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Research Article

The Impact of Physical Education on Mental Health of College Students: A Knowledge Graph Analysis Based on Co-term Analysis

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Abstract

Objective: The increasing prevalence of mental health issues among university students has prompted a growing recognition of physical education (PE) as a critical factor in promoting both physical and mental well-being. While existing research highlights the positive effects of physical activity on physical fitness and stress alleviation, there remains a lack of a systematic understanding of the underlying mechanisms through which physical education influences students' mental health. This study aims to explore how physical education can enhance university students' mental health through a multidimensional educational model, considering not only individual-level factors but also indirect influences such as curriculum design, teacher quality, and the campus sports environment.

Methods: This study employs bibliometric analysis using tools such as CiteSpace and Bibliometrix to quantitatively examine recent research on the relationship between physical education and university students' mental health. A detailed bibliometric approach is adopted to construct knowledge maps that identify key research themes, trends, and academic debates within this field. The analysis focuses on publications related to physical education's role in mental health, emphasizing the mechanisms through which physical activity may impact students' emotional regulation and stress levels.

Results: The bibliometric analysis reveals several key research hotspots, including the role of physical education in reducing academic stress, improving emotional regulation, and enhancing overall mental well-being. The study highlights the significance of factors such as curriculum design, teacher engagement, and the campus sports environment in shaping the mental health outcomes of students. Emerging trends indicate a growing emphasis on the holistic integration of physical education within university life to promote mental wellness.

Conclusion: This study provides valuable theoretical insights into the pathways and mechanisms through which physical education can enhance university students' mental health. The findings offer guidance for policymakers and educators in designing more effective physical education programs that address both physical and mental health needs. Furthermore, the study identifies gaps in existing research and suggests directions for future investigation, contributing to the development of evidence-based strategies for promoting student well-being through physical education.

Keywords: physical education, mental health, bibliometrics, knowledge map, citespace, bibliometrix

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1 INTRODUCTION

In recent years, as mental health issues among university students have gradually gained more attention, physical education, as an important part of students' overall education, is increasingly seen as a key factor in promoting both the physical and mental health of university students. Existing studies have shown that physical activities not only enhance students' physical fitness but also effectively alleviate academic stress, improve emotional regulation skills, and foster a sense of collectivism and social adaptability through team collaboration and competitive spirit[1]. Regular physical exercise contributes to the improvement of students' psychological well-being, particularly by alleviating negative emotions such as anxiety and depression, thus enhancing their emotional state and overall mental health. For instance, some empirical studies have found that students who engage in physical exercise exhibit better emotional regulation when coping with stress, reducing negative emotions such as anxiety and depression, which in turn enhances their mental health[2]. Long-term aerobic exercise training has been shown to significantly reduce students' emotional stress responses when faced with academic pressure[3]. Physical activities can further alleviate academic stress by improving self-efficacy and psychological resilience, helping students better cope with academic challenges[4]. However, despite the growing body of research on the physical and mental impacts of physical education, there is still a lack of sufficient systematic understanding of its mechanisms and deeper effects.

While existing research has revealed the positive impact of physical education on students' mental health to some extent, there are still some potential research gaps and issues. Most studies focus on the direct relationship between physical activity and mental health, overlooking the indirect effects of factors such as curriculum design, teacher quality, and campus sports atmosphere on students' psychological well-being. Additionally, many studies have limitations in their sample sizes and research methodologies, which makes it difficult to assess the long-term effects of physical education comprehensively and in depth. Current research tends to emphasize individual-level mental health, often lacking analysis of how different groups (such as gender, year of study, major, etc.) experience variations in the impact of physical education on mental health. Therefore, the comprehensive benefits of physical education in promoting university students' mental health have not yet been fully explored. This is especially true in China, a developing country where research on physical education and its effects on university students' mental health holds significant practical value. Given the large student population and regional differences in China, exploring how to improve students' mental health through physical education, especially in addressing widespread issues such as academic stress, social barriers, and emotional problems, is of considerable practical importance. Thus, studying how physical education influences university students' mental health and exploring interventions under different cultural and educational systems not only contributes to enhancing students' personal well-being but also helps foster a positive campus culture and overall student development, making it an urgent issue for higher education institutions worldwide.

However, as mental health issues among university students become more pressing, a single approach to physical exercise may not be sufficient to address this problem comprehensively. Physical education is not just about physical training; it is also an essential component of psychological education, fostering students' psychological growth and emotional development while enhancing their physical fitness. Therefore, exploring how physical education can improve university students' mental health through different educational models, curriculum designs, and forms of physical activity has become an important and pressing topic in current educational research. While many relevant studies exist, a systematic investigation into how physical education profoundly impacts students' mental health is still lacking, and there is a shortage of interdisciplinary perspectives and comprehensive analyses based on multidimensional data.

To address these issues, this study employs bibliometric methods, using CiteSpace software and the Bibliometrix R package, to conduct a systematic quantitative analysis of recent literature on the relationship between physical education and university students' mental health. By constructing knowledge maps, we aim to clearly identify research hotspots, trends, and academic debates in this field and reveal potential pathways and mechanisms through which physical education can enhance students' mental health. Through this analysis, we hope to provide theoretical foundations for policymakers and educational practitioners, while also offering guidance for future research and promoting the application and development of physical education in enhancing university students' mental health.

