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Bibliometric analysis of research trends in college students' mobile phone addiction from 2013 to 2023

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ABSTRACT

Mobile phone addiction (MPA) among college students is a growing concern affecting physical and mental well-being. This study employs CiteSpace 6.2.R6 to analyze research trends on MPA. A total of 957 articles published between 2013 and 2023 were analyzed, with key contributors including Griffiths, Mark D, and institutions like Nottingham Trent University and Toledo University. "Computers In Human Behavior" emerged as the most cited journal. Research focal points include the prevalence of MPA, its health effects, and its association with social media usage. Future research should focus on understanding the MPA-mental health correlation, improving methodologies, and conducting diverse intervention studies. This study identifies research hotspots and emphasizes the need for further investigations to expand understanding of MPA among college students. Collaboration between institutions and authors is crucial, along with diversification of research methods and tools.

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1. INTRODUCTION

The emergence of mobile phones has dramatically transformed our methods of communication, information acquisition, and entertainment. Nonetheless, the excessive utilization of these devices can precipitate mobile phone addiction (MPA) concerns, resulting in a range of psychological and behavioral problems. This dependency is marked by compulsive internet utilization, fixation with the device, and a lack of control over its usage, disrupting the individual's daily activities and yielding adverse cognitive and social repercussions [1].

Mobile phones can be considered a "double-edged sword." On one hand, they enhance the convenience of modern life; on the other hand, concerns have arisen regarding potential negative health issues associated with their use [2]. Health problems associated with excessive smartphone use include musculoskeletal pain [3], [4], swollen wrists, stiffness in the hands, pain in the cervical spine [5]–[7], eye fatigue, and decreased vision [8]–[10], as well as effects on academic performance [11]–[13], cardiorespiratory fitness [14], and sleep quality [15], [16], all of which have the potential to contribute to a decline in the quality of life.

Among the demographic groups most susceptible to this phenomenon are college students, who face a notably elevated risk of developing MPA. There are currently a lot of relevant academic papers on the global state of MPA among college students. Since different standards, methods, tools, and samples are used to measure MPA, the prevalence of MPA in this group of college students is highly diverse. Incidence of

MPA among college students worldwide ranges from 6.36% to 62% [17]–[21]. This addiction can adversely influence multiple dimensions of their existence, encompassing physical and mental health, scholastic achievement, sleep quality, and even interpersonal exchanges and relationships [22].

Fortunately, scholars have progressively acknowledged the importance of MPA, culminating in a burgeoning body of research on the topic. Researchers have investigated the prevalence of MPA, various influencing factors, and the adverse consequences associated with it [23]–[26]. Recently, additional research has been conducted on diverse intervention measures targeting MPA [27], [28]. Although qualitative reviews have described the characteristics of MPA among college students, there has been a limited application of bibliometric methodologies to comprehensively analyze the scholarly contributions and distribution within this research domain [29], [30]. Researcher have noted that qualitative evaluations may entail inherent subjective biases [31], [32]. Thus, it is essential to utilize quantitative methods for a systematic review of the MPA status among college students.

Bibliometric analysis represents a methodological approach grounded in mathematics and statistics, designed to elucidate the knowledge framework of a specific field of research [33]. This analytical technique encompasses three core components: analysis of co-words, co-authorship, and co-citations [34]. Researchers are able to rapidly identify the characteristics, evolutionary processes, and research hotspots of literature through bibliometric analysis. According to a study, there is a strong tendency in the medical research literature to use bibliometric analysis, approximately one-third of the papers on bibliometric analysis indexed in Scopus originate from the medical domain [35]. Currently, researchers have employed bibliometric analysis to investigate the prevalent themes and prospective trends concerning MPA [36]. However, there has been limited research focusing on the healthy population, especially among college students.

CiteSpace 6.2.R6 is a widely employed tool in the field of visualization, spanning disciplines such as management, education, clinical medicine, psychology, and public health [37]–[39]. It is freely accessible and adept at managing bibliographic data. Consequently, we chose articles on MPA among college students from the Web of Science Core Collection Database and used CiteSpace 6.2.R6 as our visualization analysis tool. We conducted an in-depth review of the literature from 2013 to 2023 in order to identify the most current developments in this field.

Utilizing CiteSpace 6.2.R6, we generated visually informative network maps illustrating co-occurring clusters and keywords; co-authors, institutions, and countries; co-cited references; and a burst keyword. The aims of our research include addressing the question: i) How has the literature concerning MPA among college students been distributed over the past decade? ii) Who have contributed the most to the research on college students' MPA? iii) In this field of study, what are the boundaries and hotspots? Using the created maps or tables, our objective is to achieve an objective overview of the existing status, hotspots, and frontiers of study on MPA among college students. In order to address the lack of quantitative literature reviews in this area, to the best of our knowledge, this study represents the inaugural application of bibliometric methods for the quantitative examination of literature concerning MPA among college students. Additionally, by providing references for further prevention and intervention efforts related to MPA, through our research, interested researchers will be able to extract crucial information to assist their ongoing studies and better grasp the evolution of the area from a scientific standpoint.

2. METHOD

2.1. Data collection

Data for this review were gathered on November 25, 2023, from the Web of Science, a distinguished database platform for accessing global academic information. The selection of the Web of Science Core Collection, encompassing the Science Citation Index Expanded and the Social Science Citation Index, as the database for this study was based on its recognized authority and significant influence within the scholarly research community. To ascertain the most recent developments in the field, we performed searches for articles published within the timeframe of 2013 to 2023.

The search strategy employed was as: ((((TS=(college student*)) OR TS=(university student*)) OR TS=(undergraduate*)) OR TS=(undergraduate student*)) Editions: WOS.SCI, WOS.SSCI and (((((((TS=(mobile phone addiction*)) OR TS=(smartphone addiction*)) OR TS=(mobile addiction*)) OR TS=(cell phone addiction*)) OR TS=(mobile phone dependence*)) OR TS=(cell phone dependence*)) OR TS=(smartphone dependence*)) OR TS=(problematic mobile phone use*) and Article or Review Article (Document Types) Editions: WOS.SCI,WOS.SSCI. The document types were limited to "article" or "review," spanning from January 1, 2013, to November 25, 2023. English was selected as the language of focus due to its global predominance, evidenced by the extensive number of articles published in English.

Exclusion criteria were employed to eliminate i) non-academic literature, including conference papers, newspapers, and notes; ii) duplicate articles; and iii) irrelevant articles. The search queries are

detailed in Table 1. A total of 957 records were acquired, downloaded in plain text format, and supplemented with comprehensive records and references. Following that, the data was imported into CiteSpace 6.2.R6 for additional analysis.

