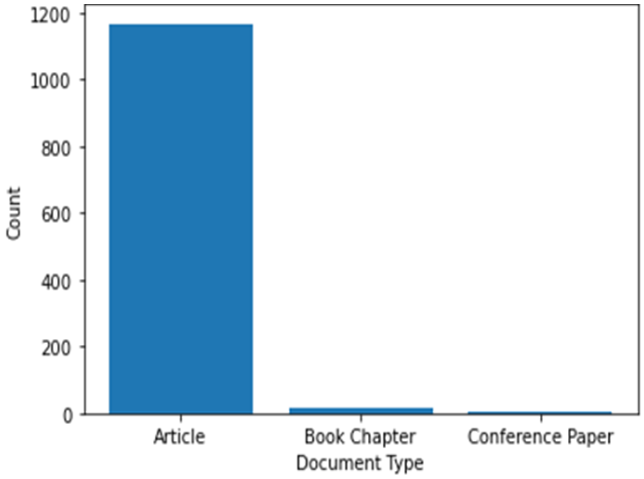

Figure 2. Counts of Document Types

Publication and Citation Analysis. Figure 3 indicates the number of journal articles that were published from 2013-2023 about school-based physical activity. In 2013, there were 70 publications about school-based PA, and it increased slightly to 84 in 2014. However, it decreased in 2015 (n = 73) before it increased in 2016 (n = 105). The number of publications remained relatively stable from 2016 to 2019, ranging the publications from 100 to 114. Further, the number of publications shifted significantly in 2020, where its rate increased to 148. It continuously grew in 2021 (n = 161) and peaked in 2022 with 180 publications, which was the highest rate of them all. However, the rate dropped again in 2023, with only 43 publications which indicates a sharp decrease. It shows in the graph that in the years 2020-2022, the number of publications was persistent from the starting point of the pandemic up until the post-pandemic period. According to Jirge (2017), during the COVID-19 pandemic, the peak of PA was witnessed. Meanwhile, the citation trends of physical activity in school research from 2013 to 2023 were also presented in this figure. Whereas 1,598 citations were recorded in 2013, and in the year 2014, it reached the highest increase rate, which accumulated 19% (n = 2,372) citations. However, it became unstable as it was seen that there were fluctuating patterns in citations per year, starting from 2015 to 2018. Meanwhile, in the pre-pandemic period, there was a continuous decrease of cited scholarly works recorded: from 2019 (n = 1,066); 2020 (n = 741.0); 2021 (n = 430); to 2022 (n = 180). It did not even reach the usual citation that is more than 1,000 recorded citations from the journals compared to the previous years before the pandemic started, and no recorded cited journals in the year 2023.

The data in Figure 3 suggests that the number of publications on school-based PA exhibited fluctuations over the years. Additionally, there were periods of rate growth, stability, and rapid decrease. Notably, there was a steady flow of articles from 2020 to 2022, spanning the pandemic's beginning and post-pandemic phases. This could be due to the COVID-19 pandemic's impact on physical activity and studies. The increase in the number of published articles, the rapid peer review process, the rapid growth in publications, the impact factor, and the increase in citations can all be used as objective indicators of PA. During the pandemic, PA became beneficial for new and young researchers to have the desire to publish, to learn more academically, to make use of their time, and to learn research and publication in a step-by-step manner, and PA usually has the most outstanding and top-ranking authors when it comes to publications (Kaur & Gurnani, 2021; Patino & Ferreira, 2019). The physical activity research field attracts more citations as newer publications continue to expand rapidly in a short period. It was seen that Physical activity and health have a great impact in terms of citation (Memon et al., 2021). Additionally, there is a growing number of citations between 2009-2018 that indicate relatively high h-index retrieved papers resulted in an increasing rate of interest to the researchers. However, the citation rate has become unstable over the past three years.