2 MATERIALS AND METHODS

2.1 Data Sources

This study selected two indexes from the Web of Science Core Collection (WoSCC) as data sources: the Science

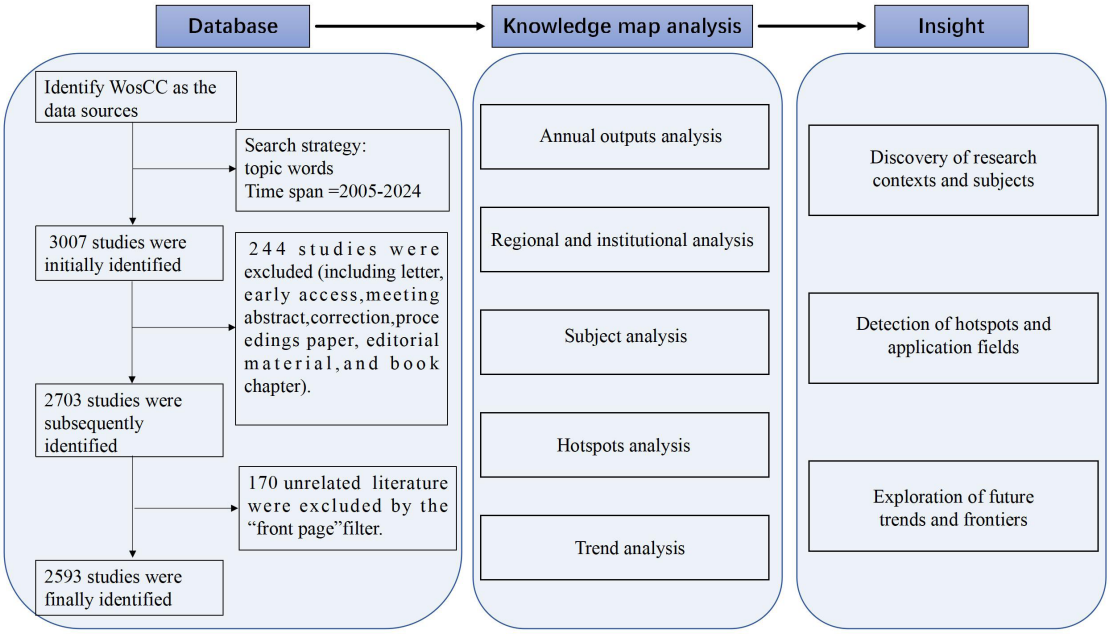

Figure 1. The Summary of the Flowchart and Study Design.

Citation Index Expanded (SCI-Expanded) and the Social Sciences Citation Index (SSCI). There are several reasons for choosing the WoS database. First, WoSCC is a standard database for knowledge graph analysis[5] and has been widely applied in bibliometric research[6-9]. Second, as a multidisciplinary database, WoSCC includes literature from over 20,000 journals in fields such as environmental science, public health, and more. This broad coverage allows for a more balanced search compared to specialized databases like PubMed, which may introduce biases towards the medical field. While interdisciplinary databases such as Scopus also offer extensive coverage, WoSCC has advantages in metadata classification. It provides categorization by author, year, discipline, and document type (similar to Scopus), but also includes classification by institution and country[10], which is particularly helpful for scholars conducting organizational distribution analyses. Considering all these factors, we ultimately selected two WoSCC indexes for further analysis.

The search strategy is as follows: [TS=("college students" OR "university students" OR "undergraduate students" OR "higher education students" OR "campus students" OR "academic students" OR "postgraduate students" OR "student population") AND TS=("mental health" OR "Mental Hygiene" OR "psychological well-being" OR "psychological health" OR "mental illness" OR "depression" OR "anxiety" OR "stress" OR "mental disorders" OR "psychological resilience" OR "psychological distress" OR "emotional well-being" OR "mental wellness" OR "mood disorders" OR "cognitive health" OR "psychological disorders") AND TS=("physical education" OR "sports education" OR "physical education (PE)" OR "physical education curriculum" OR "sports pedagogy" OR "physical activity education" OR "sports teaching" OR "sports curriculum" OR "PE instruction" OR "sports didactic" OR "sport pedagogy" OR "fitness education" OR "physical activity" OR "physical health education" OR "health education" OR "wellness education" OR "health literacy" OR "exercise" OR "public health education" OR "exercise science" OR "fitness" OR "movement education" OR "well-being education" OR "physical fitness" OR "physical exercise" OR "exercise intervention" OR "aerobic exercise" OR "strength training" OR "resistance exercise")]. The time span for the search is from 2005 to 2024. To avoid bias, all relevant records were retrieved in the "full record and cited references" format from WoSCC, and the data were collected on November 17, 2024, for further analysis. In line with previous studies[7], we included only "articles or reviews" and restricted the language to "English". Other document types and non-English articles were excluded. The reason for setting the starting point of 2005 is that research on the impact of physical education on the mental health of university students largely began in this year. Basic information for each paper was collected into text files, including details such as country, institution, journal source, author, and references. Initially, 3,007 documents were identified; after applying the filters for document type and language, a total of 2,593 documents were selected for analysis. The research framework is summarized in Figure 1.

2.2 Research Methods

This study employs knowledge mapping and bibliometric methods. The knowledge mapping approach allows for visual analysis of a specific field, involving steps such as data mining, scientometrics, information analysis, and chart generation. By presenting the distribution of literature and the overall research landscape, knowledge mapping is widely used to obtain more refined information related to the research topic[11]. Bibliometric analysis, on the other hand, is a