Table 1. The search queries

Set	Search query	Results
#1	(((((((TS= (mobile phone addiction*)) OR TS= (smartphone addiction*)) OR TS=(mobile addiction*)) OR TS=(cell phone addiction*)) OR TS=(mobile phone dependence*)) OR TS=(cell phone dependence*)) OR TS= (smartphone dependence*)) OR TS=(problematic mobile phone use*) Editions: WOS.SCI, WOS.SSCI	3,706
#2	((((TS= (college student*)) OR TS= (university student*)) OR TS=(undergraduate*)) OR TS= (undergraduate student*)) Editions: WOS.SCI, WOS.SSCI	265,030
#3	#1 AND #2 and Social Sciences Citation Index (SSCI) or Science Citation Index Expanded (SCI-EXPANDED) (Web of Science Index) and Article or Review Article (Document Types) and English (Languages) and 2013-2023 (Publication Years) Editions: WOS.SCI, WOS.SSCI	957

Signifies a prefix for the serial numbers

2.2. Analysis tool

CiteSpace 6.2.R6, based on the Java platform created by Chen [40], serves as a type of information visualization technology appropriate for a variety of real-time, dynamic, and varied analyses of intricate networks. It helps determine the essence of research boundaries, labels key terms, and detects developing trends and abrupt changes across time [41]. The plain text files, with the file name "download_xx," were downloaded and then imported into CiteSpace 6.2.R6 to convert the format and remove duplicate documents. Microsoft Excel 2013 was used to generate line graphs illustrating the annual distribution of published research quantity. The study used a one year time slice and the g-index as the selection criterion to analyze data from 2013 to 2023.Various pruning methods were configured to produce an intuitive, concise map.

Utilizing CiteSpace 6.2.R6, an array of analyses was conducted to explore collaborative networks among authors, countries, and institutions, along with investigations into co-cited documents, cited journals, cluster analysis, co-occurring keywords, burst detection of keywords, and a timeline view of MPA among college students. Lots of nodes and linkages were made in each of the several maps that were made. A node's size indicates the average frequency or number of publications, and its color indicates the year of first appearance. Similarly, linkages show co-citation or collaborative relationships, and the year of first occurrence is indicated by the color of the link [42]. The degree of connectivity is indicated by the thickness of the connections.

Betweenness centrality is a quantitative indicator of a node's significant position in a network by calculating the fraction of shortest pathways in the network [41]. A node with high betweenness centrality often represents a crucial hotspot or turning point in the field, linking two or more sizable node groups and the node itself, which is denoted by a thick purple border [43]. The degree of centrality is indicated by the thickness of the purple border. High centrality nodes are thought to be crucial locations in the field [44].

3. RESULTS AND ANALYSIS

3.1. Annual publications

The distribution of research literature in a particular academic discipline or field across different time periods can assist in identifying the developmental stages and trends within that discipline or field [45]. Our analysis included a total of 957 records. As seen in Figure 1, we constructed a line graph displaying the years on the x-axis and the number of publications on the y-axis.

The research intensity in the field of College students' MPA exhibits an overall steady upward trend. Upon closer examination, it can be divided into two distinct periods. The period from 2013 to 2019 represents a phase of slow development, with annual publication volumes consistently below 100 papers. This suggests that scholars paid relatively little attention to the issue of college students' MPA during this period. In contrast, the period from 2020 to 2023 marks a phase of rapid development, with average annual publication volumes exceeding 100 papers. Notably, in 2022, the field reached its peak with 220 publications, reflecting the increasing scholarly interest in the research area. With 152 articles as of mid-November 2023, despite a minor decline in publications, this suggests that college students' MPA is still a major area of academic research.

3.2. Co-author analysis

We utilized CiteSpace 6.2.R6 to analyze the author collaboration network, which allowed us to discover prominent writers in the area, cooperative groups, and authors with significant publishing quantities. Figure 2 displays the collaborative network, highlighting several cooperative groups with 682 linkages and 388

nodes. The number of publications and node size are correlated; more publications are indicated by bigger nodes. Cooperation is shown by linkages between writers, and the degree of the cooperation is indicated by the thickness of the links. The colors represent the timeframe from 2013 to 2023 and range from cool to warm.

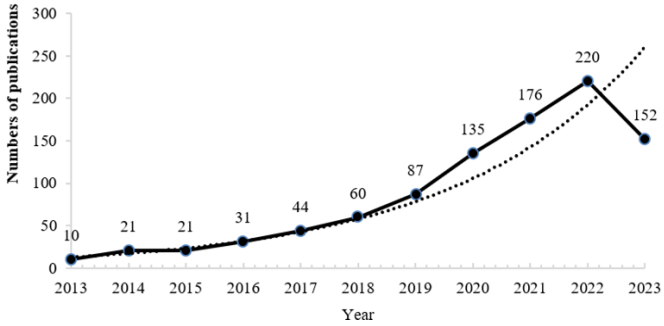

Figure 1. Publication volume trend (2013-2023)

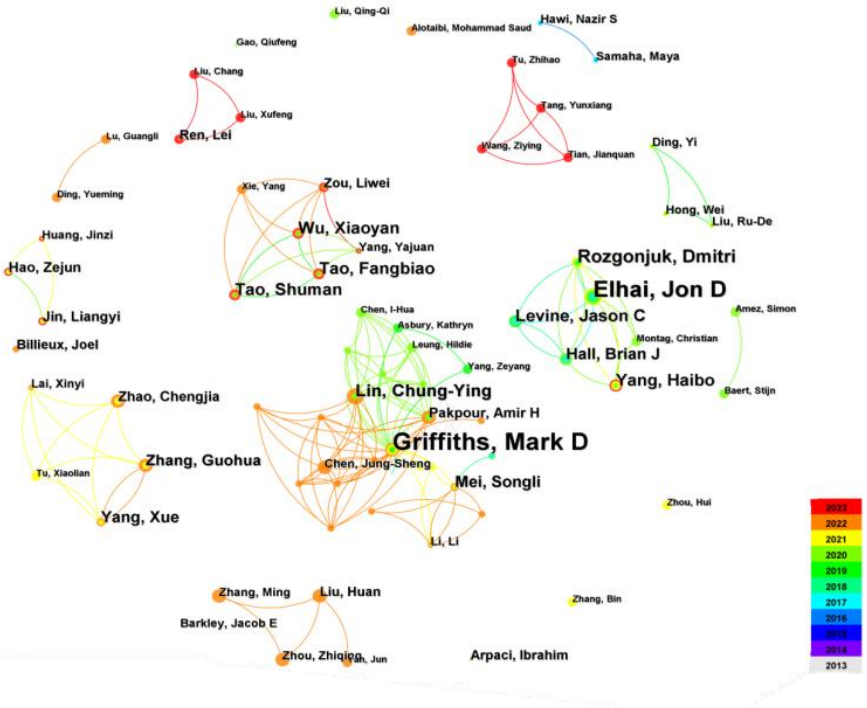

Figure 2. The network map of co-authors

Griffiths, Mark D. ranks first in terms of publication quantity, with 33 articles, constituting 3.4% of the total publications. His highest citation article suggests that personality traits can explain various addictive behaviors, including MPA, Facebook addiction, and video game addiction [46]. With 24 articles, Jon D. Elhai holds the second position. In his most widely recognized paper, he systematically investigated the connection between psychopathology and problematic utilization, consistently finding links between MPA, anxiety, and depression. When it came to small to medium effects, stress was also consistently associated, but when it came to self-esteem, the results were inconsistent and small to medium [47]. The publications of other authors in the top 15 vary from 6 to 11 articles. Among the top 15 authors, certain consistent networks of collaboration have emerged, such as Griffiths, Mark D., Lin, Chung-Ying, and Pakpour; Elhai, Jon D., Rozgonjuk, Dmitri, Levine, Jason C., and Hall Jason C., Levine, Dmitri, Elhai, Jon D., Rozgonjuk, Jason C., and Hall Jason C. also works closely with others. International cooperation is still comparatively modest. We anticipate fostering greater exchange among scholars from different countries. Additionally, only Mark D. Griffiths has a centrality value of 0.01, indicating a scarcity of authoritative or influential scholars in the field of college students' MPA.

