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Article

Visualization analysis of the research frontiers, hotspots and development trends of exercise therapy intervention in children and adolescents with sleep-wake disorders

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Abstract: Objective: Sleep-wake disorders is a common disease in children and adolescents. In recent years, there has been an increasing number of studies on the intervention of exercise therapy in sleep-wake disorders. This study aims to systematically review the development status, research frontiers, research hotspots and development trends of exercise therapy in the through bibliometric methods. **Methods:** The data comes from the Web of Science Core Collection database. Select all the original data from the establishment of the database to 26 April 2024. Summarize the external characteristics of the literature through Web of Science, Use Excel 2021, Origin 2021, VOS viewers 1.6.20 and Cite Space 6.3.R1 to visually analyze countries/regions, institutions, journals, authors, co-cited references and co-occurrence keywords, use the bibliometric online analysis platform (https://bibliometric.com/) to analyze the changes of keywords and extended keywords over the years. **Results:** We received a total of 775 publications. The works were sourced from 1429 institutions in 75 countries/regions, published in 113 journals, and written by 4332 authors. The number of publications peaked in 2012, 2018, 2019 and 2021 respectively. In the United States, Harvard University and Children (Basel) have the highest number of publications in this field. The analysis of co-cited references shows that there are three main research frontiers in this field, including 24-hour exercise behavior guidelines for children and adolescents, COVID-19 lockdown and cardiometabolic risk. Screen time, mental health, validity, depression, guidelines, stress, and mediterranean diet are still the current research hotspots in the field, and may become potential research hotspots in the future. **Conclusion:** The development of research in the field of exercise therapy for children and adolescents with sleep-wake disorders is relatively slow, and there is still a lack of cross-regional scientific research collaborations between countries/regions, institutions and individuals. Our research suggests that it may be a worthwhile research direction to promote the establishment of healthy lifestyle behaviors in the gathering environment of children and adolescents, formulate targeted policies for disease prevention, diagnosis and management, strictly implement preventive measures, improve the level of diagnosis, and dig deep into the precise treatment plan of diseases.

Keywords: visual analysis; sleep-wake disorders; exercise therapy intervention; children and adolescents

1. Introduction

Sleep-wake disorders is common in children and adolescents, and the clinical manifestations include disturbed sleep, difficulty falling asleep, nocturnal awakenings, bruxism, bedwetting, and insomnia, etc. (Breda et al., 2023). Sleep is essential for children/adolescent's health and well-being, and have a bidirectional relationship with pediatric medical and mental health disorders (Baddam et al., 2024). For example, the most common sleep-wake disorder in children with atopic dermatitis has been suggested to be associated with subsequent neuropsychiatric disorders (including depression, anxiety, and inattention) (Fishbein et al., 2021) and higher nighttime sleep quality in infancy has been associated with higher speech ability and IQ in middle childhood (Finkel et al., 2024). Poor sleep behaviors (e.g., daytime sleepiness and insomnia) in children and adolescents have also been shown to be significantly associated with anxiety, hyperactivity/hyperactivity/ADHD/inattention (Fulfs et al., 2024), and that sleep duration, quality, and insomnia among college students are broadly associated with suicidal thoughts and behaviors (Tubbs et al., 2023).

In addition, it has been suggested that sleep-wake disorders in children/adolescents with sleep-wake disorders, neurodevelopmental disorders, and disabilities may be associated with neurocognitive deficits and growth failure (Thabet et al., 2023), and that sleep-wake disorders in children with epilepsy (CWE) may be associated with a higher risk of memory impairment (Hoyer et al., 2024), as well as poor sleep quality, severe depression (Yücel et al., 2023; Carroll et al., 2024), and lower self-efficacy (Carroll et al., 2024) in their mothers. It is also emphasized that early recognition and intervention will help reduce the frequency of seizures and the risk of suicide (Roliz et al., 2022). In particular, sleep-wake disorders vary significantly in the clinical presentation of enuresis and nonurisis in children and adolescents, and it is also a risk factor for obesity in children and adolescents (Fernandes et al., 2023) and dental caries (Arroyo et al., 2023).

However, it has also been suggested that the sleep quality of infants and young children is not related to the presence or absence of psychiatric disorders in childhood (Pease et al., 2023), and it has been noted that the incidence of sleep-wake disorders in adolescents caused by anxiety syndrome has not improved significantly in the past 20 years (Xu et al., 2023). Other studies have highlighted that children and adolescents with sleep-wake disorders are often overlooked by their parents and health care professionals (Cha et al., 2022), especially complex syndromes of sleep-wake disorders that are missed by pediatricians or rehabilitation physicians, affect early diagnosis and management, and are closely related to social and individual health care burdens (Hulst et al., 2020; McDonald et al., 2019).

Currently, the treatment of children and adolescents with sleep-wake disorders includes medications, surgery, and psychology, et al. (Mingli, 2015). The study concluded that: Prolonged sleep duration may improve emotional and behavioral problems in rural preschool female children whose mothers have less education (Liu H et al., 2023), early detection and intervention in children and adolescents exposed to adverse environments is key to reducing the incidence of adverse behavioral and emotional problems and improving academic performance (Qu et al., 2024), and the use of wearable digital technology products can help to detect or screen children for

attention-deficit/hyperactivity disorder and sleep problems early (Kim et al., 2023), Focusing on and preventing cyberbullying in adolescent digital media education and counseling is an effective intervention strategy for early sleep-wake disorders (Nagata et al., 2023). However, the above methods have a long course of treatment, with many uncontrollable factors, uncertain clinical efficacy, and easy drug dependence (Kim et al., 2023; Liu et al., 2023; Mingli, 2015; Nagata, et al., 2023; Qu et al., 2024). In particular, 12.0%–37.6% of children are still at risk of developing sleep-wake disorders (Fang et al., 2023), 25%–50% of children have sleep difficulties (Navarro et al., 2022), 31.1% of adolescents have insomnia, and more than half of them will persist insomnia (Fernandez et al., 2021). Therefore, it is important to explore the optimal prevention and treatment options for this disease.

With increased social pressure, academic load, and the proliferation of electronic devices, children and adolescents with sleep-wake disorders are becoming more prominent (Angelillo et al., 2024; Schmickler et al., 2023), and educational interventions are needed to promote healthy sleep behaviors and limit screen time (Liebig et al., 2023). It has been found that exercise therapy improves sleep quality by releasing stress and reducing anxiety and depression symptoms in a relaxed and fun way (Liu, 2023; Tang et al., 2024). Children and adolescents with sleep-wake disorders is an important sub-discipline of exercise therapy, which has attracted more and more attention from scholars in recent years. Although the number of publications in this field has been steadily increasing, there have been no reports of quantitative and qualitative analysis of the field using bibliometric methods, which poses a bit of challenges to the prevention, diagnosis and treatment of the disease.

To increase the awareness of the disease among paediatricians and other health care providers, to improve the rate of early diagnosis and to improve management strategies. Based on all the relevant literature in the Web of Science core collection database, this study aims to systematically sort out the research frontiers, hotspots and development trends in the field through visual analysis, and visually display them by the method of scientific knowledge graph. It is expected to provide a reference for follow-up research.

2. Materials and methods

The data (see **Figure 1**) comes from the Web of Sciences Core Collection database. Excluding the search date (26 April 2024) and research direction (Pediatrics), the subject headings, selection and exclusion criteria, search methods, research tools, data analysis methods, and result judgment criteria of the paper search were the same as those in the previous research of our group (Li et al., 2022; Mi et al., 2023; Zhang et al., 2023).