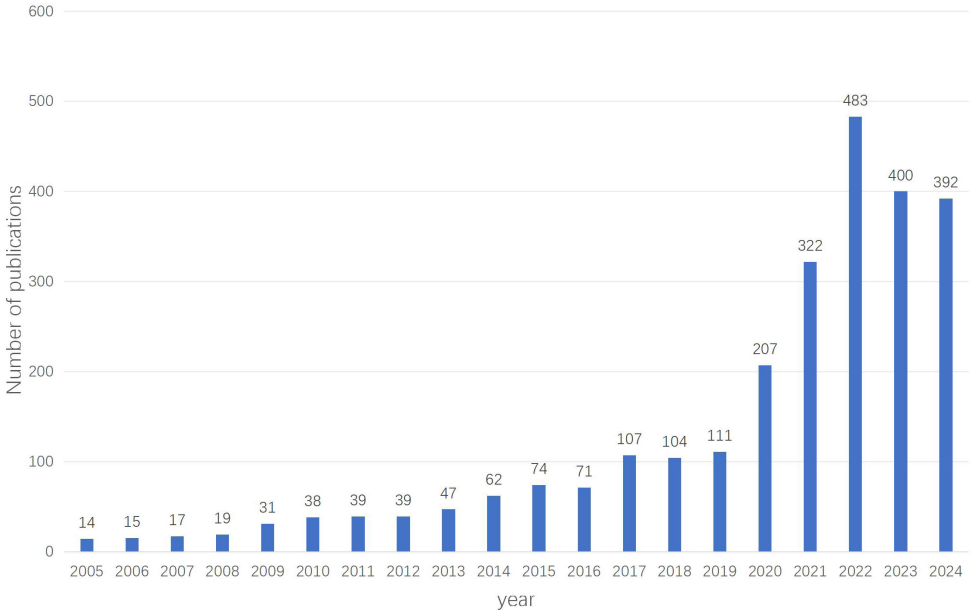

Figure 2. The Output of Publications and Growth Trends of Physical Education-mental Health Research on College Students.

widely recognized method for evaluating the development of a topic from the perspectives of library and information science[12]. It can reveal patterns in the flow of knowledge and the structure of a field, demonstrating its scientific foundations and emerging themes[13]. Ultimately, it provides in-depth analysis of a knowledge domain. By combining these two strategies, researchers can present intuitive visualizations that help readers understand the current state, frontiers, and hotspots of the field, as well as provide guidance for future research directions.

Widely used visualization tools include CiteSpace and the Bibliometrix package based on R language. CiteSpace, developed by Professor Chaomei Chen's team, is a visualization software particularly suitable for revealing the flow and evolution paths of knowledge in a specific research domain[11]. The Bibliometrix package offers powerful bibliometric algorithms and data analysis capabilities, generating rich charts and graphs to meet analytical needs. It can also be integrated with other R packages to create customized visual maps[14]. In this study, R software and CiteSpace version 6.3.1 were used in combination to adjust various functions such as time division, node types, and node filtering methods, in order to construct the knowledge map. By analyzing the annual publication volume in the field of physical education and university students' mental health, as well as analyzing authors, institutions, and clustering and burst analysis of keywords, this study provides an intuitive understanding of the research dynamics, hotspots, and frontier trends in physical education for mental health from 2005 to 2024.

In addition, knowledge maps typically consist of nodes and connecting lines to display collaboration relationships between documents[15]. Nodes represent elements such as countries, authors, institutions, journals, references, or keywords. The size of the node indicates the centrality of the literature, meaning that the larger the node, the more frequent its appearance or citation[16]. In this study, the centrality index is treated as a bridge between early and recent viewpoints, reflecting the degree to which a node is passed through in the network's paths, typically standardized to a [0, 1] range. Meanwhile, the connecting lines between nodes represent the relationships between them, with wider lines indicating closer connections between nodes.

3 RESULTS

3.1 Annual Outputs Analysis

The number of publications within a specific time period reveals, to some extent, the characteristics of the development of a research field. The publication volume of research on the impact of physical education on university students' mental health over nearly 20 years is presented in a bar chart (Figure 2). From 2005 to 2024, a total of 2,593 core journal papers on this topic were indexed by the Web of Science (WOS).

As shown in the figure, research in the field of physical education and its impact on university students' mental health has shown an increasing trend in publication volume since 2005. This suggests that the field is gradually gaining widespread attention and recognition in academia. Overall, the growth in research literature is likely related to the increasing global concern over mental health issues among university students, greater recognition of the potential

Table 1. Ranking of the Top 10 Countries and Institutions in the Field of Physical Education on College Students' Mental Health

Rank	Country	Publications	Centrality	Rank	Institution	Publications	Centrality
1	PEOPLES R CHINA	792	0.35	1	University of California System	31	0.49
2	USA	572	0	2	State University System of Florida	30	0.04
3	AUSTRALIA	176	0.08	3	University System of Ohio	30	0.06
4	ENGLAND	159	0.03	4	University of London	27	0.01
5	SPAIN	119	0.05	5	University of Toronto	27	0.03
6	CANADA	118	0.07	6	Shanghai University of Sport	24	0.1
7	GERMANY	83	0.03	7	Peking University	22	0.01
8	SOUTH KOREA	80	0.14	8	Harvard University	21	0.37
9	JAPAN	53	0	9	University of Melbourne	21	0
10	TAIWAN REGION	51	0.02	10	Anhui Medical University	21	0

effects of physical activities in promoting mental health, and increased policy support and research funding. The changes in the number of publications in this field can be broadly divided into three stages.

The first stage is the Emergent Phase (2005-2013): During this period, the number of publications was relatively low and the growth rate was slow. The average annual output was 28 papers, reflecting the early exploratory phase of research, indicating that academic attention to the relationship between physical education and mental health was still in its initial stages.

The second stage is the Preliminary Development Phase (2014-2019): From 2014 onward, the number of publications began to gradually increase, especially after 2017, when the growth rate accelerated. This period likely coincides with the growing recognition of the importance of physical education in the field of mental health, and academia started paying more attention to this area.

The third stage is the Rapid Development Phase (2020-Present): In 2020, the number of publications significantly increased to 207, reaching 322 papers in 2021, indicating rapid development. In 2022, the number peaked at 483 papers, after which the publication volume remained relatively stable in 2023 and 2024. Overall, the field is now in a phase of rapid development and is encountering greater opportunities for growth. Future research in this area is expected to become richer and more mature.

3.2 Regional and Institutional Analysis

Scholars from over 100 regions and 200 institutions have contributed a large volume of literature to the study of physical education's impact on university students' mental health. Table 1 lists the top 10 countries and institutions in detail. Figure 3A presents the collaboration network between different countries, illustrating the research landscape across multiple regions. Each point in the figure represents a country, with the size of the point reflecting the number of publications from that country. The international academic collaboration network generated by CiteSpace contains 112 nodes and 171 links, indicating that the total number of collected documents has been published in 112 countries or regions, with 171 connections established between these countries.