3.3. Country and institution analysis

Utilizing CiteSpace 6.2.R6, we conducted an analysis of the collaborative networks among countries and institutions. The collaborative networks between these countries reflect a worldwide interest and cooperative effort in tackling the issue of MPA among college students. Figure 3 and Table 2, with 309 linkages and 80 nodes, reflect the global interest and cooperative effort in addressing the issue of MPA among college students. The United States and China are the two countries with the greatest nodes, and higher centrality is indicated by the thicker purple trim. The top five countries collectively published 778 papers (81.3%), with China contributing 422 papers (44.1%), USA 163 papers (17.03%), Turkey 76 papers (7.94%), the United England 70 papers (7.31%), and Spain 47 papers (4.91%). Each country has created a solid, close-knit network of cooperation. The top five countries in terms of centrality are the United States (0.37), China (0.31), England (0.31), Australia (0.23), and Spain (0.22). This indicates that USA, China, and England have a significant impact on research related to college students' MPA.

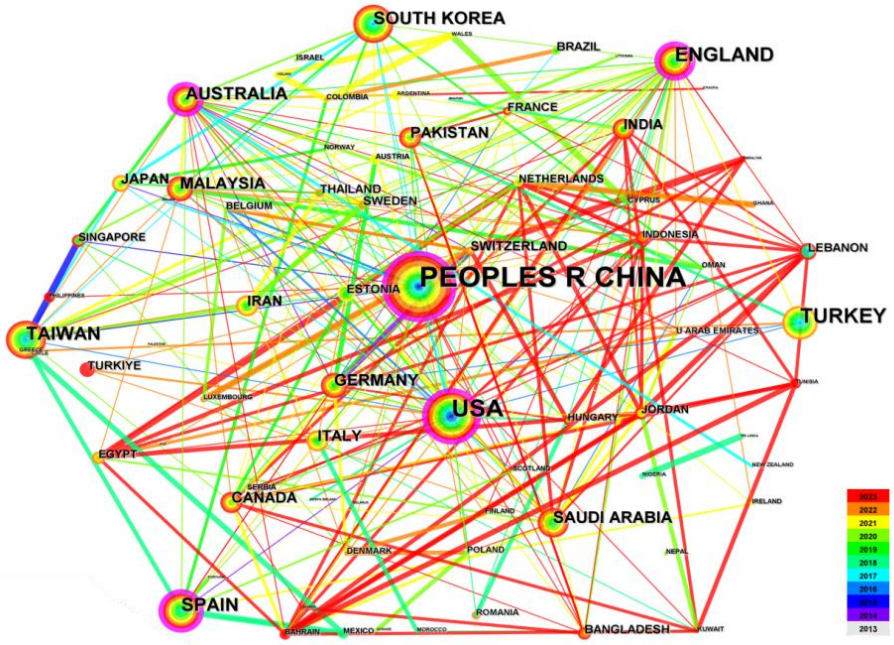

Figure 3. The network map of countries

As can be seen in Table 2, the top 5 institutions are all colleges. The top five universities in terms of quantity are Nottingham Trent University (37 papers, 3.87%), Toledo University (26 papers, 2.61%), Beijing Normal University (22 papers, 2.3%), Macau University (20 papers, 2.09%), and Tianjin Normal University (20 papers, 2.09%). Nottingham Trent University has made significant contributions in this field, ranking first in both publication quantity and centrality. Nonetheless, it is noteworthy that only the top three institutions possess centrality values exceeding 0.1, the centrality values suggest that Nottingham Trent University, Toledo University, and Beijing Normal University play more central roles in the collaborative network, while other institutions have a less pronounced impact on the overall connectivity of the network.

3.4. Analysis of cited journals

We conducted co-cited analysis of journals using CiteSpace 6.2.R6, demonstrating the importance of various publications and fields. Table 3 lists the top five journals ranked by both citation frequency and centrality, highlighting an intriguing lack of correlation between these two metrics. In terms of citation frequency, the American journal "Computers In Human Behavior" leads with 810 times, followed by "PLoS One" (633 times) and "Journal of Behavioral Addictions" (630 times). The journals with the highest centrality are "PLoS One" (0.05), "Addictive Behaviors" (0.05), and "Personality and Individual Differences" (0.05), the remaining two journals occupy the third position, each with a centrality measure of 0.04.

The findings imply that research on MPA is consistently published in journals that focus on psychology, behavior, or psychiatry. Papers on MPA among college students are numerous but spread across different journals. With an impact factor of 9.9 in 2023, "Computers In Human Behavior" emerges as the journal with the highest frequency of citations. Its focus is on the scholarly investigation of computer usage

from the perspective of psychology. The journal discusses computer usage in psychology, psychiatry, and allied fields to explore the psychological effects of computer usage on individuals, groups, and the broader society. This publication is quite prominent in the subject of psychology since the majority of its articles relate with human psychological behavior.

Table 2. The top 5 universities on the list according to volume and centrality of publications

Rank	Ranked by publication volume		Ranked by centrality	
	Institution	Number	Institution	Centrality
1	Nottingham Trent University	37	Nottingham Trent University	0.13
2	Toledo University	26	Macau University	0.12
3	Beijing Normal University	22	Beijing Normal University	0.11
4	Macau University	20	Guangzhou University	0.06
5	Tianjin Normal University	20	Shenzhen University	0.06

Table 3. The list's top five journals according to citation frequency and centrality

Rank	Ranked by cited frequency		Ranked by centrality	
	Journal	Number	Journal	Centrality
1	Computers in Human Behavior	810	PLOS One	0.05
2	PLOS One	633	Addictive Behaviors	0.05
3	Journal of Behavioral Addictions	630	Personality and Individual Differences	0.05
4	Cyberpsychology, Behavior, and Social Networking	477	Journal of Personality and Social Psychology	0.04
5	International Journal of Environmental Research and Public Health	455	European Psychiatry	0.04

3.5. Analysis of cited references

The 10 most frequently co-cited references are presented in Table 4, arranged by frequency. The main source, a 143-citation systematic review by Elhai JD [47], examines the connection between psychopathology and MPA, concentrating on depression, anxiety, stress, and low self-esteem among college students. The second article, written by Samaha M [48], explores the association between MPA and perceived stress, academic performance, and life satisfaction. The third co-cited reference recommends to adopt the term "problematic mobile phone use" to characterize the issue, contending that there is inadequate evidence to classify MPA from the perspective of addiction [49].