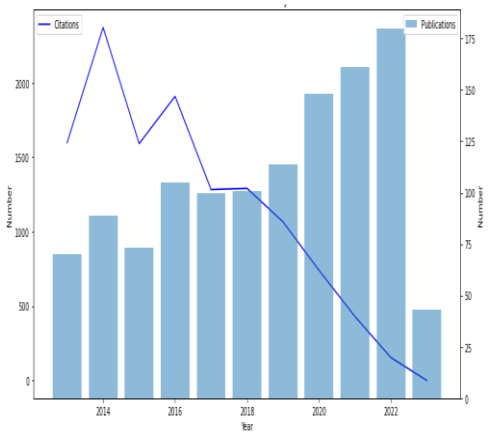

Figure 3. Number of Publications and Citation by Year

Keywords Analysis. Keywords are significant dimensions of any research journal article. Keywords as a search term greatly impact future researchers' ability to easily search for studies (Moran, 2021). The utilization of keywords has been widely used in bibliometric fields (Fernandez et al., 2022; Saleem et al., 2021; Yu et al., 2020). Moreover, developing the keywords approach as a method determines the most popular themes explored in bibliometric analysis research (Moran, 2021). Figure 4 displays the frequency of the top ten unique keywords in the school-based physical activity research studies. Based on the figure, “children” is the most used keyword or term, followed by “adolescent,” “accelerometry,” “exercise,” “intervention,” “youth,” “obesity,” “health promotion,” “health,” and "implementation." Many researchers used “children” as their keyword as children are their participants in various studies in the rest of the datasets (e.g., Babvey et al., 2021; Bates et al., 2020; Gislason et al., 2021; Lee, 2021; Szeszulski et al., 2021). Therefore, future researchers can also easily search the terms "children," "adolescent," and "youth”. Also, the keyword “children” is the most used keyword or term since a lot of studies focus on school-based physical activity only and insert literature.

Based on the figure, “accelerometry” is the top 3 most used keyword in the era of advancement according to Rastogi et al. (2020) where “accelerometry” is used as their keyword and as a digital wearable device is useful to track the measurement of human movement in terms of doing PA. The keywords "exercise," "health" and "implementation" have also been used in different studies as well as the "intervention", which is the action to change the behavior and perspective of every participant in an instance based on their study. Moreover, Figure 4 shows that "obesity" is one of the top 10 keywords by frequency, the term "obesity" was used as a keyword and was included as their objectives (e.g., Dolley et al., 2023; Marcos-Pasero et al., 2023). Meanwhile, "health promotion" was also used in different studies as a keyword and involved in the objectives of their study (e.g., Michalak, 2020; Peron & Neufeld, 2022; Schubin et al., 2021). Keywords serve as significant markers for research publications since they help with discoverability and classification. They provide insights into the prevalent topics and areas of interest in school-based physical activity research. Researchers may identify popular themes, target specific participant groups (such as children and adolescents), and investigate relevant topics such as accelerometry and health promotion.

the frequency and usage of keywords. Figure 4 data displays terms frequently used in school-based physical activity studies. The prominence of specific terms, such as "children" and "accelerometry," indicates the emphasis areas of much research in this group, whereas keywords such as "obesity" and "health promotion" may represent the significance of specific health concerns and solutions. In the study of Lemos et al. (2023) the keyword “children” is commonly used considering the children to be ages 12 years and below. Meanwhile, “adolescent” is the top 2 most used keywords in different studies with a total of 146. The keyword “accelerometry” is the top 3 most used keyword, and in the era of advancement, according to Rastogi et al. (2020), “accelerometry” is used as their keyword, and as a digital wearable device, it is useful and can be used as an "intervention" to easily track the measurement of human movement in terms of doing PA. The keywords "exercise" and "implementation" have also been used in different studies as well as the "intervention", which is the action to change the behavior and perspective of every participant in an instance based on their study. Moreover, Figure 4 shows that "obesity," "health promotion," and "health is the three least commonly used a keyword, the terms "obesity," "health promotion," and "health" were used as keywords and was included as their objectives (e.g., Dolley et al., 2023; Marcos-Pasero et al., 2023; Michalak, 2020; Peron & Neufeld, 2022; Schubin et al., 2021).

