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Physical Education Model Based on the Test of Gross Motor Development Bibliometric Analysis of Scopus Database

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Abstract

The development of fundamental motor skills is a key component of physical education; however, the availability of valid and adaptive assessment tools in schools continues to pose a challenge. This study seeks to identify research trends and future directions related to the Test of Gross Motor Development (TGMD) within the context of physical education learning from 2015 to 2024. Employing a quantitative descriptive bibliometric approach, the study analyzed 111 articles indexed in Scopus. Data processing was conducted using VOSviewer, R, and Biblioshiny to examine publication patterns, researcher productivity, journal contributions, country affiliations, and thematic emphases. The findings indicate a steady rise in publications since 2015, reaching a peak in 2024. The United States emerged as the leading contributor, followed by China, the United Kingdom, Australia, and Indonesia. Additionally, the analysis reveals a shift in research focus from basic motor skill development toward themes of inclusivity and the integration of technology. These results reinforce the role of TGMD as a strategic instrument for advancing innovative physical education practices that are inclusive, responsive to diverse learner needs, and aligned with the demands of 21st-century education. Furthermore, this study offers both empirical and conceptual contributions that can serve as a foundation for policy formulation, evaluation strategies, and future research in inclusive and technology-based physical education.

Keywords: Physical Education; Motor Skills; TGMD; Bibliometrics; Inclusive Learning

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1. INTRODUCTION

Physical education is an essential element of the educational system, designed not only to improve physical fitness but also to build character, enhance social skills, and equip students to various stages of development. Through physical education, learners engage in structured physical activities that contribute to their overall health and fitness while also promoting cognitive and emotional growth. These experiences encourage social interaction, cultivate discipline, and help strengthen students self-confidence. (Sindiani et al., 2025; Zayed et al., 2024) In elementary school children, gross motor skills become a primary focus of development, as they serve as the essential foundation for acquiring more advanced and complex movement abilities (Hui et al., 2024; Mazzardo et al., 2024; Wang & Zhou, 2024) . These competencies encompass locomotor abilities, object control, and balance, all of which play a crucial role in enabling children to perform a wide range of daily activities and engage in sports later in life. When fundamental motor skills are not developed optimally during the critical early years, it can lead to reduced participation in physical activities, a higher risk of health issues associated with inactivity, and constraints in social and emotional development, ultimately impacting overall quality of life (Chen et al., 2024; Pang et al., 2023; Vandoni et al., 2023).

To ensure that children's fundamental motor skills develop according to their appropriate stages, it is essential to use assessment instruments that are valid, reliable, and practical within physical education settings. The TGMD, with its game-based approach, aligns with the core principles of physical education that emphasize activities which are active, enjoyable, safe, and inclusive, thereby encouraging children to express their movement skills more naturally and with greater enthusiasm (Duncan et al., 2022; Graça et al., 2024; Manitsa et al., 2024; Yan et al., 2023). The application of TGMD through game-based activities in physical education also contributes to fostering an inclusive and adaptive learning environment. School physical education must accommodate the wide range of students' physical abilities, diverse needs, and varying health conditions (de Bruijn et al., 2022; Lieberman et al., 2024; Salomé Aubert et al., 2018). Therefore, teachers need an approach that is not only effective for skill assessment but also adaptable to the diverse abilities of individual students. By applying a game-based TGMD approach, teachers can provide equal opportunities for all students, including those with special

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needs, to engage in physical activities, build self-confidence, and enhance their social skills through peer interaction. (Bayburtlu et al., 2024; Lieberman et al., 2024; Wu et al., 2024). Although the use of the Test of Gross Motor Development (TGMD) in physical education has been extensively studied, there remains a research gap regarding the comprehensive mapping of developmental trends, scientific collaboration, and the direction of innovation in TGMD-based learning models globally, particularly those integrating aspects of inclusivity and technology within the context of 21st-century education. Most previous studies have tended to focus on the empirical implementation or effectiveness of the TGMD on a limited scale, and thus have not provided a comprehensive picture of the dynamics of knowledge production, patterns of inter-researcher connections, and the evolution of research themes over a specific period. Therefore, the novelty of this research lies in the use of a Scopus-based bibliometric approach to systematically identify publication trends, the structure of scientific networks, and shifts in the focus of studies related to physical education models based on gross motor development testing.