Table 4. The list's top 10 studies by frequency of co-citations

Rank	Author	Co-cited reference	Frequency
1	[47]	Problem smartphone use was consistently related to psychopathology.	143
2	[48]	The risk of smartphone addiction was found to have a positive correlation with perceived stress.	105
3	[49]	The behaviors documented in the study might more accurately be described as problematic or maladaptive smartphone usage.	104
4	[50]	Depression, anxiety, and sleep quality issues may be linked to excessive smartphone use.	91
5	[51]	There is limited evidence to support the classification of mobile phone addiction as an addictive behavior.	82
6	[52]	Smartphone addiction was prevalent among the medical college students studied. The research found links between smartphone usage, psycho-behavioral factors, and smartphone addiction.	81
7	[53]	Depression and anxiety scores were identified as independent positive predictors of smartphone addiction among university students.	80
8	[54]	The revised I-PACE model offers a theoretical framework for elucidating the process of addictive behaviors, integrating psychological and neuroscientific theories related to substance-use disorders and behavioral addictions.	71
9	[23]	Problematic smartphone use (PSU) was observed in roughly one out of every four children and adolescents, and was associated with a higher likelihood of diminished mental health.	69
10	[55]	Process-related smartphone usage is a significant factor in the development of both habitual and addictive behaviors related to smartphone use.	67

The top 10 studies ranked by centrality are shown in Table 5. The Smartphone addiction scale (SAS), with a centrality of 0.17, suggests that the first reference is frequently used to evaluate MPA [56]. Chen SK [57] uses latent profile analysis in the second-ranked literature, contending that increased problematic Internet use correlates with a higher risk of adverse psychological well-being. The reference that comes in third place has the highest co-citation frequency, indicating that it has a substantial impact on the research on MPA among college students [47]. Reviewing these references in Tables 4 and 5, it becomes apparent that most studies focus on the characteristics of MPA, its associations with psychopathology and psychological issues, as well as the assessment and outcomes of MPA. Additionally, high-quality guidelines and systematic reviews are evident in the literature.

Table 5. Top 10 studies in the list by co-citation centrality

Rank	Author	Co-cited reference	Centrality
1	[56]	The Smartphone Addiction Scale (SAS) has been demonstrated to be relatively reliable and valid.	0.17
2	[57]	Greater problematic Internet use increased the likelihood of disadvantageous psychological well-being.	0.14
3	[47]	Problem smartphone use was consistently related to psychopathology.	0.1
4	[58]	A diagnostic manual for mental disorders and statistics.	0.1
5	[59]	The 8-item Cannabis Use Disorders Identification Test-Revised (CUDIT-R) has shown enhanced performance compared to the original scale and seems well adapted for screening problematic cannabis use.	0.1
6	[60]	Problematic smartphone use was most strongly associated with the fear of missing out and inversely related to depression. Behavioral activation mediated the relationships between smartphone use and both anxiety and depression.	0.07
7	[61]	Dependency on wireless mobile devices can lead to anxiety in the absence of the device.	0.07
8	[62]	The study involves adapting the short version of the Smartphone Addiction Scale (SAS-SV) into both Spanish and French.	0.06
9	[63]	Cell phone use and texting were found to have a negative relationship with GPA and a positive relationship with anxiety.	0.06
10	[5]	The severity of problematic smartphone use (PSU) was related to the number of minutes spent on screen time, but not to the frequency of phone screen unlocking. Conversely, the severity of depression and anxiety was not related to screen time minutes but was negatively correlated with the frequency of phone screen unlocking.	0.05

3.6. Analysis of co-occurring keywords

We conducted co-occurrence keyword analysis using CiteSpace 6.2.R6. We pruned the map and combined terms with similar meanings to improve clarity. With 471 nodes and 785 linkages, we produced a keyword network map. Larger nodes indicate higher keyword frequency, as shown in Table 6 and Figure 4. Cool colors indicate earlier appearance, warm colors denote recent emergence, and a thick purple border signifies higher centrality. An article's main abstract is formed by its keywords, which may also serve as a representation of popular subjects. Greater influence is indicated by terms with high centrality in the field of MPA. In terms of MPA, keywords with high centrality indicate a more substantial influence.

Apart from "mobile phone addiction" and "college student," other frequently occurring keywords include "internet addiction" (frequency 285), "adolescent" (frequency 257), "depression" (frequency 250), and "anxiety" (frequency 239). High centrality keywords primarily include "alcohol use" (centrality 0.31), "attitude" (centrality 0.29), "Facebook" (centrality 0.23), and "behavior" (centrality 0.22). The keywords suggest a tight relationship between psychopathology and psychological problems including anxiety and depression, and MPA among college students. Researchers are also interested in its relationship with internet addiction and alcohol use. Various standardized scales are being designed and applied to measure MPA more systematically.

Table 6. Top 10 keywords in the list by co-citation frequency/centrality

Rank	Ranked by co-citation frequency		Ranked by centrality	
	Keyword	Frequency	Keyword	Centrality
1	Mobile phone addiction	562	Alcohol use	0.31
2	College student	425	Attitude	0.29
3	Internet addiction	285	Facebook	0.23
4	Adolescent	257	Behavior	0.22
5	Depression	250	Dependence	0.19
6	Anxiety	239	Internet addiction	0.15
7	Addiction	226	Game addiction	0.15
8	Mobile phone	165	Adjustment	0.15
9	Mobile phone use	124	Cell phones	0.15
10	Stress	110	Personality	0.14

3.7. Analysis of keyword clusters

In our study, we utilized the Log-Likelihood Rate (LLR) algorithm for clustering in the keyword network. The clustering analysis relies on the similarity, dissimilarity, and affinity of keywords, dividing them into relatively homogeneous modules. Cluster names were obtained by taking the feature word in a cluster with the highest LLR score and extracting cluster labels from abstracts, titles, or keywords. Silhouette and Modularity Q are two essential metrics for assessing clusters. The network's modularity is denoted by Modularity Q, which has values between 0 and 1. Better clustering outcomes and a more distinct subdomain identification are indicated by larger values. Q>0.3 indicates that the network is significant [64]. The silhouette, which ranges from 0 to 1, depicts the clusters' effectiveness and measures the homogeneity of the network. A higher value indicates closer connections between nodes within the cluster. S>0.7 signifies convincing clusters, while S>0.5 indicates reasonable clusters [65].

We created 20 clusters in total for our study, Figure 5 shows the first 10 that we colored differently. The clustering findings are meaningful and compelling, as indicated by a Q value of 0.756 and a Silhouette value of 0.8745. Table 7 shows the keyword clusters together with the terms they include. The first three

clusters are "psychological well-being", "social media" and "physical exercise". The largest clustering of "psychological well-being" indicates a significant emphasis on exploring the relationship between MPA and psychological well-being [47], [66]. According to the second-largest cluster, "Social Media," the majority of recent research focuses on the connection between social media use and MPA [67], as well as their impact on college students' academic performance and mental health [68]–[70]. The third-largest cluster, "Physical Exercise," is associated with research indicating that physical exercise significantly negatively predicts the tendency of MPA. Furthermore, it is shown that the relationship between physical exercise and MPA is entirely mediated by psychological resilience and self-control [14], [71]. Overall, the top ten clusters indicate that the majority of research is dedicated to describing the connections between MPA and mental health, behavioral addiction, and social media addiction. Additionally, network analysis and latent profile analysis are applied in the study of MPA.

3.8. A timeline perspective analysis

CiteSpace 6.2.R6 was utilized to produce a timeline perspective analysis. The relationships between clusters and the changes in keywords over time are shown in the timeline view. Various colors correspond to distinct clusters. Overall, as Figure 6 shows, there has been an increase in the quantity of keywords over the last ten years, suggesting that MPA among college students is an important area for further study. Throughout the duration of the decade, Clusters 0, 1, and 2 consistently had the largest number of terms, showing that academics were particularly interested in the connections between college students' MPA and social media, exercise, and psychological well-being. Keywords within clusters #0 (psychological well-being), #5 (mental health), and #8 (behavioral) were initially sparse in 2013 but have experienced explosive growth in recent years, indicating increased scholarly attention to these clusters. From a timeline perspective, it is notable that in 2023, there are many keywords such as esteem, chain mediation, structural equation modeling, and cumulative ecological risk. All these issues represent current research hotspots in the study of MPA among college students.