First, we can observe that the countries with the highest number of publications are China (792 publications) and the United States (572 publications), which have conducted most of the research on physical education's impact on university students' mental health. Australia and the United Kingdom are the second largest producers, with 176 and 159 publications, respectively. Spain (119 publications) and Canada (168 publications) rank third in terms of production. Overall, most countries have relatively low publication volumes, with 63 countries having 10 publications or fewer, accounting for 57.1% of the total.

In terms of centrality, the country with the highest centrality index is China, with a centrality index of 0.35, indicating that China has a significant influence and leadership role in the field of physical education and mental health research. Although the United States has the highest number of publications, its centrality index is close to 0, showing relatively low influence in the network. Australia and the United Kingdom have centrality indices of 0.08 and 0.03, ranking third and fourth, respectively, indicating that both countries also play an important role in this field.

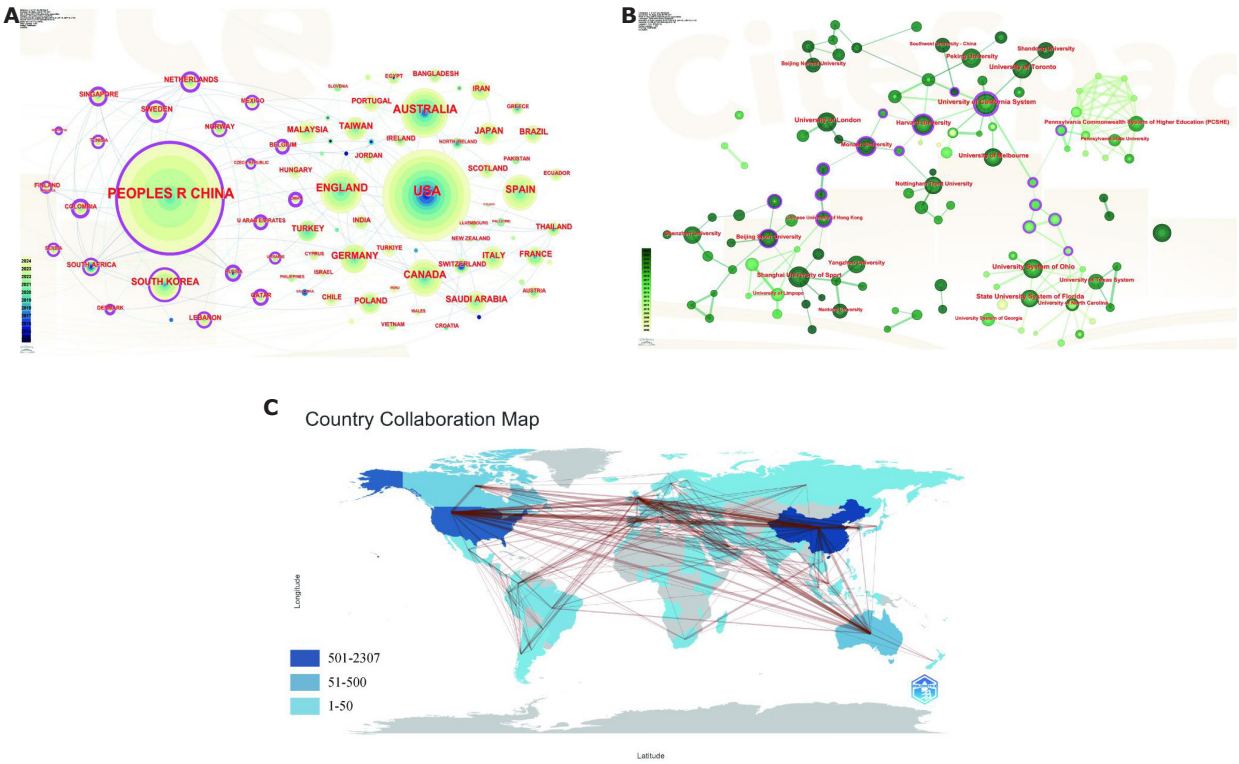

Figure 3. The Map of Countries (A), Institutions (B), and World Distribution (C).

Regarding institutional participation, Figure 3B reflects the collaboration between institutions, with 168 nodes and 163 links. Based on the definitions of links and nodes, these organizations are closely connected and have a significant impact in academia. The University of California system ranks first with 31 publications and a centrality index of 0.49, reflecting its significant contribution and leadership in research on physical education and university students' mental health. The Florida State University system and the Ohio State University system follow, with 30 publications and centrality indices of 0.04 and 0.06, respectively, ranking second and third, demonstrating their notable influence in this field. University College London, the University of Toronto, Shanghai University of Sport, Peking University, and Harvard University also make significant contributions to research in this field, with high publication counts and centrality indices. Additionally, we can see that more than half of the institutions are universities, indicating the critical role that higher education institutions play in advancing innovation in this field. However, from a clustering perspective, some non-university institutions seem to have weaker connections with other organizations, while universities tend to maintain more extensive collaboration networks.

Furthermore, the distribution of countries and regions is shown in Figure 3C. From this figure, it is evident that countries and institutions in North America, Western Europe, and Australia lead the research on the impact of physical education on university students' mental health. The figure uses the density and direction of lines to represent the collaboration network between different countries and regions, with the lines in North America and Western Europe being the most concentrated, suggesting frequent academic exchanges and collaborations within these regions. Most of the top 10 institutions in the table are from Western countries, which helps explain why Western countries lead in this field. Developed regions may have invested more resources in physical education and mental health research and placed greater emphasis on the positive impact of physical activity on university students' mental health. Through physical education—such as curriculum design, exercise interventions, and mental health education—research institutions in Western countries have made significant progress in enhancing students' mental health, reducing psychological issues, and promoting personal development.