The urgency of this research is further underscored by the need for an integrated scientific foundation to support the development of adaptive, evidence-based physical education learning models that are responsive to the diverse characteristics of learners, including within the contexts of inclusive education and digital transformation. This study seeks to map the progression of research on the Test of Gross Motor Development (TGMD) within the context of school-based physical education from 2015 to 2024. Specifically, it examines: (1) trends in the evolution of publications related to TGMD in physical education learning; (2) the productivity of researchers focusing on this area; (3) the journals that publish TGMD-related studies, along with the affiliations and countries of contributing authors; and (4) the thematic directions and emerging topics in TGMD research within physical education. The study is expected to provide a comprehensive understanding of how research in physical education learning has evolved over time. Furthermore, the findings are anticipated to identify potential opportunities for future studies, particularly in the development of technology-based physical education in school contexts.

2. RESEARCH METHODOLOGY

This study is a quantitative descriptive study using a bibliometric approach to evaluate trends in research on TGMD-based Physical Education learning, with data sourced from the Scopus database for the period 2015 to 2024. Data collection was carried out by searching for Scopus-indexed articles using the keywords “physical learning” and “test of gross motor development”, applied to the title, abstract and keywords fields. To enhance transparency and reproducibility, the data selection process was carried out systematically in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart, which comprises the following four main stages:

Identification

In this stage, the researchers conducted an initial search of the Scopus database using the predetermined keyword combination. All documents retrieved from the search results were exported in CSV and RIS formats to ensure compatibility with the analysis software. This process yielded an initial set of articles encompassing various document types with no initial restrictions other than the publication year range (2015–2024).

Screening

The screening stage involves eliminating irrelevant documents, including duplicate articles, non-scientific documents (such as conference proceedings, editorials, book chapters, and notes), as well as articles that do not focus on Physical Education or are not directly related to TGMD. Screening also takes into account the language of publication (only English-language articles) and the availability of complete metadata.

Eligibility

At this stage, articles that have passed the screening are analysed further through a review of the title, abstract and, where necessary, the full text to ensure alignment with the research objectives. Inclusion criteria include a focus on TGMD-based Physical Education learning, topic relevance, and contribution to the development of motor skills. Articles that do not meet these criteria are excluded from the analysis.

Included

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The final stage yielded 111 articles that met all inclusion criteria and were deemed suitable for further analysis. The metadata for all these articles was then processed using bibliometric software such as VOSviewer, R (Bibliometrix), and Biblioshiny to analyse the distribution of publications by year, author productivity, institutional affiliations, as well as keyword mapping and patterns of scientific collaboration.

Through this structured and transparent data selection procedure, the study possesses a higher level of reproducibility, thereby enabling other researchers to consistently replicate the data search and analysis process and obtain an objective picture of the global development of TGMD-based Physical Education research.

3. RESULTS AND DISCUSSION

This article aims to map the development of research related to the Test of Gross Motor Development (TGMD) in physical education learning in schools during the period 2015 to 2024. Covering 1) trends in the evolution of publications related to TGMD in physical education learning; 2) the productivity of researchers focusing on this area; 3) the journals that publish TGMD-related studies, along with the affiliations and countries of contributing authors; and 4) the thematic directions and emerging topics in TGMD research within physical education. The development of research publications in the field of physical education learning related to TGMD demonstrates a positive trend, particularly between 2015 and 2024. More detailed information on the distribution of these publications is presented in Table 1.

Table 1. Years of Physical Education Learning Research (TGMD)

Year	Documents	Presentation
2024	23	20.72%
2023	9	8.11%
2022	9	8.11%
2021	16	14.41%
2020	15	13.51%
2019	13	11.71%
2018	11	9.91%
2017	9	8.11%
2016	4	3.60%
2015	2	1.80%
Total	111	100%

Based on the data presented in Table 1 and Figure 1, the distribution of documents from 2015 to 2024 reveals a general upward trend in publication output over time. The peak occurred in 2024, with 23 documents (20.72%), reflecting a substantial rise compared to earlier years. Moreover, the 2020–2024 period consistently generated a higher number of publications than the 2015–2019 period, which began at a relatively low level, such as only 2 documents (1.80%) in 2015. These results suggest a clear pattern of increasing research productivity and more intensive scholarly activity, likely driven by growing research capacity, heightened demand, or stronger institutional support in recent years. Overall, the cumulative data indicates a positive trajectory in document contributions annually, with minor fluctuations during intermediate years, culminating in a marked proportional increase in the most recent period.