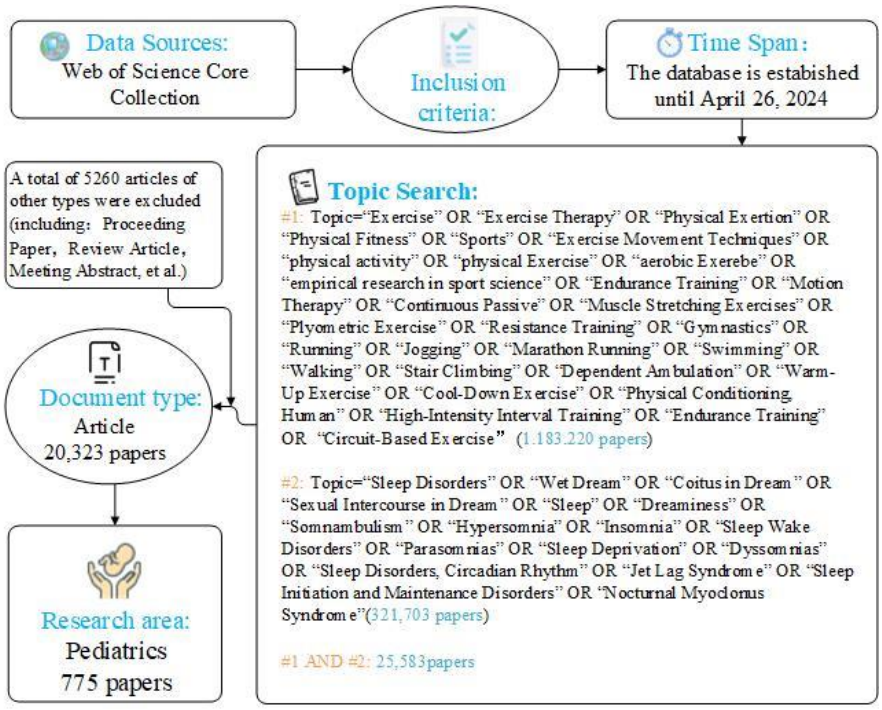


Figure 1. Literature screening flowchart.

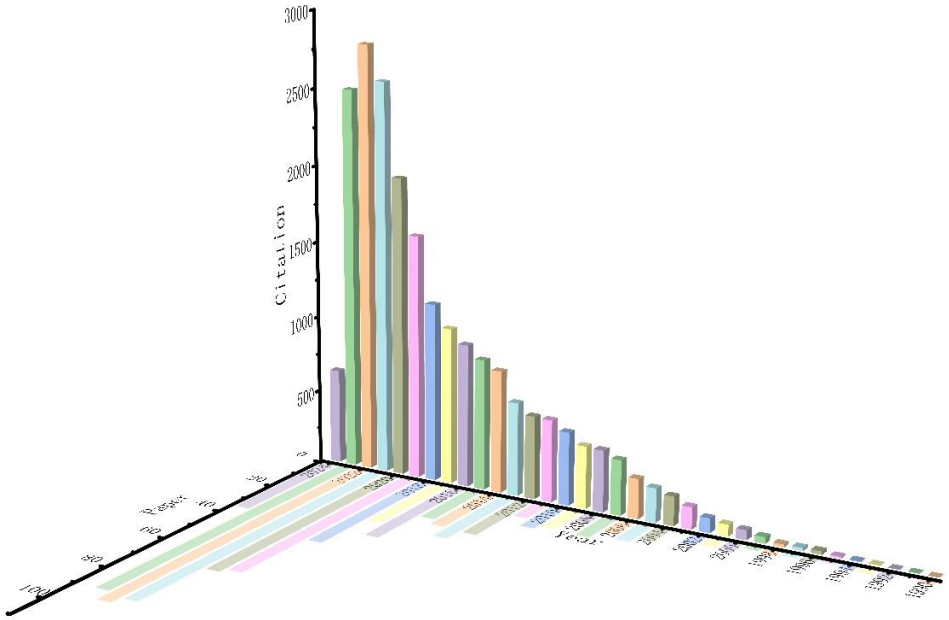
3. Results

3.1. Analysis of paper distribution and cited characteristics

A total of 775 papers were obtained. Among them, Toni et al. (1976) pointed out that stunting in children is associated with insufficient physical activity and sleep quality, and was the first publication in this subject area, and was the first publication in this subject area. Both were 0 papers from 1977 to 1989, and 119 papers were embryonic from 1990 to 2011. The papers in this group were cited 21,410 times, with an H-index of 70, of which 0 times from 1976 to 1990. In addition, there was a steady upward trend in the number of papers published and the frequency of citations from 1990 to 2024 (**Figure 2A**), which also showed peaks in 2012, 2018, 2019, and 2021, suggesting that these points may be key years for the publication of seminal literature. Our research also found that the number of papers published in this field and the total number of citations will increase rapidly over the next five years (**Figure 2B,C**).

Our results support the correlation between peaks and seminal publications. In 2012, Gopinath et al. (2012) found that adolescents who participated in regular physical activity had significantly higher health-related quality of life scores than adolescents who were sedentary for screen viewing activities (cited 153 times), and Kalak et al. (2012) showed that running for 30 minutes on a weekday morning for three weeks significantly improved sleep quality in adolescents, and emphasized the promotion of regular physical activity (135 times). In 2018, Walsh et al. (2018) demonstrated that meeting the 24-hour exercise recommendation was associated with superior overall cognition in adolescents, again emphasizing the importance of limiting recreational screen time for healthy sleep (130 times). In 2019, Viner et al. (2019) also showed that preventing cyberbullying and strengthening resilience, as well as maintaining adequate sleep and appropriate physical activity, are beneficial to the

physical and mental health of young people in the UK. In 2021, a study by Masi et al. (2021) showed that telemedicine can help address worsening neurodevelopmental disorders, mental health symptoms, and poor diet, sleep, and exercise patterns in children.



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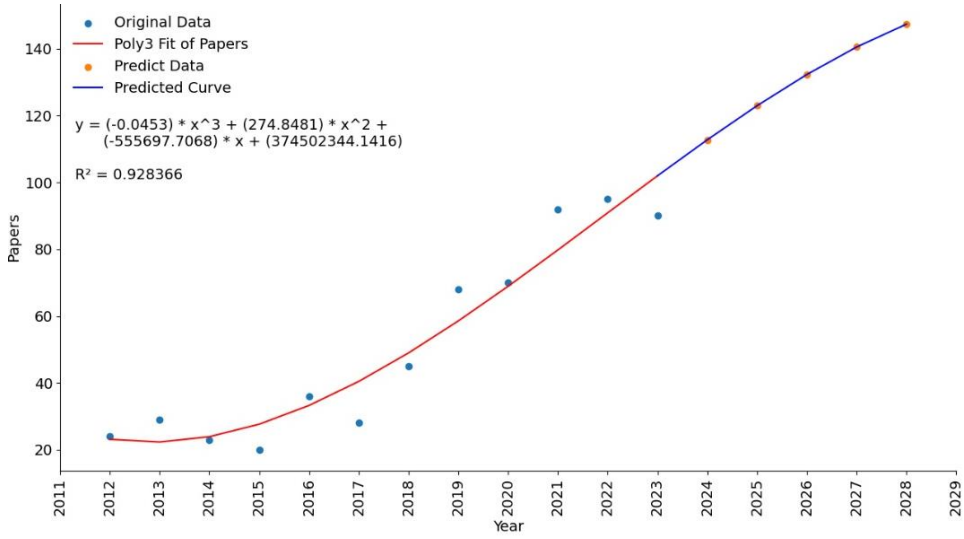

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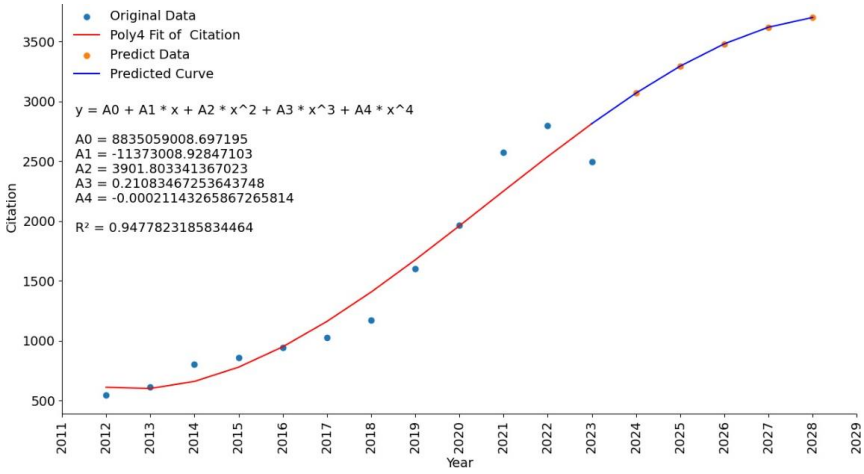
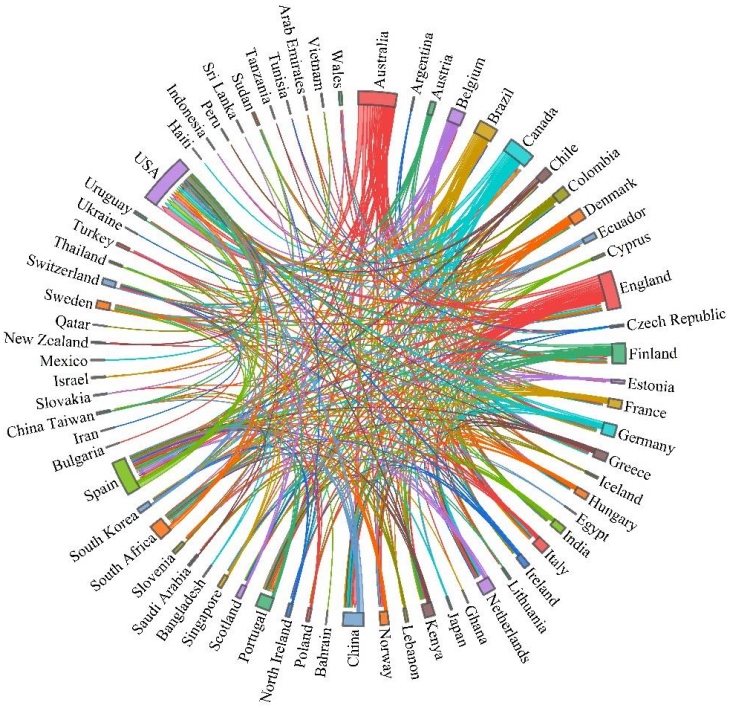