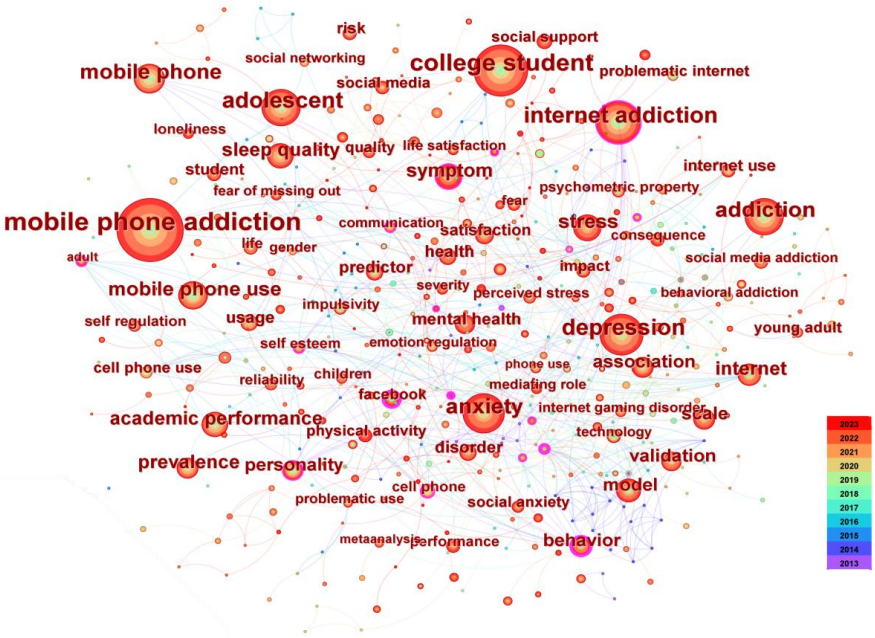

Figure 4. Map of co-occurring keywords

3.9. Keywords with citation burst

The bursts of keywords were shown using CiteSpace 6.2.R6. Kleinberg's technique is the basis for burst detection, which helps to discover keywords that have seen spikes in activity and extract significant structures from the document flow [72]. Keyword burstiness can illustrate the temporal distribution and dynamic trends of keywords during specific time intervals, aiding in a deeper understanding of historical and present hotspots. Figure 7 shows the 33 most prominent bursts. The red line denotes keyword burstiness, while the blue line shows the time intervals [73]. As depicted in the figure, these hotspots can be described in three

stages. The first stage, from 2013 to 2015, focused on issues such as college students' mobile phone dependence, problematic internet use, personality traits, self-esteem, impulsivity, gender differences and predictive factors in addiction problems. From 2016 to 2020, the psychometric characteristics of MPA and its associations with substance use, social networking, behavioral addiction, and internet addiction became the hotspots during this period. The latest research hotspots emerge in 2021 to 2023. Currently, general strain theory, physical activity, and the addiction to social media are emerging as prominent subjects in the examination of MPA among college students.

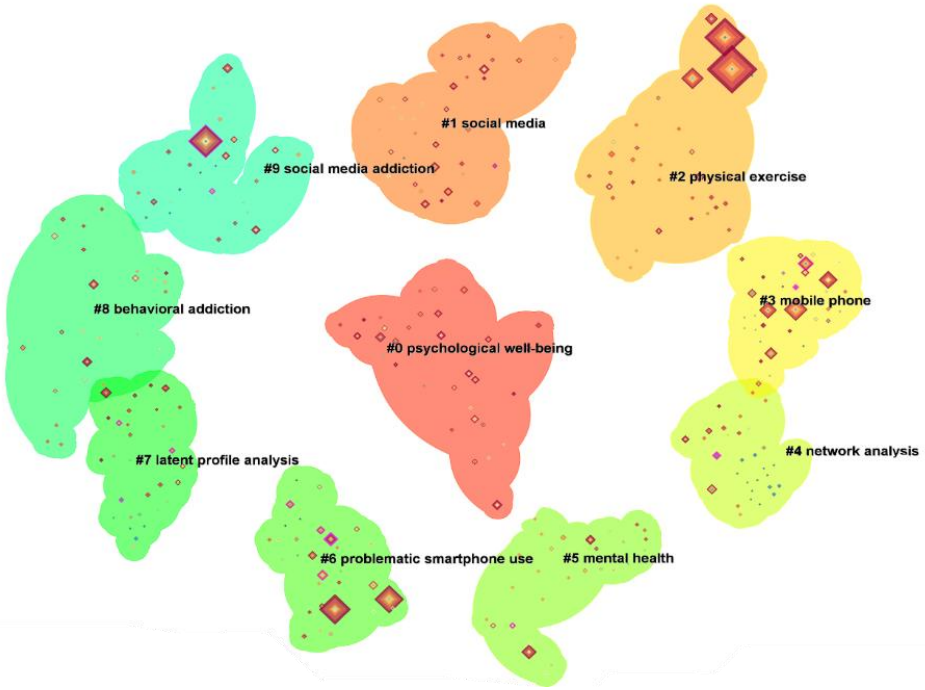

Figure 5. Keyword cluster map

Table 7. Keyword clusters together with the terms they include

Cluster	Label	Size	Silhouette	Keywords (log-likelihood ratio, p-level)
0	Psychological well-being	38	0.778	Psychological well-being (17.69, 1.0E-4); social capital (11.14, 0.001); fear of missing out (10.56, 0.005); self-esteem (10.44, 0.005); emotion regulation (8.77, 0.005)
1	Social media	38	0.92	Social media (9.62, 0.005); a mediation model (8.15, 0.005); internet dependence (8.15, 0.005); fear of missing out (fomo) (7.75, 0.01); boredom proneness (7.19, 0.01)
2	Physical exercise	34	0.829	Physical exercise (17.11, 1.0E-4); university students (14, 0.001); mobile phone addiction (13.16, 0.001); smartphone addiction (13.07, 0.001); academic burnout (11.79, 0.001)
3	Mobile phone	33	0.876	Mobile phone (22.28, 1.0E-4); self-esteem (11.44, 0.001); turkey (9.94, 0.005); marketing (9.94, 0.005); physical activity (8.63, 0.005)
4	Network analysis	31	0.964	Network analysis (26.1, 1.0E-4); and dependence (15.86, 1.0E-4); bridge node (15.86, 1.0E-4); electronic health technology (15.86, 1.0E-4); ecological momentary assessment (ema) (15.86, 1.0E-4)
5	Mental health	31	0.876	Mental health (8.86, 0.005); mhealth (8.09, 0.005); young people (8.09, 0.005); problematic smartphone use (7.13, 0.01); alcohol (6.98, 0.01)
6	Problematic smartphone use	31	0.855	Problematic smartphone use (11.34, 0.001); smartphone addiction (10.26, 0.005); student smartphone use (9.55, 0.005); smartphone dependence (9.55, 0.005); cell phone use (7.71, 0.01)
7	Latent profile analysis	30	0.837	Latent profile analysis (15.38, 1.0E-4); ecological momentary assessment (14.74, 0.001); COVID-19 pandemic (13.22, 0.001); gaming addiction (11.73, 0.001); chinese university students (10.69, 0.005)
8	Behavioral addiction	27	0.851	Behavioral addiction (21.75, 1.0E-4); physical activity (7.78, 0.01); emerging adulthood (7.34, 0.01); burnout (7.34, 0.01); sedentary behavior (7.34, 0.01)
9	Social media addiction	26	0.907	Social media addiction (24.69, 1.0E-4); internet gaming disorder (22.74, 1.0E-4); social anxiety (18.77, 1.0E-4); attachment anxiety (15.42, 1.0E-4); internet addiction (10.84, 0.001)