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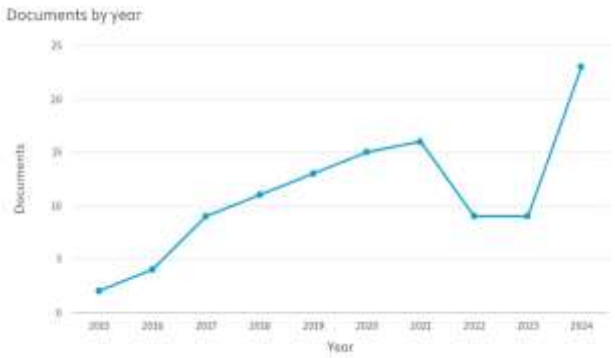

Figure 1. Publication Trends of TGMD Physical Education Learning Research

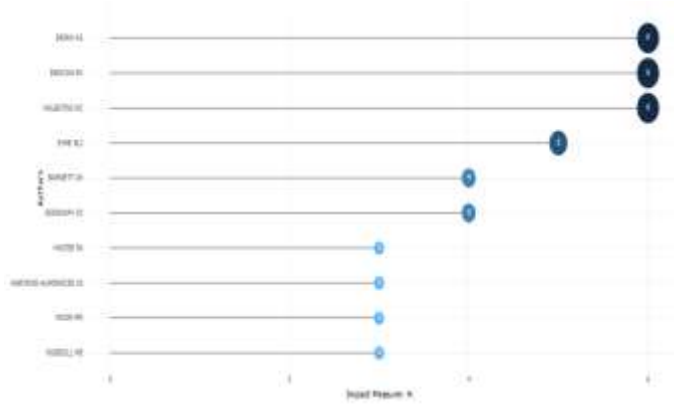

Figure 2. The Most Relevant and Productive Author in Physical Education Learning Research on the Test of Gross Motor Development (TGMD)

Based on Figure 2 and Table 2, the visualization of authors' impact (H-index) indicates that three researchers—Brian AS, Duncan MJ, and Valentini NC—hold the highest H-index value of 6, reflecting their strong influence and substantial contributions to the field. Eyre ELJ follows with an H-index of 5, while Barnett LM and Goodway JD each have an H-index of 4. In contrast, four other authors—Hastie PA, Hurtado-Almonácid JG, Noon MR, and Rudisill ME—record an H-index of 3, suggesting a comparatively lower level of scholarly impact. Overall, this distribution highlights disparities in scientific influence among researchers, where a small group of leading authors plays a dominant role in advancing knowledge within the field.

Table 2. Local Impact of Author Publication Results in Physical Education (TGMD)

Author	h_index	g_index	m_index	TC	NP	PY_start
Brian As	6	6	0.667	185	6	2017
Duncan Mj	6	9	0.75	176	9	2018
Valentini Nc	6	7	0.6	123	7	2016
Eyre Elj	5	6	0.625	147	6	2018
Barnett Lm	4	4	0.444	141	4	2017
Goodway Jd	4	4	0.444	185	4	2017
Hastie Pa	3	3	0.333	82	3	2017
Hurtado-Almonácid Jg	3	3	1	31	3	2023
Noon Mr	3	3	0.5	70	3	2020
Rudisill Me	3	3	0.333	82	3	2017

Note:

H-Index: Author's Citation Index and Number of Publications; G-Index: Author's Productivity and Publication Impact; M-Index: Author's Research Impact and Publication Metrics; and TC: Author's Article Publication Citation Count.

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Journals that publish research related to physical education learning on the Test of Gross Motor Development (TGMD) serve as essential sources for accessing a wide range of scholarly articles. These journals function as key references for researchers in examining and evaluating developments in major issues within the field. Accordingly, this article provides a graphical visualization highlighting the top ten journals that publish studies on school-based physical education learning. This visual representation is intended to illustrate the contributions of different journals in disseminating research findings. The following section briefly outlines the ten most influential journals in the field of physical education learning.