(C)

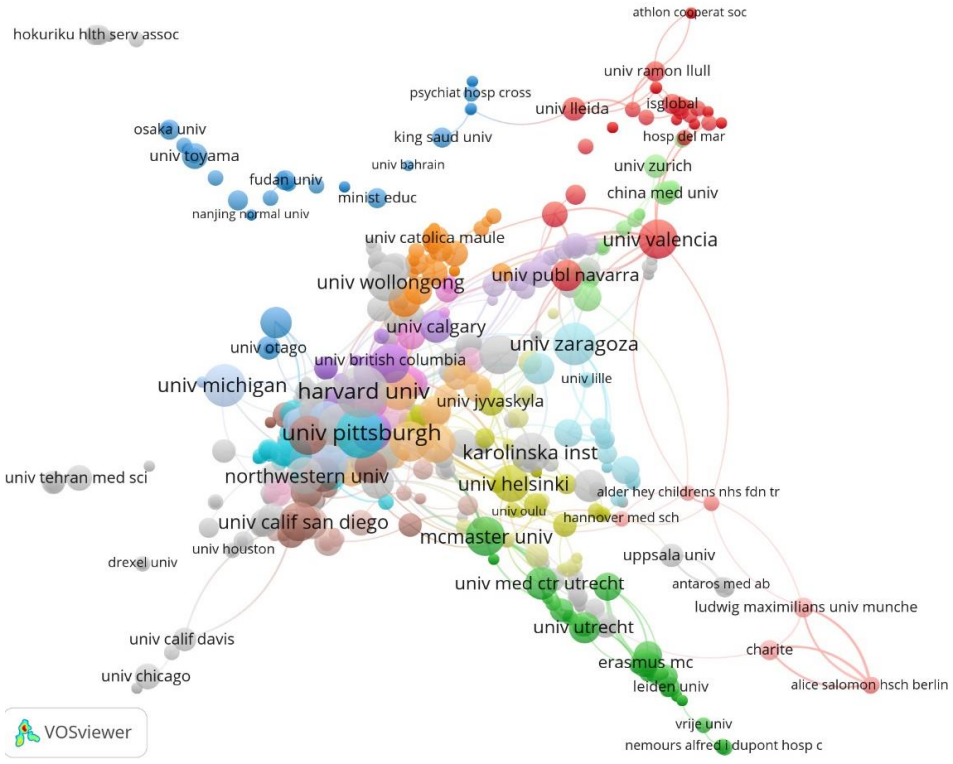
Figure 2. (A) The distribution and citation frequency characteristics of papers in the field of sleep and wake disorders in children with exercise intervention; **(B)** and **(C)** the forecast of development trends in the next five years.

3.2. Country/region and institutional analysis

775 papers were submitted from 75 countries/regions and 1429 institutions. The United States (**Figure 3A**) and Harvard University had the highest number of papers published, with Australia (0.27), Spain (0.27), the University of California System (0.11) and the Boston Children's Hospital (0.11) having the highest academic impact (**Figure 3B**). The map shows that the U.S. crossings are numerous and thick, working closely with countries such as China, the United Kingdom, and Brazil, and Australia working closely with countries such as Switzerland and Iran. Their main study has identified the potential effects of the lunar cycle on human sleep and activity behavior (Welsh, 2016), and their latest study suggests that adherence to 24-hour exercise behavior guidelines may be associated with reduced cognitive and social difficulties in children and adolescents with attention-deficit/hyperactivity disorder (Taylor et al., 2023). Harvard University has close collaboration with Harvard Medical School and Pennsylvania Commonwealth System of Higher Education (PCSHE), and the University of California System has partnered with McMaster University and University of Toronto has a close collaboration. Their representative findings have found that significantly higher than expected weight gain in pediatric patients with obstructive sleep apnea who underwent early adenotonsillectomy emphasizes nutrition education and weight monitoring, as well as encouragement of physical activity in children postoperatively (Katz et al., 2014). Their recent study suggests that adherence to 24-hour exercise behavior guidelines in children and adolescents significantly reduces the risk of subsequent overweight and obesity (Huang et al., 2023). Besides, the results of funding agencies in this area show that the U.S. leadership in this area is closely related to its strong economic base and support. In conclusion, all of these countries and institutions play an important role in scientific research cooperation in this field, but the research development between them is uneven.



(A)



(B)

Figure 3. (A) Graph of the country/region of papers in the field of exercise intervention of children and adolescents with sleep-wake disorders; **(B)** scientific research co-authorship network and institutional co-authorship map.

3.3. Analysis of co-cited journals and highly cited papers

A total of 775 papers have been published in 113 academic journals, with the largest number of papers published in Children (Basel, 61), Pediatr Obes (43) and Pediatrics (42, Supplementary **Table S1**). Among the top 12 highly cited papers in the

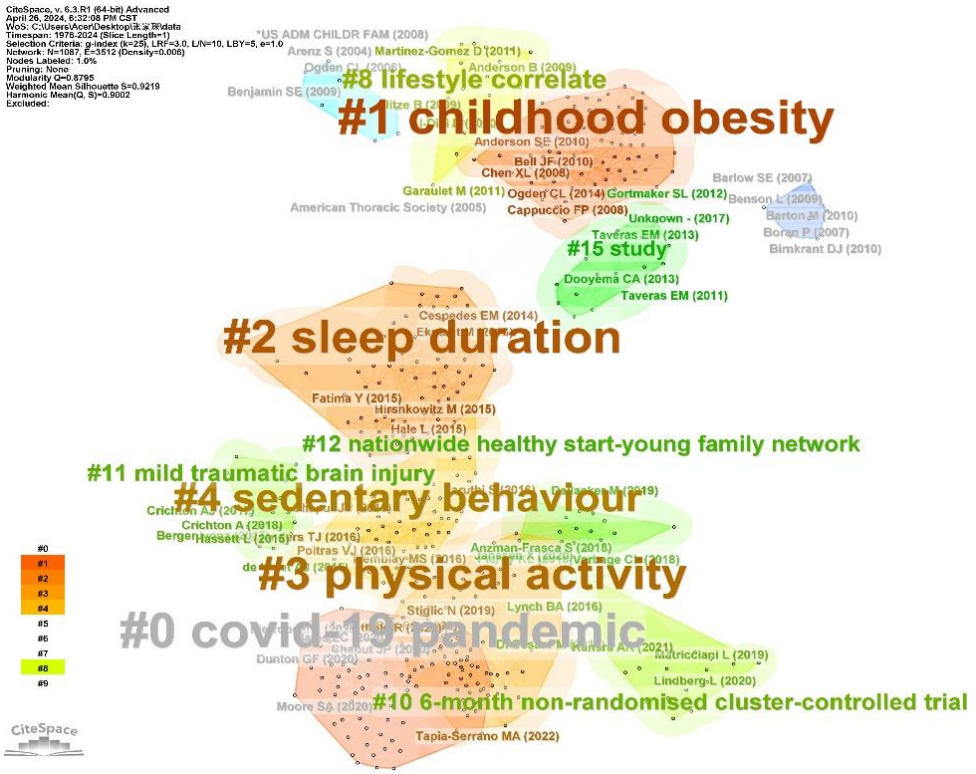
world, 24-hour exercise behavior guidelines for children and adolescents related to cognition, social difficulties, poor diet, sleep disorders, mental health, telemedicine, screen time, etc. (Supplementary **Table S2**).