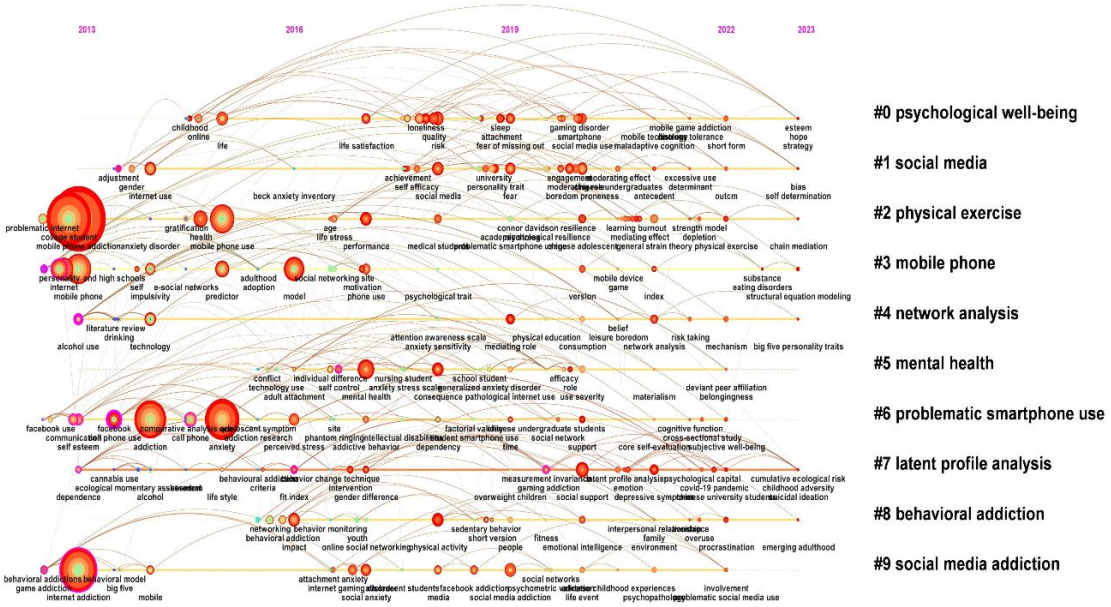

Figure 6. Timeline visualization of keywords

4. DISCUSSION

This study utilized CiteSpace 6.2.R6 for bibliometric analysis of literature concerning college students' MPA over the past decade within the scientific network. The resulting tables and maps provide a clearer and more understandable depiction of the frontiers, status, and research hotspots. Over the preceding decade, there has been a consistent rise in the volume of publications addressing this subject, suggesting that more researchers are making an attempt to publish studies on the MPA among college students. Universities and medical institutions in China, US, UK, and Australia have delved most deeply into research in this field, contributing the most articles and having the greatest impact. Mark D. Griffiths is the most prolific author, having published 33 articles. While stable collaborative networks have formed among the top 15 authors, including Griffiths, Mark D., Lin, Chung-Ying, Pakpour, Amir H., Elhai, Jon D., Rozgonjuk, Dmitri, Levine, Jason C., and Hall Jason C., they also collaborate closely. Collaboration levels between countries remain relatively low. Griffiths has a centrality value of 0.01, indicating a scarcity of authoritative or influential scholars in the field of college students' MPA.

The majority of the currently available publications were published in psychiatric, behavior, or psychology journals. Computers In Human Behavior, which covers computer usage in psychology, psychiatry, and allied fields, is the most often referenced journal. Most studies focus on the characteristics of MPA, its associations with psychopathology and psychological issues, as well as the assessment and outcomes of MPA. Future research will likely focus on intervention experiments to identify effective measures for addressing MPA. Additionally, exploring the complex connections between MPA and other health-related behaviors such as social media use, internet addiction, and physical exercise will be pursued through more rigorous studies.

4.1. Cooperation is necessary

Research contributions in the topic of MPA among college students are distributed in a highly unequal manner, despite the substantial efforts made by different authors and countries. China and the US are at the forefront of this field's study; the US, China, and the UK are ranked in the top three for centrality, demonstrating their major influence. China accounts for three out of the top five institutions, followed by the US and the UK. It seems that just a tiny portion of articles in this topic come from other countries. We hope for enhanced international collaboration among countries and institutions in this field of study. Within the co-authors network, authors have established diverse cooperation networks, with the majority of these networks being limited to small groups. The most productive author, Mark D. Griffiths, links three networks of cooperation, implying that authors can publish more articles through collaboration and emphasizing the advantages and significance of collaboration. Hence, it is essential to expand authors' connections, delve deeper into the research on MPA, and produce high-quality literature. This way, research literature will have broader global applicability.

Top 33 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2013 - 2023
problematic internet	2013	8.64	2013	2018	
personality	2013	7.02	2013	2019	
dependence	2013	5.46	2013	2017	
mobile phones	2013	5.18	2013	2018	
cell phones	2013	3.12	2013	2016	
self esteem	2013	2.86	2013	2017	
impulsivity	2014	5.88	2014	2017	
cell phone use	2014	4.86	2014	2019	
facebook	2014	4.54	2014	2018	
gender	2014	3.11	2014	2017	
predictor	2015	5.32	2015	2017	
social networking	2015	3.59	2015	2016	
mobile phone use	2015	2.5	2015	2016	
substance use	2016	3.36	2016	2018	
networking	2016	3.15	2016	2019	
psychometric property	2016	2.51	2016	2018	
cellular phone	2016	2.5	2016	2017	
behavioral addiction	2016	4.19	2017	2019	
social networking site	2017	3	2017	2019	
online social networking	2017	2.5	2017	2019	
self regulation	2018	4.34	2018	2018	
internet addiction	2013	3.47	2018	2018	
smartphone usage	2018	2.94	2018	2020	
media	2018	2.62	2018	2020	
model	2016	2.53	2018	2018	
nomophobia	2019	3.35	2019	2021	
nursing students	2020	3.3	2020	2021	
use severity	2020	2.94	2020	2021	
general strain theory	2021	3.2	2021	2023	
risk factor	2018	2.99	2022	2023	
physical activity	2018	2.74	2022	2023	
sleep	2019	2.62	2022	2023	
social media addiction	2019	2.61	2022	2023	

Figure 7. Top 33 Keywords with the strongest citation bursts

4.2. The research hot spots

Keyword clustering classifies keywords using specific algorithms. Keywords are brief summaries of literature. Combining keyword analysis with clustering allows us to identify three research hotspots in this field.

4.2.1. Prevalence of MPA and individual differences

MPA refers to prolonged use of a mobile phone, an inability to control the duration of mobile phone usage, and experiencing uneasiness and anxiety without a mobile phone, negatively affecting an individual's learning and interpersonal communication [1]. It is frequently described as a behavioral addiction that includes salience, emotional tolerance, withdrawal, modification, conflict, and relapse [74]. More and more studies are pointing out that MPA may interfere with regular functioning, harm social interactions, and have adverse impacts on both physical and mental well-being [23], [75]–[77].