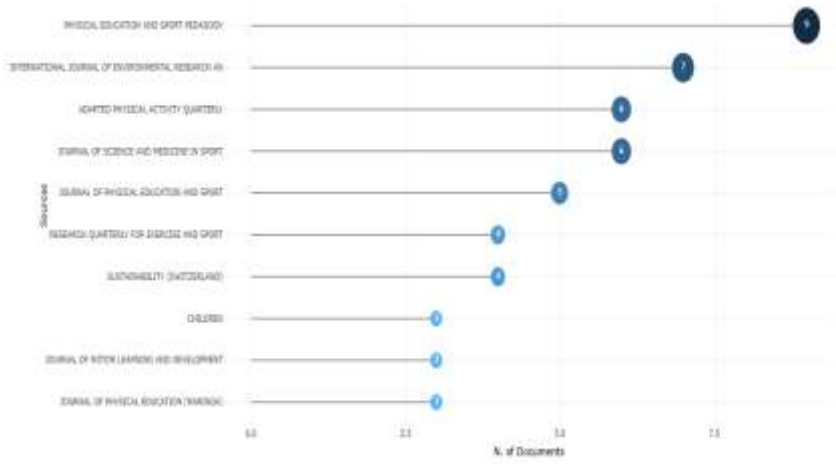

Figure 3. Most Relevant Sources of Reputable Journals in Publication (TGMD)

Based on Figure 3 and Table 3, the distribution of published documents across different sources reveals that *Physical Education and Sport Pedagogy* leads with nine documents, making it the most prominent outlet in this field of study. It is followed by the *International Journal of Environmental Research and Public Health* with seven publications, while *Adapted Physical Activity Quarterly* and the *Journal of Science and Medicine in Sport* each contribute six documents. Other journals, including the *Journal of Physical Education and Sport* (five documents) and both *Research Quarterly for Exercise and Sport* and *Sustainability (Switzerland)* (four documents each), also provide notable support. In contrast, *Children*, the *Journal of Motor Learning and Development*, and the *Journal of Physical Education (Maringá)* show the lowest contributions, with three documents each. Overall, this pattern suggests that research in physical education, sport, and physical activity is concentrated within a group of leading journals that demonstrate greater publication capacity and scientific influence compared to others.

Regarding country contributions to research on physical education learning using the Test of Gross Motor Development (TGMD), reputable journals function as key platforms for disseminating scholarly work and serve as important references for examining trends and strategic issues in this domain. In line with this, the article presents a graphical overview of the ten leading journals that have published studies on TGMD-based physical education learning in schools. This visualization aims to highlight the role and contribution of various journals in advancing research within the field. The following section provides a brief overview of the ten most relevant journals supporting studies on TGMD-based physical education learning.

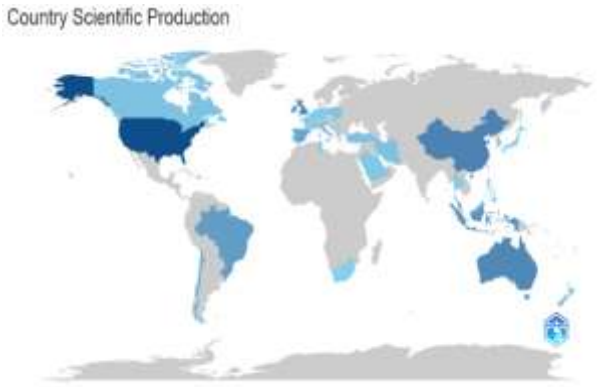

Figure 4. The United States is a Major Contributor to TGMD Research

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Based on Figure 4 and Table 4, the country-based citation distribution indicates that the United States (USA) leads with the highest number of citations (49), highlighting its dominant role in contributing to the field. It is followed by China (28 citations), the United Kingdom (27 citations), and Australia (26 citations), reflecting strong participation from both Asian and European regions. Indonesia ranks fifth with 22 citations, suggesting a growing and competitive presence in the international research landscape. Meanwhile, Brazil (18), Ireland (15), Spain (15), Chile (12), and Malaysia (9) show comparatively lower citation counts, yet still represent a broad cross-continental spread of research activity. Overall, these findings demonstrate that the field is supported by extensive international collaboration, with leading contributions concentrated in countries with well-established research capacities, alongside increasing participation from emerging contributors such as Indonesia and Malaysia in the Asian region.