However, China, as a developing country, has also made significant contributions to the research on the impact of physical education on university students' mental health. Given China's large student population and regional disparities, researching how to improve university students' mental health through physical education—especially in addressing prevalent academic stress, social challenges, and emotional issues—is of great practical significance. Therefore, studying how physical education influences university students' mental health and exploring interventions in different cultural and educational contexts is an important issue for global higher education institutions. This research not only helps improve students' individual well-being but also plays a profound role in building a positive campus culture and promoting students' overall development. In summary, although Western countries and institutions seem

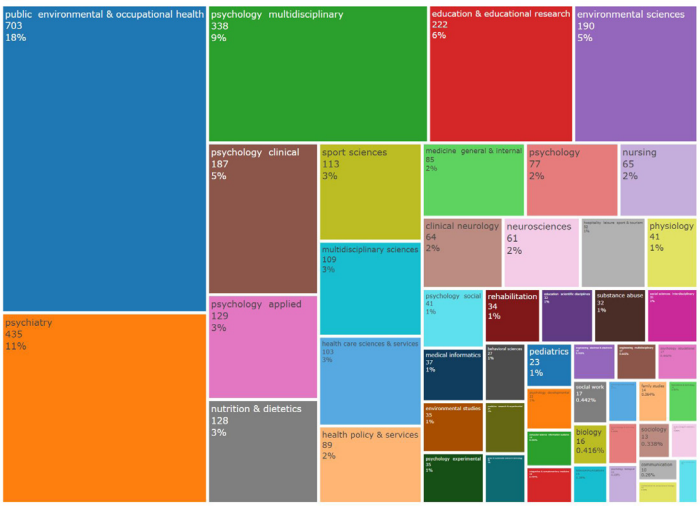

Figure 4. The Subject Tree Map of Physical Education-mental Health Research on College Students.

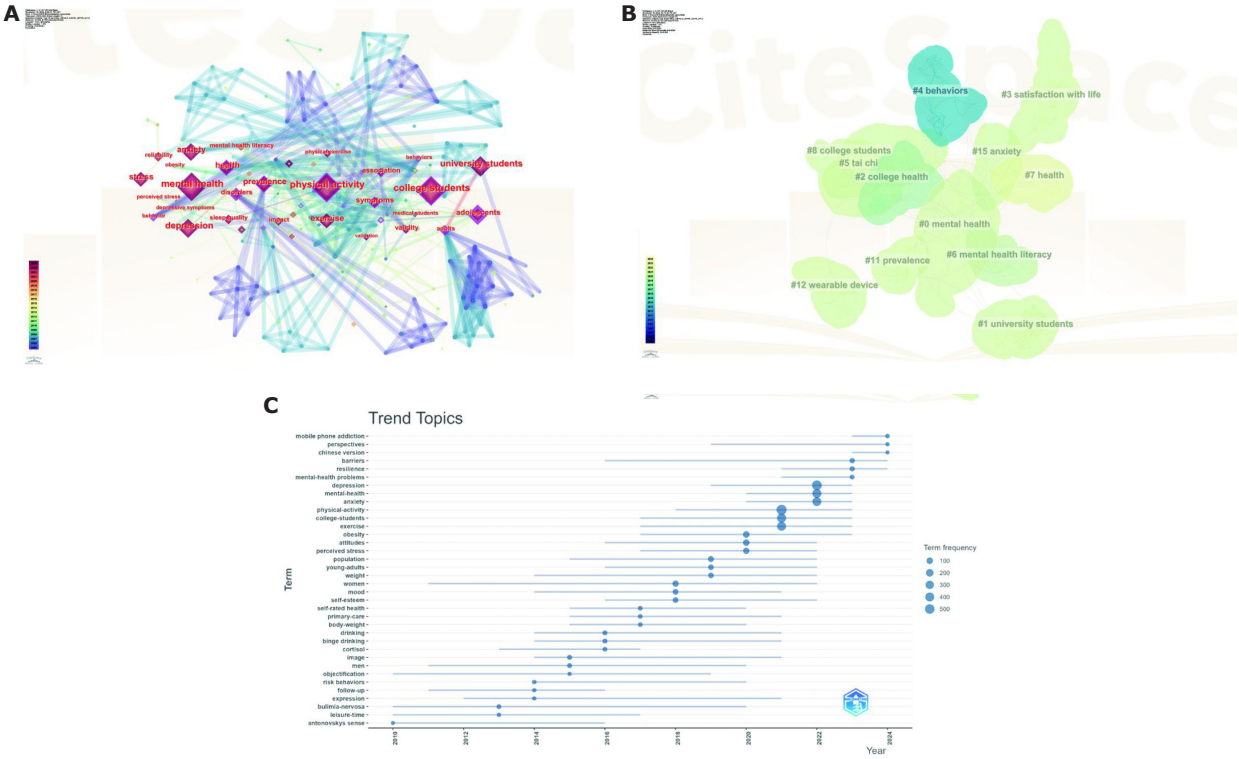

Figure 5. Keyword Co-occurrence (A), Keyword Clustering (B), and Trend Topics (C).

to be the main drivers, research institutions worldwide are contributing to the knowledge base in this field. Future research should focus more on cross-cultural and cross-regional collaboration to achieve a more comprehensive understanding and development.

3.3 Subject Analysis

Figure 4 presents a tree map that shows the academic disciplines involved in the study of the impact of physical education on university students' mental health. This figure reveals the number of publications and the proportion of each discipline in the field, providing valuable perspectives for academic research. Among the disciplines, Public, Environmental & Occupational Health is the dominant field, with 703 publications, accounting for 18% of the total research, indicating a strong focus on the impact of physical education on university students' mental health within this area. The second major discipline is Psychiatry, with 435 publications, accounting for 11% of the total. Multidisciplinary Psychology, Education & Educational Research, and Environmental Science follow, with 338 (9%), 222 (6%), and 190 (5%) publications, respectively, occupying the third, fourth, and fifth positions. In addition, Clinical Psychology and Applied Psychology also make significant contributions to this field, highlighting the practical and theoretical application of psychological principles in physical education. It is worth noting that the diversification of disciplines has provided multiple perspectives for the research on the impact of physical education on university students' mental health.