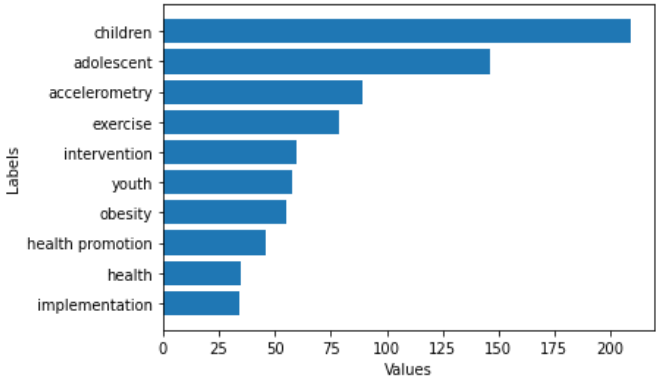

Figure 4. Top 10 Keywords by Frequency

Geographical Distribution. The graph demonstrates that, out of the top 10 countries, the USA has the greatest number of publications (*n* = 296) followed by Australia (*n* = 98). It was observed that most of the top countries' contributors are from European Countries such as the United Kingdom (*n* = 88), Spain (*n* = 73), Denmark (*n* = 28), Finland (n=27), and Norway (*n* = 26), which leads to a sum of (*n* = 242) publications. However, the United States continues to lead the top contributors of European countries combined in terms of the number of publications. This aligns with the study of Wattanapisit et al. (2022), where it was found that the dominant countries in publishing papers are high-income countries such as the USA and European countries, unlike low and middle-income countries such as countries in Asia. This implies that one of the major factors of research productivity is reflected by a country's income.

China is the only country in Asia with evidenced publications based on the dataset (*n* = 36). According to An et al. (2019), the research in China in terms of environmental correlates in physical activity was rapidly increasing. Hence, among the Asian Countries, China stood out as one of the most productive developing countries since it expanded and increased its influence in various fields of scientific research up until the present (Liu & Avello, 2021). Overall, the United States has a total of 25.17% published papers out of 1,184 collected articles. Furthermore, Muller et al. (2018) analyzed the origin of the research, showing that most of the papers published by authors are from the United States. Memon et al. (2021) stated that the USA was ranked first in terms of contributions to the most cited physical activity papers. This proves that the United States always topped the list of nations in the volume of publications and citations.

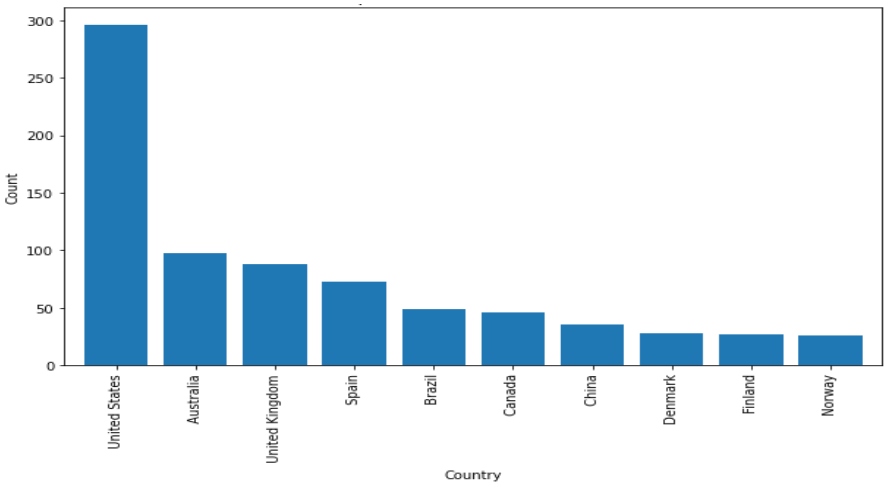

Figure 5. Top 10 Countries in Affiliations

Analysis of the Top 50 Most-Cited Journal Articles

The study conducted a separate bibliometric analysis of the top 50 most-cited journal articles in the dataset. This analysis examined factors such as the distribution of authors, patterns of publication and citation, keywords employed, and geographical representation.