Table 4. Countries Contributing to Physical Education Research (TGMD)

Country	Citation
Usa	49
China	28
Uk	27
Australia	26
Indonesia	22
Brazil	18
Ireland	15
Spain	15
Chile	12
Malaysia	9

Mapping the direction of research topic development in physical education learning related to the Test of Gross Motor Development (TGMD) shows that these topics tend to evolve across different educational levels, making them a dynamic and continuously developing area of study. This condition creates opportunities for researchers to undertake more comprehensive investigations, particularly in exploring the approaches and methodologies used in physical education learning, supported by the integration of information technology in school settings. The following section presents a graph illustrating trends in the development of research topics related to TGMD-based physical education learning in schools.

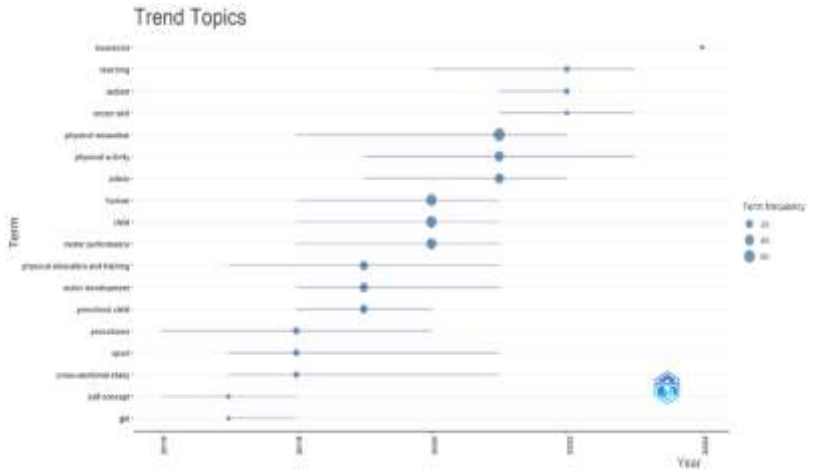

Figure 5. Trends in Physical Education Learning Research Topics (TGMD)

Based on the topic trend map from 2016 to 2024, research themes in physical education, physical activity, and children's motor development demonstrate a dynamic pattern of growth. Topics such as locomotor skills, teaching, autism, and motor skills show a marked increase in prominence, particularly after 2020, reflecting a stronger emphasis on instructional strategies, special needs education, and motor development. Core terms like physical education, physical activity, and human remain consistently dominant, indicating their sustained importance within academic discussions in this field. In contrast, topics such as self-concept, girls, procedures,

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and sport appeared earlier but with lower intensity, suggesting a shift in research attention from more general issues toward more specific and applied areas of study. Overall, this trend illustrates a transformation toward more inclusive, interdisciplinary research that aligns with the evolving needs of child development and contemporary physical education.

Regarding the network visualization of research topics in physical education learning related to the Test of Gross Motor Development (TGMD), the analysis generated using VOSviewer reveals clusters of closely interconnected themes within the domains of physical education, physical activity, and motor development. Key terms such as physical education, physical activity, motor skills, human, and motor development appear as dominant nodes, indicating their high frequency and strong relevance in the literature. These central concepts are linked to various subtopics, including fundamental motor skills, motor competence, autism, intellectual disability, sport, and gender differences, forming an interdisciplinary network that connects education, health, child development, and special needs. The density and patterns of connections among these nodes suggest that the field is advancing through an integrative approach, where fundamental concepts of physical education and motor skills serve as the foundation for linking research on development, intervention, and inclusion within both educational and public health contexts.

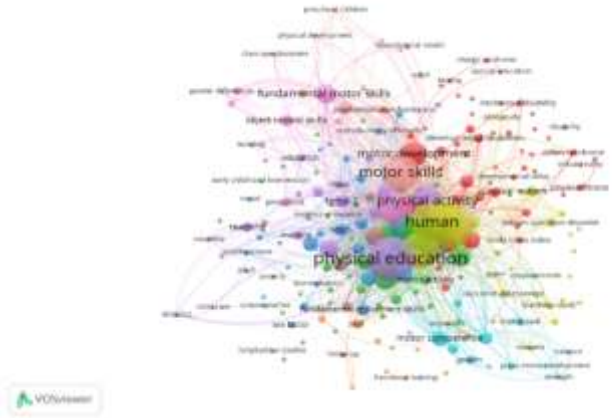

Figure 6. Network Visualization in Physical Education Learning (TGMD)