The integration of psychological principles in the study of physical education's effect on university students' mental health has undoubtedly provided both theoretical support and practical guidance for this research. Particularly, the contributions of Clinical Psychology and Applied Psychology have deepened our understanding of how physical activity influences students' mental states from the perspective of mental health intervention. Clinical psychology focuses on diagnosing and treating individual psychological disorders, emphasizing the prevention and intervention of mental health issues, while physical education, as a common method for psychological regulation, can effectively help university students alleviate stress and prevent anxiety, depression, and other psychological problems. Applied Psychology, on the other hand, focuses on applying psychological theories and methods to real-life situations and educational settings, with a particularly prominent role in physical education, especially in psychological training and emotional management. By incorporating exercise psychology principles, educators can design physical education curricula and activities that not only enhance students' physical fitness but also improve their mental health, thus achieving dual goals.

Moreover, in recent years, the trend of disciplinary diversification has provided more opportunities for exploring and integrating multiple perspectives in the research on physical education's impact on university students' mental health. In this context, interdisciplinary research has gradually become mainstream, with physical education intersecting with various academic fields such as psychology, medicine, sociology, and education, thus opening up new possibilities for applying physical education in mental health interventions. For example, Exercise Physiology offers insights into the physiological mechanisms of how physical activity affects mental states, while Sociology emphasizes the positive role of social factors, such as group exercise and teamwork, in improving individual mental health[17]. Through the synergy of these disciplines, researchers can more comprehensively assess the multidimensional effects of physical education on university students' mental health, not only in terms of emotional regulation but also in enhancing social adaptation and strengthening group identity.

This trend of interdisciplinary integration urges us, when studying the impact of physical education on university students' mental health, to consider not just individual forms of physical activity but also the combined effects of various educational methods and psychological interventions. For instance, combining Cognitive Behavioral Therapy (CBT) with physical education can help students improve their psychological adaptation by engaging in self-reflection and emotional management while participating in physical activities[18]. Similarly, Social Support Theory suggests that university students who engage in group sports can effectively reduce feelings of loneliness and social anxiety by receiving support and encouragement from their peers[19]. Therefore, the design of physical education programs should not only focus on the direct physical effects but also integrate psychological and sociological theories to create a multifaceted interactive mechanism for promoting mental health. In summary, the impact of physical education on university students' mental health is not only the direct effect of physical activity on mental states but also shaped by the interaction of psychological principles, social environments, and other factors. With the advancement of interdisciplinary integration, researchers are likely to gain a more comprehensive understanding of the psychological benefits of physical education, which will provide more targeted and scientifically grounded guidance for future educational practices.

3.4 Hotspots Analysis

Keyword co-occurrence analysis provides a valuable method for identifying the main research interests and hotspots within a particular field. In this study, CiteSpace software was employed to conduct a keyword co-occurrence analysis of the research on the impact of physical education on the mental health of university students (Figure 5A). The resulting network consists of 254 nodes and 707 links, where the nodes represent keywords and the links indicate relationships between them. Among the 200+ keywords identified, the three most frequently occurring terms are "physical activity" (906 occurrences), "college students" (754 occurrences), and "mental health" (734 occurrences). This clearly suggests that physical activity, the college student population, and mental health are the central themes of research in this field, emphasizing the close interconnection between these three concepts.

Other high-frequency terms with significant centrality in the network include "stress reduction", "depression", "anxiety", and "physical fitness", all of which appear as key topics within the research. Specifically, the term "stress reduction" appeared 523 times, underscoring the importance of stress relief as a primary outcome of physical activity on the mental health of university students. As academic pressure increases among university students, research indicates that physical activity plays a crucial role in alleviating academic stress and improving emotional well-being[20].

Additionally, the terms "depression" and "anxiety" frequently appeared (478 and 462 occurrences, respectively), highlighting the significant role that physical education plays in mitigating psychological issues such as depression and anxiety. This suggests that a large body of research focuses on how physical education can promote mental health by

addressing negative emotional states and psychological challenges.

Other high-frequency terms such as "self-esteem", "social support", and "well-being" also appeared frequently, indicating that scholars have started to focus on the impact of physical activity on university students' self-esteem, social support, and overall well-being[21]. The presence of these terms suggests that the effects of physical education extend beyond alleviating symptoms of anxiety and depression, also contributing to enhancing students' sense of self-worth and social integration, thereby improving their overall mental health.

Overall, the keyword co-occurrence analysis reveals the multidimensional nature of the research on the impact of physical education on the mental health of university students. The high-frequency terms and their interconnectedness provide important insights into the key directions and research hotspots in this field, offering valuable clues for further analysis of the mechanisms by which physical education promotes mental health in university students.

To further clarify the emerging research themes in the field of physical education and mental health, a cluster analysis of the keyword co-occurrence network was performed. As shown in Figure 5B, CiteSpace generated 12 distinct clusters: #0 mental health, #1 university students, #2 college health, #3 satisfaction with life, #4 behaviors, #5 tai chi, #6 mental health literacy, #7 health, #8 college students, #11 prevalence, #12 wearable device, and #15 anxiety. The size of each cluster is indicated by its number, with larger clusters receiving smaller numbers. After performing a clustering analysis of the literature on the impact of physical education on university students' mental health, 12 clusters were identified, resulting in a high Q value of 0.8554, indicating a well-defined network structure. This high Q value suggests that the clusters clearly represent different research directions within the field. The S value of 0.9384 further confirms the reliability of the clustering results, showing that each cluster exhibits strong homogeneity and effectively represents the forefront of research on the impact of physical education on the mental health of university students.

3.5 Research Trend Analysis

Building on the analysis of research hotspots, the bibliometric tool biblioshiny in R software was used. This R-based bibliometric analysis platform presents the research trends in a particular field through visualized data. As shown in Figure 5C, it provides an intuitive reflection of the historical trajectory of the research field, revealing the temporal relationships between different research directions. This helps in understanding the research hotspots of the field in different time periods and exploring future research frontiers and development trends.