3.4. Author and co-cited author analysis

The 775 papers were co-authored by 4332 authors, and the number of papers published by Olds T, Tremblay MS and Chaput JP et al. was the largest, Tremblay MS, Chaput JP and Cole TJ et al. were the most concerned, and Carskadon MA, Ogden CL and Kahn A et al. had the highest academic impact (Supplementary **Table S3**, Supplementary **Figure S1A,B**). The spur analysis suggested that Poitras VJ, Saunders TJ, Guthold R, and Moore SA were currently active high-impact authors.

3.5. Co-cited reference analysis explores research frontiers and evolutionary paths

A total of 24,741 references were cited in 775 papers. The contours of the 12 visible clusters in the co-cited reference cluster map we drew (**Figure 4A**) are well structured and have high internal homogeneity (Q = 0.8795, S = 0.9219), which constitute the six main research trends. 1st: primarily involving 24-hour exercise behavior guidelines for children and adolescents and COVID-19 lockdown and cardiometabolic risks (#0, #2, #3). 2nd: involving obesity in children and adolescents and physical activity and media (#1, #10, #15, #26). 3rd: studies of lifestyle and sleep duration, such as physical activity, sedentary behavior, and eating habits of adolescents (#4, #8). 4th: Key findings that active early morning physical activity is associated with happier children (#12). 5th: studies primarily concerned with physical activity and nerve injury (#11). 6th: Studies primarily concerned with disease and sleep (#31). As of now, the main research frontiers in this field are the study of 24-hour exercise behavior guidelines and cardiometabolic risk in children and adolescents, and mechanisms that induce sleep-wake disorders (#0, #1, #3, #31). In addition, **Figure 4B** shows that: the adverse lockdown effect may have a lasting impact on the level of obesity in children or adolescents (Pietrobelli et al., 2020), and in line with the global trend of insufficient physical activity among adolescents (Guthold et al., 2020), the World Health Organization (WHO) developed guidelines on physical activity and sedentary behavior in 2020 (Chaput et al., 2020), and screen time restriction is associated with improved obesity, unhealthy diet, depressive symptoms, and quality of life (Schmidt et al., 2020), related to the current research frontiers.



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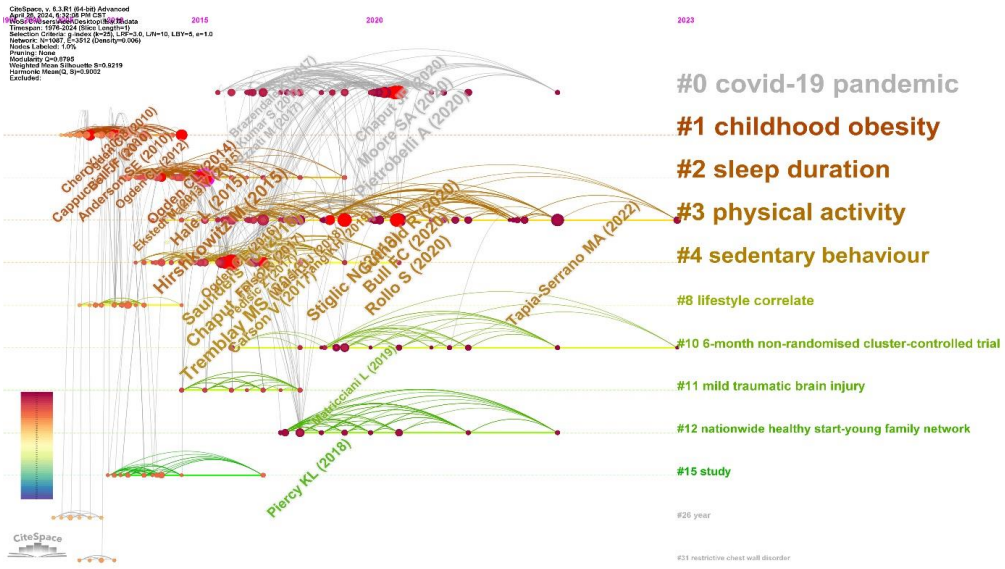


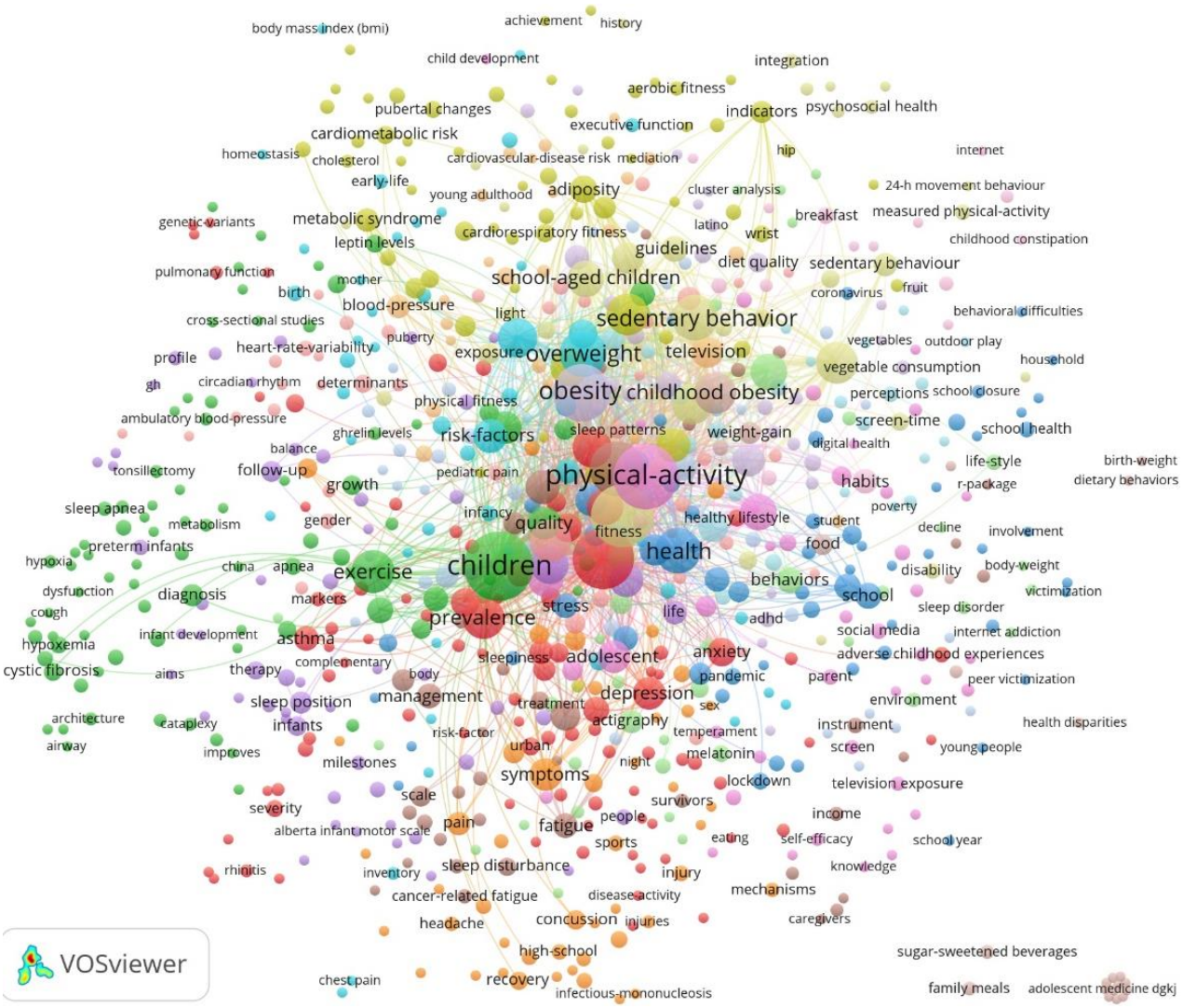
(B)

Figure 4. (A) Cluster map; and **(B)** timeline diagram of co-cited references in the field of exercise intervention in children with sleep-wake disorders.

3.6. Keyword co-occurrence analysis explores research hotspots

We extracted a total of 2787 co-occurrence keywords. Among them, the co-occurrence frequency of physical activity, children and adolescents ranked the top 3, and the academic influence of children, exercise and adolescents ranked the top 3 (Supplementary **Table S4**). The evolution process of the 18 visible clusters from warm

to cool in **Figure 5A** reflects the development process of the research hotspots in the subject area from near to far in time, and the research content involved in the red clustering clusters represents the current research hotspots, such as: obesity, overweight, health, sedentary behavior, sleep duration, screen time and validity et al. Besides, we conducted a burst analysis of the keyword co-occurrence network graph, and found that screen time, health indicators, mental health, validity, depression, guidelines, stress, and mediterranean diet are still research hotspots in this field (**Figure 5B**), which together reflect the research trend in the field and may become potential research hotspots in the future.