The visualization of research topic novelty in physical education learning related to TGMD, based on overlay analysis using VOSviewer, illustrates the temporal progression of themes within the domains of physical education, physical activity, and motor development. Nodes displayed in turquoise represent earlier research topics (approximately 2018–2020), such as fundamental motor skills, physical education, and motor development, which serve as the foundational basis of studies in this field. In contrast, nodes shown in yellow to light green highlight more recent topics (2021–2023), including autism spectrum disorder, virtual reality, developmental delay, feasibility studies, and game-based measurement. These emerging themes reflect a shift in research emphasis toward the integration of technology, attention to special needs populations, and the evaluation of intervention programs. Overall, this pattern demonstrates a transition from foundational research on motor skills and physical education toward more innovative, inclusive, and technology-oriented approaches that align with advances in science and evolving societal demands.

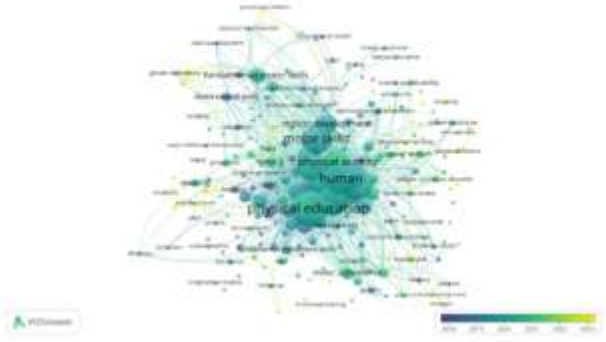

Figure 7. Visualization of the Physical Education Research Topic Overlay (TGMD)

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The visualization of research opportunities in physical education learning related to TGMD, based on density mapping using VOSviewer, highlights the concentration of key topics within the field. Areas shown in bright yellow represent the highest density, including core terms such as human, physical activity, physical education, motor skills, and motor development. This indicates that these topics are the most frequently studied and serve as the central focus in the literature on physical education, physical activity, and motor development. The green areas reflect topics with moderate frequency, such as fundamental motor skills, motor competence, sport, teaching, and autism. Although less dominant than the core themes, these topics remain significant in supporting the development of more specialized research. Meanwhile, the blue areas indicate topics with relatively low occurrence, representing more specific or emerging areas of study. Overall, this visualization suggests that research is largely centered on the relationship between physical education, physical activity, and human motor development, while also highlighting opportunities to further explore less-studied topics that offer potential for future research expansion.

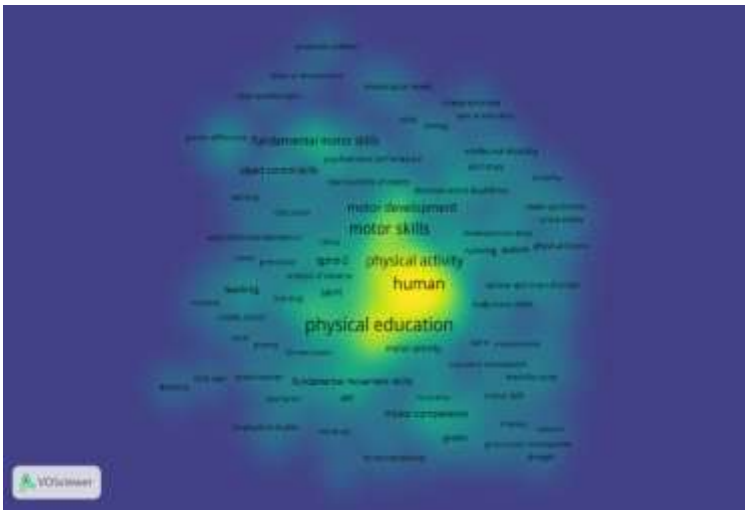

Figure 8. TGMD Research Topics Density Visualization

The Test of Gross Motor Development (TGMD), including both the TGMD-2 and TGMD-3 versions, is a fundamental assessment tool for evaluating motor development, recognized for its strong reliability and validity, and its ability to provide valuable insights within physical education contexts. In terms of reliability, systematic reviews indicate that TGMD demonstrates consistently high test–retest coefficients, with Pearson correlation values exceeding 0.80 across all evaluations and Intraclass Correlation Coefficient (ICC) values above 0.75 in more than 95% of studies, with some findings even reporting ICC values greater than 0.90 (Rey et al., 2020) . In Myanmar, the application of TGMD-2 among kindergarten children also demonstrated strong to excellent levels of inter-rater, intra-rater, and test–retest reliability (Aye et al., 2017) Moreover, in children with visual impairments, the TGMD-2 has demonstrated internal consistency ranging from 0.71 to 0.72 and ICC reliability values between 0.82 and 0.95, suggesting that the instrument is reliable and suitable for application in inclusive populations (Castiglioni et al., 2025).