Figure 5C summarizes the trend topics in research on the impact of sports education on university students' mental health from 2005 to 2024. From 2005 to 2024, the most frequently cited keywords in research on sports education and university students' mental health included: Mental-health problems, Depression, Mental-health, Anxiety, Physical activity, College students, Exercise, and Obesity. These keywords reflect the primary focus areas in the field of sports education and mental health research. A detailed analysis is as follows:

Mental-health problems, Depression, Anxiety, Mental-health: These keywords have been consistently cited at high frequencies, indicating that mental health issues, especially depression and anxiety, remain prevalent and severe psychological health problems within the university student population[22,23]. For years, university students have faced multiple challenges, such as academic pressure, interpersonal relationships, and career planning, which often lead to or exacerbate emotional issues and mental disorders. Therefore, research has increasingly focused on the role of sports education in improving mental health, particularly in alleviating symptoms of depression and anxiety.

Physical activity, Exercise: As primary means of promoting mental health among university students, physical activity and exercise reflect the positive impact of physical exercise on mental health[24]. Research has shown that regular exercise not only improves physical fitness but also significantly reduces stress, anxiety, and depression. Thus, these keywords' high citation frequency suggests the crucial role that physical activity plays in university students' mental health. College students: University students, as a distinct group, face significant pressures from academics and employment, making their mental health issues particularly prominent. The focus on this demographic in sports education research highlights the central theme of improving mental health among this group. Obesity: The growing issue of obesity within the university student population is closely linked to mental health. Obesity not only affects physical health but can also have negative psychological effects, particularly on self-esteem, anxiety, and depression[25,26]. Consequently, sports education's role in addressing obesity has become a major research focus.

Continuing Keywords of Interest:Some keywords have continued to be highly cited over time, and their importance

has not diminished. In fact, these keywords may continue to play a significant role in future research. These keywords include:Mobile phone addiction: Mobile phone addiction has become an increasingly prominent mental health issue among university students in recent years. With the widespread use of smartphones and social media, the potential addiction risk posed by smartphone usage has become a global public health concern[27]. Research shows that excessive use of smartphones can lead to loneliness, anxiety, and depression, particularly in the absence of effective time management, which can exacerbate mental stress[28,29]. One study pointed out that physical exercise can effectively reduce smartphone addiction[30], thereby improving mental health.Perspectives: The shift in research perspectives may reflect a growing understanding and evolving methodologies related to sports education and mental health. Scholars might explore the impact of physical activity on university students' mental health from diverse disciplinary, cultural, or methodological viewpoints, thus broadening the research scope in related fields.Chinese version: This likely refers to research on sports education and university students' mental health in specific contexts within China. As mental health concerns among Chinese university students have gained attention, many studies have focused on Chinese versions of mental health interventions and sports education models.Barriers: Barriers typically refer to factors that affect university students' participation in physical activities or the improvement of their mental health. These may include physical health conditions, time management challenges, and insufficient social support. Investigating these barriers helps in the development of effective interventions to encourage university students' participation in physical activities and, consequently, improve their mental health.Resilience: Resilience refers to an individual's ability to adapt to and recover from stress, setbacks, or adversity[31]. In recent years, researchers have increasingly focused on how physical activity can enhance university students' psychological resilience. Students with higher resilience are better able to adjust to psychological stress and mitigate negative emotions and mental health issues[32]. Thus, resilience is seen as an important research direction for improving mental health among university students.

4 DISCUSSION

This paper systematically analyzes the impact of sports education on the mental health of university students using knowledge graph analysis and bibliometric methods. The study covers the period from 2005 to 2024, and uses CiteSpace software and the Bibliometrix package in R software to construct a knowledge graph on the relationship between sports education and the mental health of university students. This study identifies research hotspots and development trends in this field and reveals the potential pathways and mechanisms through which sports education can enhance the mental health of university students. The findings show that the impact of sports education on university students' mental health is a multidimensional, interdisciplinary area involving psychology, education, environmental science, and other disciplines. Research hotspots include core topics such as physical activity, university student groups, and mental health, as well as terms closely related to mental health, such as stress relief, depression, and anxiety. Additionally, the study found that sports education plays an important role in enhancing university students' self-efficacy, psychological resilience, self-esteem, and social support.

4.1 Negative Issues Caused by Mental Health

Mental health issues have gradually become an increasingly serious problem among university students[33], affecting students' learning efficiency, quality of life, and future career development. Academic pressure, interpersonal relationships, and career planning challenges are some of the major factors leading to mental health problems among university students. First, academic pressure is often one of the root causes of psychological issues in university students[34]. Many students face significant academic tasks and exam pressure, especially in the later years of study and in the context of increasing employment pressures, which makes symptoms of anxiety and depression more common[35]. Overemphasis on academic performance and uncertainty about future careers can lead to strong anxiety, and some students may experience emotional disorders because they are unable to cope with intense academic pressure[36].

Interpersonal relationship issues are also a major factor contributing to mental health problems among university students[37]. A wealth of evidence shows that good interpersonal relationships are positively correlated with subjective well-being and academic performance[38], while relationship difficulties are positively correlated with loneliness[39] and mobile phone addiction[40]. Many students face new social circles in university and may feel excluded or lonely due to differences in personality, interests, or family background. Loneliness can lead to psychological issues such as anxiety and depression[41]. This is particularly true for freshmen, who may struggle with social anxiety and loneliness due to a lack of good social skills or the ability to adapt to their environment, thus affecting their mental health.

Changes in modern lifestyles, especially the rapid development of information technology, have also exacerbated mental health issues among university students. Mobile phone addiction and excessive use of social media have become

common phenomena[42], with many students suffering from widespread negative impacts on their physical and mental health[43] and sleep quality[44] due to over-reliance on electronic devices, leading to feelings of loneliness and anxiety. In the virtual world, people often display their best selves, which causes university students to feel inferior when they see others' "perfect" lives, further exacerbating their psychological distress[45,46]. A recent meta-analysis confirmed that there is a negative correlation between physical activity and mobile phone addiction among young people, regardless of the time of data collection, country, region, or population[47]. Physical activity can significantly improve mobile phone addiction, especially moderate-intensity physical activities.