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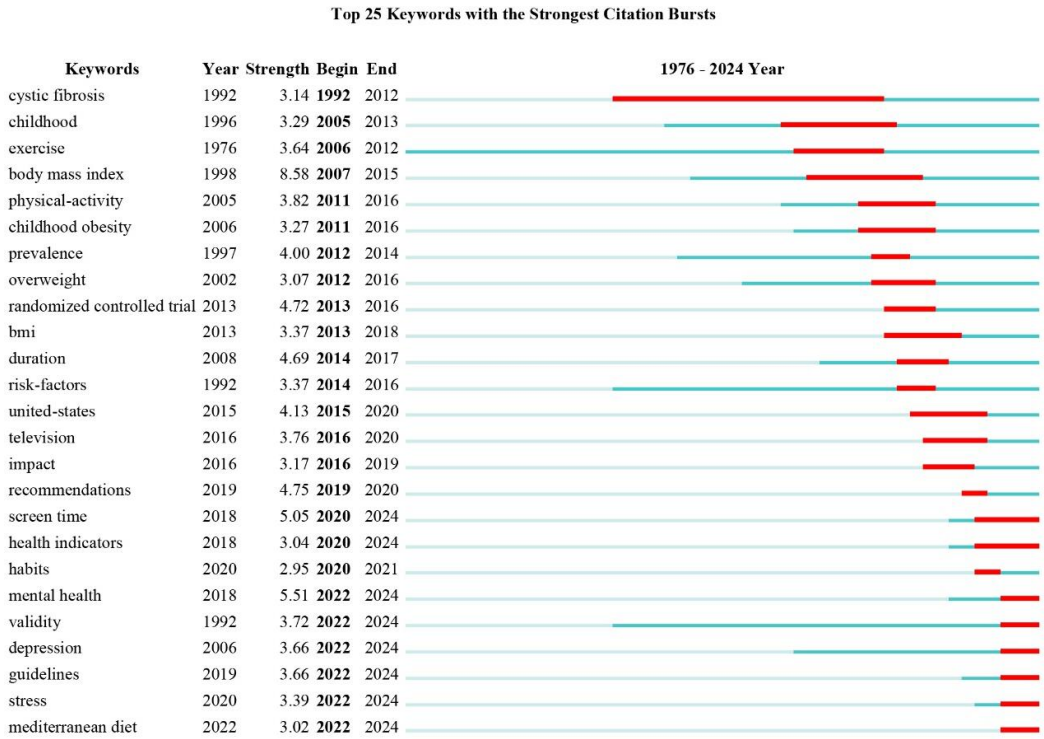

(B)

Figure 5. (A) Keyword co-occurrence map; **(B)** burst map in the field of sleep and wakefulness disorders in children with exercise intervention.

4. Discussion

4.1. Analysis of the current status

Our study shows that over the past 49 years, research on exercise intervention for sleep-wake disorders in children has gone through a long embryonic period (1976–2011), and has shown a gradual increase in recent years. The United States, Harvard University, Olds T, and Tremblay MS have absolute leading advantages in academic productivity in this field. But Australia, the University of California System and Carskadon MA have the highest academic influence in the world. We also found that the development of the field is relatively slow, and there is still a lot of room for improvement. The imbalance in the development of research levels between different countries/regions, institutions and scholars may be related to the different economic development of different countries/regions and the degree of attention and support from government departments.

4.2. Research frontier analysis

This study explores the research frontier through co-cited reference analysis, and finds that it mainly involves 24-hour exercise behavior guidelines for children and adolescents and cardiometabolic risk and the mechanism of exercise therapy affecting the occurrence of sleep-wake disorders:

4.2.1. Frontier analysis of exercise therapy for cardiovascular diseases caused by children and adolescents with sleep-wake disorders

Cardiometabolic disorders in children may be associated with long-term

circadian rhythm disturbances (such as inappropriate feeding timing) (Melkani et al., 2017), which are major causes of cardiovascular disease and type 2 diabetes in adulthood (Leiter et al., 2011). Exercise therapy is a safe, effective, and systematic intervention in cardiac rehabilitation. It has been suggested that higher levels of physical activity significantly reduce the incidence of arteriosclerosis (Agbaje, 2024), particularly through healthy lifestyle interventions and weight loss, can partially reverse cardiovascular dysfunction in children (Genoni et al., 2021). A decrease in body mass index-SD score (BMI-SDS) of 0.25 or higher significantly improves hypertension, hypertriglyceridemia, and low HDL-cholesterol in children with obesity, and doubles this effect when greater than 0.5 (Reinehr et al., 2016). In addition, it has been suggested that dance sport classes can also activate the adaptive mechanisms of the cardiovascular system in children with hearing impairment with sleep sleep impaired (Барладин et al., 2022). Preconception lifestyle interventions for obese women will help improve the cardiac structure and function of their children and reduce their risk of future cardiovascular disease (den Harink et al., 2022). However, although resistance training combined with aerobic training has been found to significantly improve outcomes in adults with cardiovascular disease, children and adolescents were unfortunately not included in this study (El-Sobkey, 2022).

4.2.2. Frontier analysis of exercise therapy for obesity caused by children and adolescents with sleep-wake disorders

Childhood obesity exposes individuals to cardiometabolic disorders that may exacerbate cardiovascular disease. At present, the global prevalence of obesity in children and adolescents has stabilized at a high level (Zhang et al., 2024). Close surveillance, regular screening, and early comprehensive intervention are key measures to prevent overweight, obesity, and cardiometabolic disease due to severe obesity in children (Lister et al., 2023). Treatments for obesity include nutritional therapy, exercise therapy, pharmacotherapy, and surgical therapy (Nur Zati Iwani et al., 2023), with lifestyle, especially exercise, is the primary therapeutic strategy for the treatment and management of metabolic problems caused by obesity (Alruwaily et al., 2022). Interventions based on the Mediterranean diet have been shown to reduce body mass index and obesity in children and adolescents (Park et al., 2023). In particular, meeting all 24-hour exercise recommendations may be a key factor in maintaining healthy weight levels in young adults (López-Gil et al., 2023). In addition, when physical activity lowers the mean BMI-SDS of >1, >1.2, or >0.7 in obese children, it may reduce systolic blood pressure, LDL, and triglycerides, respectively (López-Gil et al., 2023), thereby reducing weight loss and cardiovascular disease risk (El-Medany et al., 2020). However, the prevention of obesity requires the joint development of comprehensive and systematic intervention strategies and measures by multiple government departments, and the implementation of them.

4.2.3. Frontier analysis of the intervention of exercise therapy in children and adolescents for other diseases caused by sleep-wake disorders

Exercise therapy has emerged as one of the recommended options for the treatment of mental health problems in children and adolescents (Liu et al., 2022). For example, music combined with exercise therapy can significantly improve the quality of life and attention of children with ADHD (Lee et al., 2024). Salivary gland

abobotuliniumtoxinA combined with oral exercise therapy can effectively improve swallowing, salivation, and sleep-wake disorders in children with cerebral palsy (Marquez-Vazquez et al., 2022). In addition, intermittent hypoxia and sleep disruption caused by obstructive sleep apnea syndrome in children can induce comorbidities such as obesity, hypertension, and cardiovascular disease by altering the composition of the gut microbiome (Liu et al., 2022). Active video games combined with multiple exercise modalities have been shown to shorten the time to awakening in overweight/obese children and have a positive effect on their muscle health, motor capacity, and skills (Comeras-Chueca et al., 2022). However, the reasons for the increase in the incidence of children and adolescents with sleep-wake disorders after vaccination are unknown, and the mechanism of autism spectrum disorder combined with children and adolescents with sleep-wake disorders needs to be studied and demonstrated, which is of great significance for the treatment and prognosis of this disease.

4.3. Research hotspots analysis

The keyword relationship map we draw suggests: obesity, overweight, health, sedentary behavior, sleep duration, screen time, quality of life, weight status, growth, screen devices, sugar sweetened beverages and position statements, etc. are the research hotspots in the field, which is consistent with the above research frontiers. We also found that screen time, mental health, validity, and depression are still current research hotspots.