Distribution of Number of Authorship. In Figure 6, the number of authors' distribution per article was presented. The data reveals that the prevalence of multiple authorship, particularly with five authors or more, has significantly dominated the distribution among the top 50 most-cited journal articles, comprising approximately 66% (*n* = 33 papers). Interestingly, only one (1) article has single authorship and collaborative authorship within this set of scholarly works. Summing up all papers from one author per article to four authors (*n* = 17), five or more authorships still have the highest distribution rates. The number of authors per article in the top-cited journal articles demonstrates the significance of collaboration in scientific research. Most of the papers in this dataset had multiple authors, with five or more being the most prevalent. This study gives support to the assumption that collaborative efforts improve the exposure and impact of research. Empirical evidence showed that publications co-authored by multiple individuals tend to garner greater visibility and impact. Over the last few decades, the significance of collaboration in scientific research has increased. (Abramo & D'Angelo, 2015).

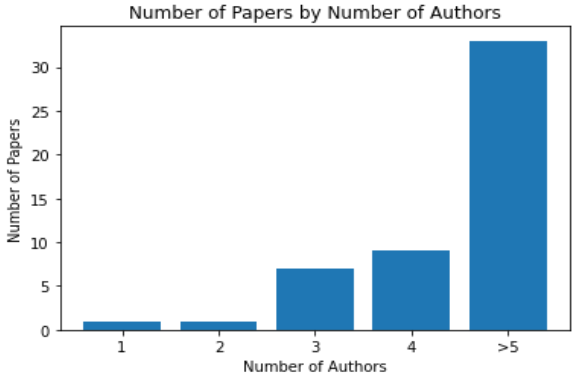

Figure 6. Number of Papers by Number of Authorship/s

Top 50 Most Cited Articles Publication and Citation Analysis. Figure 7 presents the annual publication pattern of the top 50 most-cited published journal articles in school-based physical activity. It shows that 2014 had the highest rate of publication between the years 2013-2023, which accumulated 38% (*n* = 19) of the published papers. The pattern shows that after an increased rate in 2014, it became unpredictable and fluctuated from 2015 to 2019. Looking at the graph, we can observe that there are no published papers from the beginning of the pandemic in 2020 up until the post-pandemic period in 2023. This shows that the pandemic had a considerable influence on research productivity, resulting in a total halt of publication activity during that period. In the study of Raynaud et al. (2021), the effects of COVID-19 on publication dynamics were explored, and it revealed that during the pandemic, there was a huge impact on non-COVID-19 related studies in terms of publication, wherein there is an increase of publications related and dedicated to the virus happened in 2020 while there is a decreased in non-COVID-19 publication by 18%. Meanwhile, the figure also displays the citation trends from the year 2013 to 2023 of the top 50 most-cited articles on physical activity in school research. There were 37% (*n* = 1,230) citations in the year 2014, reaching the highest rate within the top 50 most-cited journal articles. However, in the following year, the citations shifted to a continuous decrease of cited articles recorded: from 2015 (*n* = 599), 2016 (*n* = 485), and 2017 (*n* = 108). Consequently, a sudden increase happened in 2018 and then dropped again in 2019 as it reached the lowest rate of citations.

Figure 7 revealed the high rates of publications and citations of the top 50 most-cited journal articles. Both publications and citations reached their highest rate in the year 2014; hence it clearly shows that the researchers are most active in the field of physical activity in school research during the year 2014. As stated by Muller et al. (2016) in the past years, physical activity and aging research grew and increased rapidly as there were high citations in publications in the year 2014. However, in the year of 2015, the publication rate started to decrease, like the rate of citations. Furthermore, the rate of publications continuously decreased up until 2017 while citation rates fluctuated until 2019 when it reached the lowest rate since this was the beginning of the pandemic.

Meanwhile, no publications have been recorded in this figure since the pandemic started up until post-pandemic. This means the research productivity in terms of school-based physical activity research has been affected by the pandemic as schools and universities have been closed face-to-face interaction has become limited as well and physical activities in public are being suspended or canceled. Although they have the highest rate of citation from the dataset, the publication rates are low starting from 2020 since the graph stopped by 2019 compared to the analysis of the whole dataset where the peak of the publication rate started from 2020, the beginning of the pandemic. As such, it can be implied that the citation and publication rates were affected when the pandemic happened. According to Wunsch et al. (2022), an increase in the number of research studies has examined the impact of the pandemic on various facets of physical activity. In line with this, it was stated in the study of Zhang et al. (2022) that between the years 2020 and 2022, physical activity and COVID-19 research started to trend globally, and this indicates that this field of research is being well-developed.