Studies on MPA frequency among college students have been steadily increasing over the last ten years. Since different standards, methods, tools, and samples are used to measure MPA, the prevalence of MPA in this group of college students is highly diverse. Prevalence of MPA among college students worldwide ranges from 6.36% to 62% [18], [78]–[80]. It's interesting to note that there are some distinctions between the more current research and the earlier literature. The predominant focus of early research has been on personality qualities like impulsivity and esteem as well as gender differences in problems with addiction [52], [81], [82]. However, recent literature is more inclined to focus on different patterns of MPA [1], [83], [84]. As research

progresses, we will delve further into various patterns of MPA issues among college students. As a result, we can better comprehend MPA issues across various user patterns, which will enable us to create future intervention strategies that are specifically designed for diverse user groups.

4.2.2. The associations between MPA and physical and mental health

Among the top 10 keywords with co-citation frequencies, terms such as "psychological well-being" and "mental health" were prominent. Additionally, Cluster 2, focused on "physical exercise," encompassed more keywords. More publications were investigating the correlation between MPA and mental as well as physical health, recognizing their intricate and bidirectional interactions.

The realm of mental health concerns encompasses a spectrum of adverse affective states, comprising but not limited to, depression, anxiety, and stress. College students undergo numerous changes during their university experience, making them more susceptible to mental health issues arising from academic pressure, social interactions, and work-related challenges. Elhai *et al.* [47] conducted a systematic review to investigate the correlation between depression, psychopathology, anxiety, and smartphone usage. Even though the impact sizes were modest, the research discovered a consistent association between anxiety and problematic smartphone utilization. Furthermore, A notable correlation was identified between the degree of depression and problematic smartphone usage, indicating moderate to high effect sizes. In a subsequent investigation by Elhai *et al*. [66], the mediating role of fear of missing out (FOMO) between depression, anxiety, and problematic smartphone use (PSU) severity was explored. Engaging 1,034 Chinese undergraduate participants through an online survey, the study measured variables including smartphone use frequency, PSU, depression, anxiety, and FOMO. The findings posited FOMO as a pivotal element elucidating the association of certain psychopathologies, like anxiety, with PSU. Several studies have examined the relationship between stress and MPA, and have found evidence of a positive relationship between the two. According to Gao *et al.* [85], stress is a significant predictor of MPA. People who experience more stress are more likely to become addicted to their phones [86]. Although the above studies show that MPA behavior is related to mental distress such as anxiety and depression. However, it is still necessary to theoretically explain the relationship between psychological factors (including anxiety, depression and stress) and MPA. Compensatory internet use theory (CIUT) appears to make the connection between psychopathic symptoms and excessive Internet use more explicit [87]. According to CIUT, a lot of people try to lessen the stress brought on by unpleasant emotions by using the Internet excessively after going through stressful life events (such as MPA). Of course, people can also abuse drugs, and alcohol to accomplish similar goals, but due to their practicality and accessibility, mobile phones may now be the most popular items [47].

Research on the college student population indicates that a decrease in physical activity contributes to poor health outcomes [88]. Research conducted by Pereira *et al*. [89] revealed that inactive adolescents are more likely to experience MPA compared to their physically active counterparts. Additionally, girls are more prone to MPA issues than boys. Excessive smartphone usage might result in diminished physical activity levels, as many individuals prefer using these devices over engaging in recommended physical exercises [90]. A study suggests that physical exercise can, to a certain extent, reduce MPA, with self-control playing a significant mediating role. Improving self-control through physical exercise might be an effective approach to addressing MPA issues among college students or other young individuals worldwide [91]. Currently, cross-sectional and longitudinal evidence regarding the connection between physical activity and MPA remains ambiguous. Researchers are recommended to consider physical activity and MPA to be associated behaviors, which means that in order to support future findings, high-quality research involving a variety of groups must be conducted.

4.2.3. The associations between MPA and social media

Within the top 10 co-citation frequency keywords, clusters 1 and 9 are associated with "social media" and "social media addiction," respectively. Additionally, within the top 33 burst keywords, notable terms include "social networking," "Facebook," and "social media addiction," indicating these as prominent and trending topics in the field. The pervasive influence of social media is evident, particularly within the realm of contemporary communication, with a notable impact on college students. Social media platforms, including Facebook, Twitter, and Instagram, have undergone a transformative evolution, reshaping interpersonal interactions and gaining substantial popularity among young adults, specifically college students [92]. Concurrently, the escalating utilization of social media correlates associated with a heightened tendency toward addictive behavior regarding this technological advancement. Studies have identified a correlation between addiction to social media and various adverse outcomes. These encompass a decline in productivity [93], the cultivation of unhealthy social relationships [94], and a reduction in overall life satisfaction [95].

Social media use, which often occurs on mobile phones, has been recognized as a potential factor contributing to mobile phone dependence. According to a study by Salehan and Negahban [96], those who use social networking sites (SNS) more frequently and with a greater number of connections are more likely to

download and use mobile social networking site applications. Research demonstrates that MPA is significantly predicted by the use of mobile social networking site applications. Lopez-Fernandez *et al*. [97] investigated the prevalence and correlates of mobile phone dependence in young adults across seven European countries. The findings of the study indicate a positive association between the usage of SNS and mobile phone dependence. The authors posit that the engagement with SNS may serve as a contributing factor to the emergence and development of mobile phone dependence.

In relation to the association between social media and MPA, research suggests that smartphones provide adjustable and unrestricted means to gather information, experience enjoyment, and interact with minimal obstacles, leading users to feel compelled to use their mobile devices. Certain categories of social media applications (such as WhatsApp, and Facebook) have been found to positively correlate with happiness, yet the persistent connectivity trend has given rise to a range of issues related to MPA [98]. Smartphones may contribute to the sharing of innate reflections or experiences within a user's social network. Self-centered adolescents, seeking validation, particularly as a way to overcome social exclusion on social media, may experience adverse effects [99], ultimately resulting in counterproductive behavioral patterns [100]. Early adolescent egocentrism, characterized by increased validation-seeking, predicts subsequent disclosures on social media, MPA, and interaction pressure [101], [102]. Smartphones can facilitate the sustained use of social media by adolescents to fulfill intentions of building confidence, relationships, and social attention [103], thereby generating increased levels of stress and dependency associated with these devices [99].

Furthermore, some studies analyze social media addiction from the perspective of technological use. Social media, characterized as feature-rich information technology, is acknowledged for providing elevated levels of perceived usefulness and usability [104]. It caters to diverse user needs [105] and establishes diverse frameworks within distinct usage contexts [106]. For example, an individual's encounters with social overload, exposure, and invasion on social media may result in the perception of social media as a source of stress. However, in response to these stressors, individuals may opt to utilize other features within the same social media application as a means of diverting attention from negative experiences, essentially treating it as a distraction. Notably, researchers have identified that the concurrent interpretation of social media as both a stressor and a distractor can serve as a predictor for addictive usage patterns [106]. This dual role of social media, as both a source of stress and a potential coping mechanism through distraction, underscores the intricate dynamics influencing users' addictive behaviors in the realm of technological engagement.