4.3.1. Analysis of research hotspots on exercise therapy for the prevention of children and adolescents with sleep-wake disorders

Recent studies have found that patients with sleep-wake disorders in refugee children and adolescents need targeted prevention and counseling of adverse psychological conditions based on their traumatic experiences (Richter et al., 2020). Reducing screen time by engaging children in physical activity of varying intensity and maintaining appropriate sleep duration will help improve their levels of cardiovascular inflammatory markers (Reis et al., 2024). However, decreasing sedentary time in children and adolescents may be more helpful in improving sleep quality and body mass index than increasing moderate to vigorous physical activity (Reis et al., 2024).

4.3.2. Analysis of research hotspots on the intervention of exercise therapy in children and adolescents with sleep-wake disorders

In addition, the effectiveness of intervention methods has been a hot topic in this field, for example, brief behavioral sleep intervention by parents can significantly improve sleep quality and clinical symptoms in children with ADHD (Li et al., 2024). School sleep education can effectively enhance parents' sleep knowledge and improve children's behavioral outcomes, but it cannot completely alleviate children's sleep-wake patterns and sleep problems (Chen et al., 2023). Physical activity and melatonin supplementation have also been shown to have similar effects in improving sleep quality in children with autism (Tse et al., 2023).

In short, the above research hotspots are related to national history, social culture, economic level and personal values, and we should promote the establishment of

healthy lifestyle behaviors in the environment where children and adolescents gather, formulate targeted policies for disease prevention, diagnosis and management, strictly implement preventive measures, improve the level of diagnosis, and dig deep into the precise treatment of diseases, which we believe may be a worthy research direction.

5. Limitations

Due to the applicability of the software, our study only searched the Web of Science Core Collection database for relevant articles, which may have missed some important findings. Therefore, in the future, we will conduct scientometric analysis of other database sources to further demonstrate the overall quality and prediction accuracy of this study.

6. Conclusion

In this study, we scientifically reproduced the research trajectory in the field of exercise intervention in children with sleep-wake disorders. We also found that there is a lack of cross-regional research collaborations between countries, institutions, and individuals, which play an important role in promoting the further development of the field. At present, the research frontier in this field mainly involves the relationship between 24-hour exercise behavior guidelines and the occurrence of cardiometabolic diseases in children and adolescents, as well as the mechanism of exercise therapy affecting sleep-wake disorders. In addition, its research hotspots mainly involve screen time, mental health, validity, and depression. In conclusion, our study found that a healthy lifestyle, especially exercise therapy, is the main treatment strategy for the treatment and management of physical and mental health problems in children and adolescents, and it is worthy of being used as a reference for follow-up research and clinical practice.

Supplementary materials: Supplementary **Table S1,2,3,4** and Supplementary **Figure S1A,B** are provided in Supplementary Materials. The supplementary material in this article is a supplement to the results and contains the content mentioned in the results, but due to the space of the article, it is not possible to list all of them. The results are presented in the form of images and tables, and are uploaded in the form of supplementary materials for readers to consult when needed. The content of the supplementary materials includes the top 5 journals in the world in terms of the number of papers, citations and subject influence, the top 10 highly cited papers, the top 5 authors and co-occurrence frequency of the global papers in the field of motor intervention in children with sleep-wake disorders, and the top 20 keywords in the world in terms of subject impact.

Author contributions: Conceptualization, JZ (Jiachen Zhang) , LZ and YZ; methodology, LZ and LC; software, JZ (Jiachen Zhang) and ZL; validation, JZ (Jiachen Zhang), XP and ML; formal analysis, JZ (Jiachen Zhang) and LC; investigation, JZ (Jiachen Zhang), YZ and JZ (Jianping Zhou); resources, LZ; data curation, LZ and JZ (Jiachen Zhang); writing—original draft preparation, JZ (Jiachen Zhang); writing—review and editing, LZ and YZ; visualization, JZ (Jiachen Zhang) , YZ and LC; supervision, LZ; project administration, JZ (Jiachen Zhang) and JZ

(Jianping Zhou); funding acquisition, LZ. All authors have read and agreed to the published version of the manuscript.

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References

Arroyo Buenestado, A., & Ribas-Pérez, D. (2023). Early Childhood Caries and Sleep Disorders. J Clin Med, 12(4), 1378. https://doi.org/10.3390/jcm12041378

Angelillo, S., Sansone, V., Paduano, G., et al. (2024). The quality of sleep: evaluation among university students. Frontiers in Public Health, 11. https://doi.org/10.3389/fpubh.2023.1270426

Agbaje, A. O. (2024). Mediating effect of fat mass, lean mass, blood pressure and insulin resistance on the associations of accelerometer-based sedentary time and physical activity with arterial stiffness, carotid IMT and carotid elasticity in 1574 adolescents. Journal of Human Hypertension, 38(5), 393–403. https://doi.org/10.1038/s41371-024-00905-6

Alruwaily, A., Alruwaili, H., Garvey, J., et al. (2022). Can Weight Loss Improve the Cardiovascular Outcomes of Patients with Obesity and Obstructive Sleep Apnea? Hearts, 3(2), 54–65. https://doi.org/10.3390/hearts3020008

Breda, M., Belli, A., Esposito, D., et al. (2023). Sleep habits and sleep disorders in Italian children and adolescents: a cross-sectional survey. Journal of Clinical Sleep Medicine, 19(4), 659–672. https://doi.org/10.5664/jcsm.10400

Baddam, S. K. R., Canapari, C. A., Van de Grift, J., et al. (2024). Screening and Evaluation of Sleep Disturbances and Sleep Disorders in Children and Adolescents. Psychiatric Clinics of North America, 47(1), 65–86. https://doi.org/10.1016/j.psc.2023.06.005

Барладин, О.Р., Вакуленко, Л. О., Храбра С. З., et al. (2022). Dance Therapy in The Rehabilitation of Children with Hearing Impairments (Ukrainian). Naukovyy chasopys Ukrayins′koho derzhavnoho universytetu imeni Mykhayla Drahomanova, 7(152), 24–29. https://doi.org/10.31392/NPU-nc.series15.2022.7(152).06.

Carroll, A. J., Appleton, J., & Harris, K. M. (2024). Child sleep problems, maternal sleep and self-efficacy: Sleep's complicated role in maternal depression. J Sleep Res, 33(2), e14005. https://doi.org/10.1111/jsr.14005

Calcaterra, V., Rossi, V., Tagi, V. M., et al. (2023). Food Intake and Sleep Disorders in Children and Adolescents with Obesity. Nutrients, 15(22), 4736. https://doi.org/10.3390/nu15224736

Cha, E. J., Lee, Y. J., & Jeon, H. J. (2022). Mother-Adolescent Discrepancies in Reporting Sleep Disturbances: Effects of Diagnosis and Mother's Occupation. J Korean Med Sci, 37(6), e46. https://doi.org/10.3346/jkms.2022.37.e46

Chaput, J. P., Willumsen, J., Bull, F., et al. (2020). 2020 WHO guidelines on physical activity and sedentary behaviour for children and adolescents aged 5–17 years: summary of the evidence. International Journal of Behavioral Nutrition and Physical Activity, 17(1). https://doi.org/10.1186/s12966-020-01037-z

Chen, S. J., Li, S. X., Zhang, J. H., et al. (2023). School-Based Sleep Education Program for Children: A Cluster Randomized Controlled Trial. Healthcare, 11(13), 1853. https://doi.org/10.3390/healthcare11131853

Comeras-Chueca, C., Villalba-Heredia, L., Perez-Lasierra, J. L., et al. (2022). Active Video Games Improve Muscular Fitness and Motor Skills in Children with Overweight or Obesity. International Journal of Environmental Research and Public Health, 19(5), 2642. https://doi.org/10.3390/ijerph19052642

de Toni, E., & Aicardi, G. (1976). Radioimmunological determination of growth hormone after stimulation with insulin and arginine in 168 subjects with growth disorders (Spanish). Minerva Pediatr, 28(17), 1027–1034.

den Harink, T., Blom, N. A., Gemke, R. J. B. J., et al. (2022). Preconception lifestyle intervention in women with obesity and echocardiographic indices of cardiovascular health in their children. International Journal of Obesity, 46(7), 1262–1270. https://doi.org/10.1038/s41366-022-01107-1

Donath, C., Atzmüller, L., Florack, J., et al. (2024). The Effect of Exercise Therapy on Adolescent Mental Health: A Systematic Review with Practical Example (German). Z Kinder Jugendpsychiatr Psychother, 52(2), 94–108. https://doi.org/10.1024/1422-4917/a000960

El-Sobkey, S. B. (2022). Resistance training is an effective exercise therapy in cardiac rehabilitation program for patients with coronary artery disease: a systematic review. Beni-Suef University Journal of Basic and Applied Sciences, 11(1), 22. https://doi.org/10.1186/s43088-022-00206-2

El-Medany, A. Y. M., Birch, L., Hunt, L. P., et al. (2020). What Change in Body Mass Index Is Required to Improve Cardiovascular Outcomes in Childhood and Adolescent Obesity through Lifestyle Interventions: A Meta-Regression.