In addition, physical health issues are closely related to university students' mental health. Problems such as obesity and lack of exercise not only affect students' physical health[48] but may also damage their self-identity and self-esteem, leading to mental health problems[49]. Therefore, mental health issues among university students are a complex and multifaceted phenomenon that spans academic, social, and lifestyle domains. Addressing this issue requires comprehensive measures from multiple perspectives, focusing on students' physical and mental well-being and providing necessary psychological support and interventions.

4.2 The Role of Physical Activity in Promoting Mental Health

Physical activity, as the main means of promoting university students' mental health, reflects the positive impact of exercise on mental well-being. Research shows that regular exercise not only improves physical fitness but also significantly reduces stress, anxiety, and depression[50]. Therefore, the significant role of physical activity in university students' mental health has been frequently cited and widely recognized. The integration of sports psychology and psychological interventions, such as combining CBT with sports education, has been shown to effectively reduce anxiety, depression, and other psychological issues[18]. Additionally, sports education has been supported by research for its role in enhancing self-esteem and self-identity, as the challenges and sense of accomplishment in physical activities can enhance students' sense of self-worth, leading to overall improvement in their mental health. These findings emphasize the multidimensional benefits of sports education in promoting the mental health of university students and provide important guidance and inspiration for future educational practices and research.

4.3 The Role of Sports Education in Enhancing Self-Esteem and Self-Identity

Physical activity also has an important impact on university students' self-esteem, self-confidence, and self-identity. Related research shows that through sports education, university students experience a sense of success and self-transcendence in sports, which enhances their self-identity and self-esteem[51]. For example, team spirit in group activities and individual performance in competitions can help students improve their social skills and emotional regulation, thus improving their psychological state[17]. The challenges and sense of accomplishment in physical activities can enhance university students' self-worth, further promoting overall improvements in their mental health.

5 CONCLUSION

5.1 Summary

In summary, our research reveals long-term trends and research hotspots in the field of physical education and university student mental health. From 2004 to 2024, mental health issues, physical activity, depression, and anxiety have remained the focus of research, while emerging issues such as mobile phone addiction, barriers to physical activity, and resilience have become important directions for future research. These trends reflect both the persistence of mental health problems among university students and the new challenges posed by social changes and technological advancements. Therefore, future research may focus more on how physical education can help university students enhance psychological resilience, overcome mental health barriers, and strengthen their ability to cope with the pressures of modern society.

5.2 Future Perspective

Long-Term Stability and Continued Attention: From 2005 to 2024, mental health issues among university students, such as depression, anxiety, and obesity, remained a primary focus of research. This indicates that mental health problems within the university student population have not been fundamentally resolved, especially in today's rapidly changing society, where students continue to face significant psychological pressures. Therefore, physical education is seen as an important means of alleviating these issues.

Emerging Issues: The rise of problems such as mobile phone addiction reflects the new impact of information

technology development and the widespread use of the internet on university students' mental health. With the popularity of smartphones, university students' lifestyles and social patterns have undergone profound changes, leading to new mental health challenges. The continued attention to this issue suggests that future research may focus more on how to address the negative impacts brought by technology.

Integration of Multidimensional Perspectives: The frequency of citations of terms like "perspectives" and "Chinese version" suggests that with the advancement of globalization and interdisciplinary collaboration, researchers are beginning to examine the relationship between physical education and mental health from various angles, especially within the specific context of China's physical education model. This trend implies that the field of physical education research will become more diversified, and cross-cultural and interdisciplinary cooperation will strengthen.

Emphasis on Resilience and Barriers: With the deepening of research, an increasing number of scholars are focusing on how to enhance university students' psychological resilience and investigating barriers to participating in physical activities. This indicates that future research will not only focus on the positive impact of physical activity on mental health but also on how to overcome barriers that prevent students from engaging in sports, ultimately improving participation and enhancing mental health.

5.3 Strength and Limitations

The main strength of this study lies in its long-term systematic analysis, covering a time span from 2004 to 2024, and providing a comprehensive summary of the research trends in physical education's impact on university students' mental health. This extended timeframe effectively reveals both persistent issues and emerging trends in the research field, offering a comprehensive perspective on the influence of physical education on student mental health. By combining knowledge mapping and visual analysis, the study quantitatively reflects both the current research status and practical applications, highlighting cooperation across different countries, regions, and disciplines.However, the study also has limitations. While it uses structured information, including co-cited literature and keyword clustering analysis, it is limited in its application of unstructured knowledge and qualitative methods. Furthermore, the study only analyzed data from the Web of Science Core Collection, and relying on a single database may not be comprehensive enough. In practice, the limitation arises from the fact that current knowledge mapping software does not support the extraction of multi-database records or meta-analysis. Although this study discusses the potential impact of physical education on university students' mental health, it offers limited discussion on specific interventions and their practical effectiveness. Future research could further explore which types of physical activities are most effective in alleviating depression, anxiety, and other mental health issues, and how to design more targeted physical education programs to improve intervention outcomes.

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Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author Contribution

Zheng H led manuscript writing and conducted data analysis, focusing on bibliometric analysis and result interpretation; Sun S was in charge of figure and chart creation and visualization; Shu M contributed to literature collection, data organization, data analysis, and manuscript revision; Du X managed part of the data analysis, particularly network analysis, and drafted the methods section; Peng J assisted with literature screening, data organization, and figure creation; Wang Y participated in literature screening, data processing, and literature review writing; Zhang Y helped develop the research framework, analyzed data, and supported the discussion section; Fang W oversaw study design, methodology, and critical manuscript revisions, ensuring research quality.

Abbreviation List

CBT, Cognitive Behavioral Therapy
PE, Physical education
SSCI, Social Sciences Citation Index

SCI-Expanded, Science Citation Index Expanded
WOS, Web of Science
WoSCC: Web of Science Core Collection

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