Moreover, assessments of the TGMD-3 measurement properties based on the COSMIN (Consensus-based Standards for the Selection of Health Measurement Instruments) framework show that the instrument demonstrates sufficient inter-rater, intra-rater, and test–retest reliability. Its content and structural validity are supported by evidence of moderate to high quality. However, certain aspects, particularly construct validity and responsiveness, still require further investigation due to inconsistent findings (Zhu et al., 2025). A more detailed investigation into the reliability of TGMD-3 revealed that ICC values for the total score and its subscales (locomotor and ball skills) ranged from 0.92 to 0.96, reflecting very high inter-rater reliability. However, reliability at the level of individual skills showed greater variation, with ICCs ranging from 0.51 to 0.93. Similarly, intra-rater reliability varied between 0.77 and 0.98, with some instances indicating lower consistency. These findings highlight the importance of more comprehensive training for TGMD-3 assessors to ensure consistent scoring (Maeng et al., 2017). Beyond its measurement properties, experimental studies have demonstrated that physical activity programs can significantly enhance TGMD outcomes. For instance, a 12-week intervention implemented through the Comprehensive School Physical Activity Program (CSPAP) increased TGMD-2 scores from an

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average of 72.6% to 82.4%, with a Cohen's *d* effect size of 0.67, with greater improvements observed among younger children (Burns et al., 2017) . Likewise, a study involving preschool children who took part in a 10-week physical activity program using TGMD-2 reported significant improvements in locomotor and ball control skills compared to the control group ($p < 0.05$) (Ali et al., 2021) .

In terms of validity and discriminative capacity, the TGMD-3 has been shown to be sensitive in identifying delays in fundamental motor development among children with various disabilities, including intellectual disabilities, autism, and ADHD. Scores for these groups were significantly lower than those of matched control groups based on age, gender, and other factors ($p < 0.001$ for intellectual disabilities and autism, and $p = 0.032$ for ADHD). These findings highlight the effectiveness of TGMD-3 in detecting motor skill deficits and informing the need for adaptive physical education interventions (Pitchford & Webster, 2020) . Empirical findings indicate that both TGMD-2 and TGMD-3 possess strong methodological quality, characterized by high reliability, solid validity across diverse populations, and sensitivity to intervention effects and variations in motor development. These strengths position the TGMD as a highly effective assessment tool in physical education research, particularly within learning environments that emphasize play-based motor skill evaluation, promote inclusivity, and support the design of targeted and adaptive intervention strategies.

4. CONCLUSION

This study reinforces that the Test of Gross Motor Development (TGMD) is a valid, reliable, and adaptable instrument for assessing fundamental motor skills within physical education settings. A bibliometric analysis of Scopus-indexed publications from 2015 to 2024 reveals a marked increase in research output, particularly from 2020, reaching its peak in 2024. The United States, China, the United Kingdom, Australia, and Indonesia emerge as the leading contributors to the advancement of TGMD-related studies. In addition, the research focus has evolved from basic motor skill assessment toward broader themes such as inclusivity, special needs education, and the integration of digital technologies in physical education. These findings highlight TGMD not only as an assessment tool but also as a foundation for developing innovative learning strategies that are responsive to student diversity and aligned with the demands of 21st-century education. Several recommendations can be proposed. First, physical education teachers are encouraged to incorporate TGMD into game-based learning approaches, enabling motor skill assessments to be conducted in a more engaging, inclusive, and low-pressure environment. Second, future researchers are advised to explore the integration of technology—such as digital platforms or virtual reality—to enhance the efficiency, objectivity, and student engagement of TGMD assessments. Third, further studies should emphasize the application of TGMD among children with special needs to strengthen the role of physical education in promoting social inclusion. Finally, educational institutions and policymakers are expected to support professional training for teachers in the effective use of TGMD, ensuring more consistent assessment outcomes and contributing to improved learning quality. Through these efforts, TGMD has strong potential to serve as a strategic tool in advancing sustainable, innovative physical education that supports holistic child development.

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