Childhood Obesity, 16(7), 449–478. https://doi.org/10.1089/chi.2019.0286

Fishbein, A. B., Cheng, B. T., Tilley, C. C., et al. (2021). Sleep Disturbance in School-Aged Children with Atopic Dermatitis: Prevalence and Severity in a Cross-Sectional Sample. The Journal of Allergy and Clinical Immunology: In Practice, 9(8), 3120–3129.e3. https://doi.org/10.1016/j.jaip.2021.04.064

Finkel, M. A., Duong, N., Hernandez, A., et al. (2024). Associations of Infant Sleep Characteristics with Childhood Cognitive Outcomes. Journal of Developmental & Behavioral Pediatrics. https://doi.org/10.1097/dbp.0000000000001311

Fulfs, T., Poulain, T., Vogel, M., et al. (2024). Associations between sleep problems and emotional/behavioural difficulties in healthy children and adolescents. BMC Pediatrics, 24(1), 15. https://doi.org/10.1186/s12887-023-04487-z

Fernandes, A. E. R., Roveda, J. R. C., Fernandes, C. R., et al. (2023). Relationship between nocturnal enuresis and sleep in children and adolescents. Pediatric Nephrology, 38(5), 1427–1438. https://doi.org/10.1007/s00467-022-05818-5

Fang, Y., van Grieken, A., Windhorst, D. A., et al. (2023). Longitudinal associations between parent, child, family factors and dyssomnias in children from birth to 8 years: The CIKEO study. Journal of Affective Disorders, 323, 496–505. https://doi.org/10.1016/j.jad.2022.12.012

Fernandez-Mendoza, J., Bourchtein, E., Calhoun, S., et al. (2021). Natural history of insomnia symptoms in the transition from childhood to adolescence: population rates, health disparities, and risk factors. Sleep, 44(3). https://doi.org/10.1093/sleep/zsaa187

Gopinath, B., Hardy, L. L., Baur, L. A., et al. (2012). Physical Activity and Sedentary Behaviors and Health-Related Quality of Life in Adolescents. Pediatrics, 130(1), e167–e174. https://doi.org/10.1542/peds.2011-3637

Godoy-Cumillaf, A., Fuentes-Merino, P., Farías-Valenzuela, C., et al. (2023). The Association between Sedentary Behavior, Physical Activity, and Physical Fitness with Body Mass Index and Sleep Time in Chilean Girls and Boys: A Cross-Sectional Study. Children, 10(6), 981. https://doi.org/10.3390/children10060981

Guthold, R., Stevens, G. A., Riley, L. M., & Bull, F.C. (2020). Global trends in insufficient physical activity among adolescents: a pooled analysis of 298 population-based surveys with 1.6 million participants. Lancet Child Adolesc Health, 4(1), 23–35. https://doi.org/10.1016/S2352-4642(19)30323-2

Genoni, G., Menegon, V., Monzani, A., et al. (2021). Healthy Lifestyle Intervention and Weight Loss Improve Cardiovascular Dysfunction in Children with Obesity. Nutrients, 13(4), 1301. https://doi.org/10.3390/nu13041301

Hulst, R. Y., Pillen, S., Voorman, J. M., et al. (2020). Sleep health practices and sleep knowledge among healthcare professionals in Dutch paediatric rehabilitation. Child Care Health Dev, 46(6), 703–710. https://doi.org/10.1111/cch.12799

Hoyer, S., Dietz, M., Ambrosi-Schneider, A. S., et al. (2024). Memory Consolidation and Sleep in Children with Epilepsy: A Systematic Review. Pediatric Neurology, 158, 66–70. https://doi.org/10.1016/j.pediatrneurol.2024.05.020

Huang, S., Huang, Y., Gu, Y., et al. (2023). Adherence to 24-Hour Movement Guidelines in Relation to the Risk of Overweight and Obesity Among Children and Adolescents. Journal of Adolescent Health, 73(5), 887–895. https://doi.org/10.1016/j.jadohealth.2023.06.009

Kim, W. P., Kim, H. J., Pack, S. P., et al. (2023). Machine Learning—Based Prediction of Attention-Deficit/Hyperactivity Disorder and Sleep Problems with Wearable Data in Children. JAMA Network Open, 6(3), e233502. https://doi.org/10.1001/jamanetworkopen.2023.3502

Kalak, N., Gerber, M., Kirov, R., et al. (2012). Daily Morning Running for 3 Weeks Improved Sleep and Psychological Functioning in Healthy Adolescents Compared with Controls. Journal of Adolescent Health, 51(6), 615–622. https://doi.org/10.1016/j.jadohealth.2012.02.020

Katz, E. S., Moore, R. H., Rosen, C. L., et al. (2014). Growth After Adenotonsillectomy for Obstructive Sleep Apnea: An RCT. Pediatrics, 134(2), 282–289. https://doi.org/10.1542/peds.2014-0591

Lister, N. B., Baur, L. A., Felix, J. F., et al. (2023). Child and adolescent obesity. Nature Reviews Disease Primers, 9(1). https://doi.org/10.1038/s41572-023-00435-4

Li, X., Lau, F. L. F., Chiu, W. V., et al. (2024). An Open-Label Pilot Trial of a Brief, Parent-Based Sleep Intervention in Children With ADHD. Journal of Attention Disorders, 28(8), 1173–1185. https://doi.org/10.1177/10870547241233731

Liu, H., Ma, S., Feng, L., et al. (2023). Longitudinal association of nighttime sleep duration with emotional and behavioral problems among rural preschool children. European Child & Adolescent Psychiatry, 33(1), 267–277. https://doi.org/10.1007/s00787-023-02153-4

Liu, W., Du, Q., Zhang, H., et al. (2022). The gut microbiome and obstructive sleep apnea syndrome in children. Sleep Medicine, 100, 462–471. https://doi.org/10.1016/j.sleep.2022.09.022

Liebig, L., Bergmann, A., Voigt, K., et al. (2023). Screen time and sleep among medical students in Germany. Scientific Reports, 13(1), 15462. https://doi.org/10.1038/s41598-023-42039-8

Liu, Y. (2023). Ideological and political reform in physical education courses combined with recreational exercise therapy on depression among college students. CNS Spectrums, 28(S2), S75–S76. https://doi.org/10.1017/s1092852923004406

Li, J., & Chen, C. (2022). CiteSpace: Text Mining and Visualization in Scientific Literature. Beijing: Capital University of Economics and Business Press.

López-Gil, J. F., Tapia-Serrano, M. A., Sevil-Serrano, J., et al. (2023). Are 24-hour movement recommendations associated with obesity—related indicators in the young population? A meta-analysis. Obesity, 31(11), 2727–2739. https://doi.org/10.1002/oby.23848

Liu, J., Zhu, L., Chen, Z., et al. (2022). Effects and dose-response relationship of exercise training on cardiometabolic risk factors in children with obesity. Journal of Pediatric Endocrinology and Metabolism, 35(10), 1278–1284. https://doi.org/10.1515/jpem-2022-0395

Lee, M. W., Yang, N. J., Mok, H. K., et al. (2024). Music and movement therapy improves quality of life and attention and associated electroencephalogram changes in patients with attention-deficit/hyperactivity disorder. Pediatrics & Neonatology. https://doi.org/10.1016/j.pedneo.2023.11.007

Leiter, L. A., Fitchett, D. H., Gilbert, R. E., et al. (2011). Cardiometabolic Risk in Canada: A Detailed Analysis and Position Paper by the Cardiometabolic Risk Working Group. Canadian Journal of Cardiology, 27(2), e1–e33. https://doi.org/10.1016/j.cjca.2010.12.054

López-Gil, J. F., García-Hermoso, A., Sotos-Prieto, M., et al. (2023). Mediterranean Diet-Based Interventions to Improve Anthropometric and Obesity Indicators in Children and Adolescents: A Systematic Review with Meta-Analysis of Randomized Controlled Trials. Advances in Nutrition, 14(4), 858–869. https://doi.org/10.1016/j.advnut.2023.04.011

Mi, J., Zhang, L., Sun, W., et al. (2023). Research hotspots and new trends in the impact of resistance training on aging, bibliometric and visual analysis based on Cite Space and VOS viewer. Frontiers in Public Health, 11. https://doi.org/10.3389/fpubh.2023.1133972

McDonald, A., & Joseph, D. (2019). Paediatric neurodisability and sleep disorders: clinical pathways and management strategies. BMJ Paediatr Open, 3(1), e000290. https://doi.org/10.1136/bmjpo-2018-000290

Mingli, R. A. O. (2015). Neurology, 3rd ed. Beijing: People's Medical Publishing House.