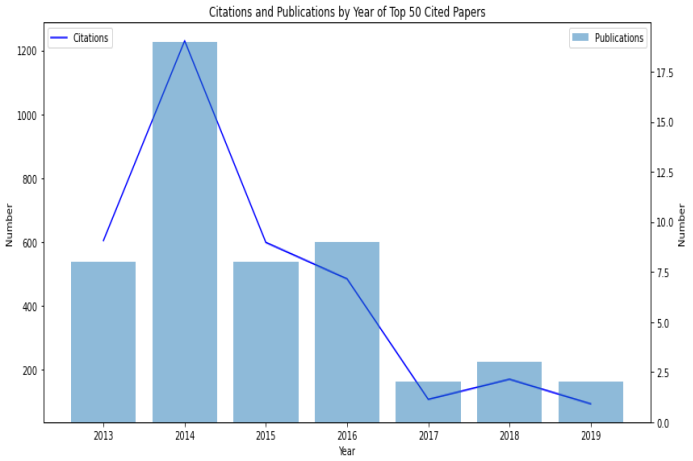

Figure 7. Number of Publications and Citations by Year of the Top 50 Cited Papers Format and Style

Top 10 Keywords by Frequency of Top 50 Cited Papers. Figure 8 presents the top 10 keywords in the top 50 cited papers by frequency. It was seen in the figure that the first keyword is “children.” It is followed by the remaining keywords, which are "intervention," "cognition," "exercise," "adolescent," "accelerometry," "academic achievement," "health promotion," “light physical activity,” and “primary”. It can be noted that “children” was the first and most used keyword in the top 50 cited papers and the rest of the dataset. Therefore, among the top 10 keywords in the top 50 cited papers by frequency used and mentioned the term “children” as a keyword. The term "intervention" was the second most used in the top 10 by frequency of the top 50 cited papers. Drummy et al. (2016) used "intervention" as a keyword in their study. Also, the terms "cognition" and “exercise” are both shown in the figure as the third most used keyword in the top 10 keywords by frequency of the top 50 cited papers. However, the term "cognition" in the study is the third most used keyword (e.g., Jäger et al., 2014; Schmidt et al., 2015). Based on the two figures, "exercise" is both fourth in rank

and included in the top 10 used as a keyword. Moreover, "accelerometry," "academic achievement," and "health promotion," are labeled the same in the figure when used as keywords. Many researchers used the term "accelerometry" as their keyword (e.g., Brusseau et al., 2016; Casado-Robles et al., 2020; Fairclough et al., 2013; Moller et al., 2014;). The term "academic achievement" is listed in the figure, and it is also used in the two research studies as a keyword (e.g., Cerda et al., 2021; Mullender-Wijnsma et al., 2015). As shown in each of the graphs, "health promotion" is listed as third in rank in both the top 10 keywords by frequency and the top 10 keywords by frequency of the top 50 cited papers.