Despite the existing research investigating the relationship between social media and MPA, a predominant proportion of these studies adopts a cross-sectional approach. For future inquiries, it is imperative to undertake extensive longitudinal studies on a large scale to substantiate the intricate mechanisms that underlie the relationship between social media usage and MPA. Additionally, the incorporation of path analysis offers a versatile tool with variable directions, enabling the identification of more effective and feasible intervention measures. Delving into indirect relationships can further augment current findings and contribute to a more holistic comprehension of the dynamics involved.

Moreover, if practical, scholars and clinical experts are encouraged to apply relevant theories to intervene in the mediation or moderation of factors. This proactive approach involves exploring avenues for mitigating the impact of social media on MPA by considering theoretical frameworks that address underlying mechanisms. Such endeavors not only contribute to academic advancements but also have practical implications for the development of targeted intervention strategies in the realm of technology-induced addictive behaviors.

4.3. College students' MPA development trends and frontiers

4.3.1. The development trends of hot spots

The research on MPA among college students can be categorized into three phases, as revealed by the analysis of timeline views and keyword citation bursts. During the initial stage spanning from 2013 to 2015, the research hotspots in keywords citation burst were college students' mobile phone dependence, problematic internet use, personality traits, self-esteem, and impulsivity, as well as gender differences and predictive factors in addiction problems. From the perspective of the timeline, the key areas of focus for researchers during this period were MPA, health, predictors, and anxiety. Clearly, the research during this period was primarily dedicated to providing a broad understanding of the current situation of MPA, its influencing factors, and the consequences it may lead to [82]. The research during this phase aimed at providing a comprehensive understanding of the landscape of MPA, its influencing factors, and potential consequences. Notably, scholars in this stage lacked an in-depth understanding of these research subjects, and their efforts were geared towards swiftly gaining an overall comprehension of college students' MPA. Personality emerged as a prominent research hotspot during this period, and personality was defined as a collection of psychological characteristics that are connected to emotions, thoughts, and behaviors [107]. several hypotheses have been posited about personality structure; the most well-known being Eysenck's three-factor model and the big five personality traits. Eysenck's three-factor model comprises extraversion, psychoticism, and neuroticism [107]. MPA and

neuroticism and psychoticism are positively correlated, according to a recent meta-analysis on the association between Eysenck's personality traits and MPA [108].

The second stage, spanning from 2016 to 2020, witnessed scholars delving deeper into the concept of MPA. During this period, there was a more comprehensive exploration of the psychometric properties associated with MPA, offering a refined understanding of its meaning. In fact, substance use associated with MPA is often encompassed within broader studies that take into account users' lack of healthy lifestyle habits, along with symptomatology and psychiatric comorbidities [82]. From the psychological and neurobiological basis of addiction, personality issues, and psychiatric symptoms often coexist with substance use and behavioral addiction [109]–[111], as found in issues related to internet addiction [112]. This lays the groundwork for a deeper understanding of the psychometric properties of MPA issues. On the other hand, an increasing number of psychological measurement scales were designed, and additional research was conducted to validate their reliability and effectiveness, contributing to the maturation of measurement tools for MPA [113]–[115]. Additionally, some researchers have summarized existing research findings and authored guides or systematic reviews, providing a reference for interested scholars or clinical professionals [23], [47], [116].

From 2021 to the present, research factors have become more diverse, including emotions, environment, physical activity, interpersonal relationships, and social media addiction, making them hot points of study during this period. One reason for this broadening scope is the gradual increase in researchers' understanding of MPA. Another reason may be the significant changes in students' lives during the pandemic, impacting their mental and physical health as well as health-related behaviors. The changes in the environment have led students to rely more on smartphones to maintain interpersonal relationships and divert attention from negative experiences by browsing social media [117]–[119]. Furthermore, some studies have employed research methodologies such as latent profile analysis, structural equation modeling, and mediation analysis to understand the intricate relationships between two or more variables within specific populations or contexts [120]–[122]. Some theories, such as the general strain theory, have also been employed to explain the conceptual framework of perceiving stress as a predictive factor for MPA [86]. Observing the evolving trends in research hotspots is intriguing as it highlights the continuous deepening of studies in this field.

4.3.2. The research frontiers

In the context of keyword burst analysis, keywords exhibiting the strongest citation bursts hold significant utility in uncovering new trends and abrupt shifts in research focus. Notably, within the research hotspots of the third stage, general strain theory, risk factor, and physical activity emerge as the top three keywords with the most intense bursts. The strong citation bursts associated with these keywords suggest a surge in scholarly attention and activity, signifying the dynamic evolution and emergence of novel themes within the research landscape on college students' MPA during this stage.

In our analysis of early research on MPA, we found that the majority of previous studies in the field have been quantitative, employing methods such as cross-sectional surveys. The primary focus has been on the college student population, investigating prevalence rates, influencing factors, and consequences of MPA. However, there is currently a lack of qualitative and mixed-methods research to provide a deeper understanding of smartphone usage habits and potential undiscovered influencing factors in addictive use.

In terms of research methods, there is a need for longitudinal studies and randomized controlled trials to re-examine existing models and theories. This would help establish causal relationships between influencing factors and adverse outcomes of MPA, as well as identify effective interventions for MPA. Additionally, early research has predominantly concentrated on college students, and it is essential to shift attention to adolescents, children, or non-student samples. Comparative studies across different age groups or research on smartphone use and addiction in different countries, ethnicities, and cultural backgrounds are warranted.

Moreover, current assessments of MPA primarily rely on self-report questionnaires. There is a need to explore objective data, such as through smartphone applications, to obtain more accurate and authentic information. Furthermore, analyzing different types of MPA, such as smartphone gaming addiction or short video addiction, is necessary. This approach will help us gain a deeper understanding of the variations among different types of MPAs.

4.3.3. Strengths and limitation

The focal point of this study lies in its pioneering use of CiteSpace 6.2.R6 for conducting bibliometric analysis on the literature concerning college students' MPA spanning from 2013 to 2023. Employing visually informative knowledge maps and tables, we present a comprehensive portrayal of the developmental trends, research hotspots, and frontiers within the domain of college students' MPA. In addition, the incorporation of high-quality literature from the Web of Science Core Collection Database improves the dependability of our findings by providing helpful references and directing future paths for investigation.

However, there are several drawbacks to this study. The inclusion criteria were limited to English literature over the last ten years that was found in a specific database using a particular search query. Consequently, there exists the possibility that not all relevant literature was encompassed, and some less pertinent studies may have been included, potentially affecting the generalizability of the results. To address this limitation in future bibliometric analyses within this field, it is recommended to design a more refined search string that encompasses a broader range of literature, without constraints on language, document type, or publication time, if feasible. This approach would contribute to a more exhaustive and inclusive exploration of the literature landscape on college students' MPA.

5. CONCLUSION

This study conducted a visual analysis of relevant literature on MPA among college students, highlighting research hotspots and frontiers. Noteworthy areas of focus include the prevalence of MPA among college students, individual differences, and the intricate relationships between MPA and physical and mental health, as well as social media. The necessity of extending existing research is emphasized by the demand for randomized controlled trials and longitudinal research. By simplifying attempts to explore the frontiers of this topic, our study acts as a significant guide and reference for researchers to develop their future studies. Educators and clinical practitioners can implement targeted interventions and practices to address MPA issues among students. Furthermore, there is a need to strengthen collaboration among nations, institutions, and authors for more in-depth research. The ultimate goal of all these studies is to maintain the health of global college students

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