Masi, A., Mendoza Diaz, A., Tully, L., et al. (2021). Impact of the COVID-19 pandemic on the well-being of children with neurodevelopmental disabilities and their parents. Journal of Paediatrics and Child Health, 57(5), 631–636. https://doi.org/10.1111/jpc.15285

Marquez-Vazquez, J. F., Arellano-Saldaña, M. E., Rojas-Martinez, K. N., & Carrillo-Mora, P. (2022). Comparative Efficacy of Botulinum Toxin in Salivary Glands vs. Oromotor Therapy in the Management of Sialorrhea in Cerebral Palsy Impact on Sleep Quality. Front Rehabil Sci, 3, 875235. https://doi.org/10.3389/fresc.2022.875235

Melkani, G. C., & Panda, S. (2017). Time-restricted feeding for prevention and treatment of cardiometabolic disorders. The Journal of Physiology, 595(12), 3691–3700. https://doi.org/10.1113/jp273094

Nagata, J. M., Yang, J. H., Singh, G., et al. (2023). Cyberbullying and Sleep Disturbance Among Early Adolescents in the U.S. Academic Pediatrics, 23(6), 1220–1225. https://doi.org/10.1016/j.acap.2022.12.007

Navarro Vergara, A., & González Rabelino, G. (2022). Sleep disorders and their impact on neurodevelopment (Spanish). Medicina (B Aires), 82(3), 30–34.

Nur Zati Iwani, A. K., Jalaludin, M. Y., Roslan, F. A., et al. (2023). Cardiometabolic risk factors among children who are affected by overweight, obesity and severe obesity. Frontiers in Public Health, 11. https://doi.org/10.3389/fpubh.2023.1097675

Pease, E., Shekunov, J., Savitz, S. T., et al. (2023). Association between early childhood sleep difficulties and subsequent psychiatric illness. J Clin Sleep Med, 19(12), 2059–2063. https://doi.org/10.5664/jcsm.10756.

Pietrobelli, A., Pecoraro, L., Ferruzzi, A., et al. (2020). Effects of COVID-19 Lockdown on Lifestyle Behaviors in Children with Obesity Living in Verona, Italy: A Longitudinal Study. Obesity, 28(8), 1382–1385. https://doi.org/10.1002/oby.22861

Park, H. J., Rhie, S. J., & Shim, I. (2023). The effects of physical exercise therapy on weight control: its regulation of adipocyte physiology and metabolic capacity. Journal of Exercise Rehabilitation, 19(3), 141–148. https://doi.org/10.12965/jer.2346232.116

Qu, G., Liu, H., Han, T., et al. (2024). Association between adverse childhood experiences and sleep quality, emotional and behavioral problems and academic achievement of children and adolescents. European Child & Adolescent Psychiatry,

33(2), 527–538. https://doi.org/10.1007/s00787-023-02185-w

Roliz, A. H., & Kothare, S. (2022). The Interaction Between Sleep and Epilepsy. Curr Neurol Neurosci Rep, 22, 551–563. https://doi.org/10.1007/s11910-022-01219-1

Richter, K., Baumgärtner, L., Niklewski, G., et al. (2020). Sleep disorders in migrants and refugees: a systematic review with implications for personalized medical approach. EPMA Journal, 11(2), 251–260. https://doi.org/10.1007/s13167-020-00205-2

Reis, L. N., Reuter, C. P., Okely, A., et al. (2024). Replacing screen time, with physical activity and sleep time: influence on cardiovascular indicators and inflammatory markers in Brazilian children. Jornal de Pediatria, 100(2), 149–155. https://doi.org/10.1016/j.jped.2023.10.007

Reinehr, T., Lass, N., Toschke, C., et al. (2016). Which Amount of BMI-SDS Reduction Is Necessary to Improve Cardiovascular Risk Factors in Overweight Children? The Journal of Clinical Endocrinology & Metabolism, 101(8), 3171–3179. https://doi.org/10.1210/jc.2016-1885

Schmickler, J. M., Blaschke, S., Robbins, R., et al. (2023). Determinants of Sleep Quality: A Cross-Sectional Study in University Students. International Journal of Environmental Research and Public Health, 20(3), 2019. https://doi.org/10.3390/ijerph20032019

Schmidt, S. C. E., Anedda, B., Burchartz, A., et al. (2020). Physical activity and screen time of children and adolescents before and during the COVID-19 lockdown in Germany: a natural experiment. Scientific Reports, 10(1). https://doi.org/10.1038/s41598-020-78438-4

Tubbs, A. S., Taneja, K., Ghani, S. B., et al. (2023). Sleep continuity, timing, quality, and disorder are associated with suicidal ideation and suicide attempts among college students. Journal of American College Health, 1–9. https://doi.org/10.1080/07448481.2022.2155828

Thabet, F., & Tabarki, B. (2023). Common sleep disorders in children: assessment and treatment. Neurosciences, 28(2), 85–90. https://doi.org/10.17712/nsj.2023.2.20220111

Tang, J., Chen, L. L., Zhang, H., et al. (2024). Effects of exercise therapy on anxiety and depression in patients with COVID-19: a systematic review and meta-analysis. Frontiers in Public Health, 12. https://doi.org/10.3389/fpubh.2024.1330521

e, A. C. Y., Lee, P. H., Sit, C. H. P., et al. (2023). Comparing the Effectiveness of Physical Exercise Intervention and Melatonin Supplement in Improving Sleep Quality in Children with ASD. Journal of Autism and Developmental Disorders. https://doi.org/10.1007/s10803-023-06172-7

Taylor, A., Kong, C., Zhang, Z., et al. (2023). Associations of meeting 24-h movement behavior guidelines with cognitive difficulty and social relationships in children and adolescents with attention deficit/hyperactive disorder. Child and Adolescent Psychiatry and Mental Health, 17(1). https://doi.org/10.1186/s13034-023-00588-w

Viner, R. M., Gireesh, A., Stiglic, N., et al. (2019). Roles of cyberbullying, sleep, and physical activity in mediating the effects of social media use on mental health and wellbeing among young people in England: a secondary analysis of longitudinal data. Lancet Child Adolesc Health, 3(10), 685–696. https://doi.org/10.1016/S2352-4642(19)30186-5

Walsh, J. J., Barnes, J. D., Cameron, J. D., et al. (2018). Associations between 24-hour movement behaviours and global cognition in US children: a cross-sectional observational study. Lancet Child Adolesc Health, 2(11), 783–791. https://doi.org/10.1016/S2352-4642(18)30278-5.

Welsh, J. S. (2016). Commentary: Are Children Like Werewolves? Full Moon and Its Association with Sleep and Activity Behaviors in an International Sample of Children. Frontiers in Pediatrics, 4. https://doi.org/10.3389/fped.2016.00094

Xu, G., Li, L., Yi, L., et al. (2023). A pooled analysis of temporal trends in the prevalence of anxiety-induced sleep loss among adolescents aged 12–15 years across 29 countries. Front Psychiatry, 14:1259442. https://doi.org/10.3389/fpsyt.2023.1259442

Yücel, G., Kadir Arslan, A., Özgör, B., et al. (2023). Sleep quality and depression in mothers of children with epilepsy and its relation to their children's sleep. Epilepsy & Behavior, 149, 109493. https://doi.org/10.1016/j.yebeh.2023.109493

Zhang, Y., Yao, J., Li, W., et al. (2023). Global research trends and hotspots in pharmaceutical care: a bibliometric analysis and visualisation using Cite Space and VOS viewer. European Journal of Hospital Pharmacy, ejhpharm-2022-003617. https://doi.org/10.1136/ejhpharm-2022-003617

Zhang,X., Liu, J., Ni, Y., et al. (2024).Global Prevalence of Overweight and Obesity in Children and Adolescents: A Systematic Review and Meta-Analysis. JAMA Pediatr. 178(8):800-813. doi: 10.1001/jamapediatrics.2024.1576