The prevalence of the word “children” may indicate that research about school-based PA has a strong focus among this group. Considering the word “class”, it has been observed that the term “children”, “adolescents”, or young people are present in all the clusters, with “education” being one of the most pertinent. That corresponds with the findings, which list "children" as one of the most relevant search terms among keywords about PA in school (Young et al., 2021) while “intervention” as the second most used keyword suggests that many studies about PA implement an intervention. Among all keywords “intervention” is the most common keyword and has the highest centrality in publications (Zhang et al., 2022). Particularly, the keyword "intervention" along with other terms contributed to establishing the year 2020 about PA based on the theme pattern of the writers' keywords throughout the preceding five years (Feng, 2022). The study finds that PA interventions and PA in children and adolescents with ASD improve symptoms like stereotyped behavior and motor function in patients with ASD, as well as lowering childhood obesity rates and improving quality of life may be possible. It also demonstrates that the term "intervention" is more concerned by academics in this field, reflecting that the research direction related to these keywords is the core research content of the PA intervention in ASD study (Wang et al., 2022). Additionally, “cognitive”, “academic achievement” and “exercise” was also prominent word in the top 50 this may indicate that researchers have an interest in investigating the relationship between them. However, "exercise" as well as other keywords like “cognitive” and “academic achievement” continued to be researched worldwide from the outbreak year until 2021, indicating that researchers realized that improving motor skills through PA and exercise may have a good effect on the health and fitness of ASD groups (Feng, 2022). Furthermore, the inclusion of the terms “accelerometry” and “health promotion” suggests that the measurement of the physical level can be connected to the promotion of health. The word “accelerometry” is used as a keyword, and it can used as a digital wearable device to track the measurement of human movement in terms of doing PA. This highlights the need for greater emphasis on preventative health promotion practice and subsequent referral pathways into these dedicated community programs to support PA promotion (Lobelo et al., 2018; Rastogi et al., 2020).

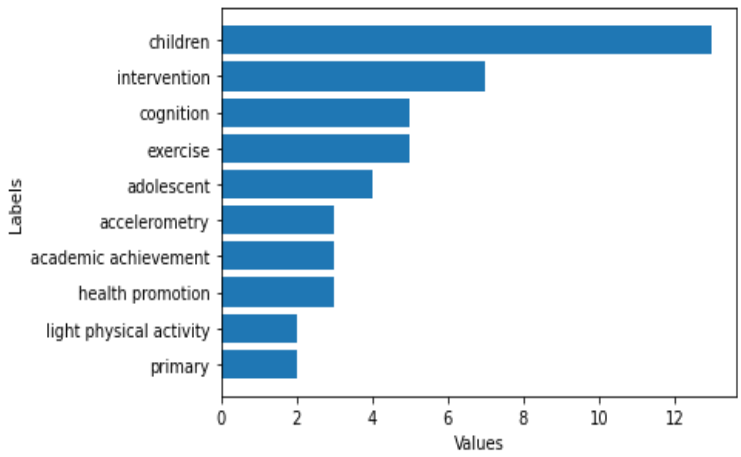

Figure 8. Top 10 Keywords by Frequency of the Top 50 Cited Papers

Top 50 Most-Cited Papers' Geographical Distribution. This analysis encompasses the leading countries in terms of publications in the top 50 most cited papers, and it shows that the United States is the leading country with the greatest number of published papers which accumulated 20% (*n* = 10) compared to the rest of the countries. Similarly, in the study of Gu et al. (2023), it was mentioned that the first in the most influential countries is the United States, as it had the highest citation in publications. Moreover, the United States has the largest number of publications and produces more scientific knowledge; therefore, the United States stands out among the rest of the countries (Fresno-Alba et al., 2022). Meanwhile, the second highest is Australia, as there were (*n* = 8) published papers, and the United Kingdom (*n* = 7) is the third on the top list, followed by Canada (*n* = 5). The Netherlands has (*n* = 4), and Switzerland has (*n* = 3). Further, the number of published papers in China is (n = 2), along with Denmark and Sweden, and the last one is Finland, with only (*n* = 1) published papers. In line with this, it was also shown that European countries are the most contributors. Hence, if European countries such as the United Kingdom, Finland, Sweden, Denmark, Switzerland, and the Netherlands combined, there is a total (n = 19) published papers that dominate the United States for having a high number of published papers. Yet, China is the only country in Asia that is active in studying physical activity. Day (2016) stated that the rate of published papers over time in China had increased modestly. Erfanmanesh et al. (2013) also claimed that China is the most productive among other countries, which has the greatest number of publications indexed in the Scopus database and is the first in terms of scientific productivity in Asia. It proves that even in the analysis of the top 50 highly cited papers, the USA still has the most publications. On the other hand, China remains the only country in Asia that has produced papers about PA.

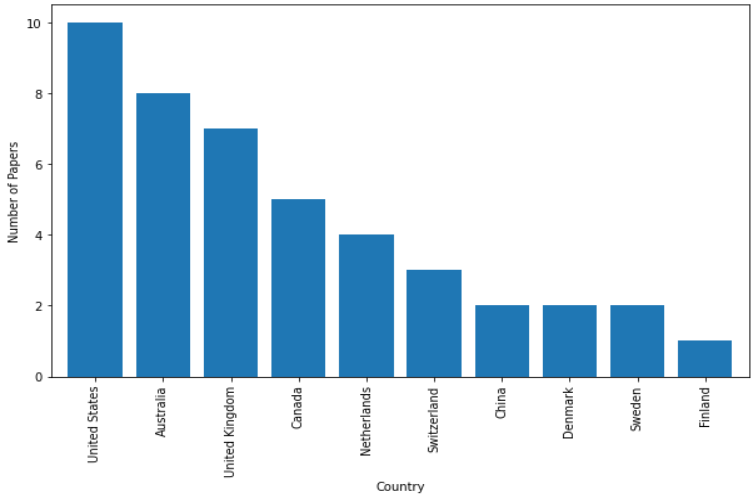

Figure 9. Top 10 Country Distribution of Papers of the Top 50 Cited Papers

Analysis of the relevant keywords employed by the top 50 most-cited articles and the rest of the dataset

The comparison of Figures 4 and 8 highlights the similarities and differences in the top 10 keywords between the top 50 cited papers and the entire dataset in terms of frequency. In both analyses, the keyword "children" emerged as the most frequently commonly used term. This indicates that children have received a high interest from the researchers of the analyzed articles and were included in their study as their participant/respondents (e.g., Carson et al., 2014; Eather et al., 2013; Mei et al., 2016; Wells et al., 2014). The term "intervention" ranks as the second most frequently used keyword in the top 50 cited papers. This suggests that most of these studies concentrated on implementing interventions to increase physical activity or change behavior among the target

group (e.g., Engelen et al., 2013; Kipping et al., 2014; Meyer et al., 2014; O'Dwyer et al., 2013). The frequent use of the term "intervention" indicates that the purpose of this research was to assess the effectiveness or impact of interventions on children's physical activity levels. In contrast, the keywords "cognition," "academic achievement", "light physical activity", and "primary" appear exclusively in the top 50 cited papers and are not as prevalent in the analysis of the entire dataset. This implies these specific topics have received more attention and acknowledgment in the more important or impactful studies on school-based physical activity.

Researchers in the most cited studies investigated the relationships between physical activity and cognitive functions, academic achievement, levels of light physical activity, and primary education. On the other hand, keywords such as “youth”, “obesity”, and “implementation” were seen in the general analysis of the dataset but are not among the top 50 cited literature. This suggests that, while these topics have been tackled across a broader range of research, they may not have gained as much attention effect as keywords in highly cited articles. The keyword "exercise" maintains its position as the fourth most frequently used word in both Figure 4 and Figure 8. This indicates the consistent focus on studying the impact of exercise on children's physical activity levels and related outcomes. Similarly, “health promotion” remains the seventh-used term.

Lastly, "accelerometry" remains a prominent keyword but drops from the third rank in the overall dataset to the sixth rank in the top 50 cited papers. This suggests that while the use of accelerometry as a measurement tool for assessing physical activity remains prevalent, it may not have received as much attention or citation impact in the more influential studies. In conclusion, while certain keywords, such as "children", "exercise", and "health promotion", remain consistently important across the entire dataset and top 50 cited papers, specific topics, such as "cognition" and "academic achievement," gain importance in highly cited research, the comparison displays keyword usage trends. It provides insights into research interests and focus areas on the subject of school-based physical activity.

Conclusions

The following conclusions have been derived based on the findings that were obtained.

1. The results of the study described the general state of scholarly works on school-based physical activity in terms of their document type, publication, citation rate, keywords used, and geographical distribution.
   1.1. Out of all the scholarly works that were analyzed, *Article* as document type was the highest that was recorded, followed by the *Book Chapter* and *Conference Paper,* respectively.
   1.2. The highest number of publications was recorded in 2022, while in 2014, it reached its highest rate of citations. However, the analysis shows the state of both publications and citations from the year 2013-2023 were unstable.
   1.3. In terms of the relevant keywords that were utilized by the research articles, “children” was the most used among them. The prevalence of the keyword "children" indicates that population is a major focus of school-based physical activity research.
   1.4. The analysis clearly shows that the United States is the most prominent contributor among the top ten countries. Furthermore, European countries such as the United Kingdom, Spain, Denmark, Finland, and Norway provide considerable contributions. Meanwhile, China is the only country in Asia that has contributed in terms of research publications, which means that Asian countries should publish more papers related to physical activity in schools.
2. The study revealed the notable patterns of the top 50 most-cited journal articles in terms of their authorship distribution, publication and citation rate, keywords used, and geographical location.
   2.1. Most of the papers have one to five authors in different studies in the scope

of school-based physical activity or physical activity in schools.

2.2. In the years between 2013-2023, 2014 reached the highest rate of publications, but it gradually decreased in the following years.

2.3. The United States has the most publications, making it the most productive country for studying physical activity in school.

2.4. The term "children" has the highest number of frequencies used as a keyword on the cover of the top 50 cited papers. Therefore, it could be concluded that children are best used as a keyword for school-based physical activity.

3. The word " children " is the highest number of most used keywords in the top 50 most cited papers, as well as the other datasets, is the word "children". As a result, it can be stated that "children" is one of the most frequently used keywords in the top 50 most cited papers as well as the other datasets indexed in the Scopus database about school-based physical activity.

Limitations of the Study

The study revealed certain limitations that could potentially impact future research endeavors.

1. The data used in the study was gathered solely from the Scopus database. The study did not include the criteria required for determining whether the publications were indexed in notable journal indexing institutions such as Google Scholar, Web of Science, PubMed, DOAJ, or ERIC. The researchers limited access to these databases, as well as the time-consuming process of undertaking a bibliometric analysis, contributed to the lack of inclusion. This may not represent the complete amount of literature on physical activity in school research.
2. The study only included the years 2013 to 2023. Thus, it may not have captured long-term patterns or recent innovations in the field of school-based physical activity. On the other hand, the analysis did not consider other characteristics such as publication quality, journal impact factors, or the precise causes of the observed changing patterns.
3. The study primarily focused on the general characteristics of the articles, such as document type, keywords, publication, citation, and authorship, without exploring the exact research strategies and methodologies used in the studies. This omission limits analysis for the methodologies employed in school-based physical activity research.

Recommendations

1. Taking into consideration the challenges and limitations that had arisen during the pandemic period, the publications, and citations of scholarly works in terms of physical activity in school reached their lowest rate. Future researchers should explore new ways to study physical activity or investigate public health concerns. This may be used by other methodologies and data collection to conduct a more in-depth investigation.
2. Future studies may take into consideration a larger and more representative sample of scholarly works, investigate additional factors influencing publication and citation patterns, analyze keyword effectiveness more comprehensively, and explore contextual factors influencing geographical variations in study results.
3. This study has only limited information in terms of the general state of scholarly works and the top 50 most-cited articles, such as Document type, Publication and Citation analysis, Keywords, Geographical Distribution, Countries, and Authors. It is suggested that future researchers should also include methodological approaches and research designs to identify what usual or dominant approaches and designs were utilized in physical activity research.
4. This study collected data from the Scopus database only. Future researchers may also consider collecting data from different journal-indexing databases such as Google Scholar, Web of Science (WOS), PubMed, DOAJ, and ERIC to determine a similar analysis.
5. Asian countries are encouraged to publish more papers related to physical activity in

schools, as seen in the results that China is the only recognized country that is actively publishing literature. This will contribute to the broader knowledge base and visibility of research from Asian countries.

6. Future researchers have the option to do a comparative analysis of the literature encompassing three distinct periods: pre-pandemic, pandemic, and post-pandemic, to explore the emerging trends and changes that happened during each period. Future researchers will be able to get insights into the impact of the pandemic in this field of research.

Acknowledgment

The researchers would like to express their deepest gratitude to the College of Education of Don Honorio Ventura State University for extending their help in this study.

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