



Original article. Development of fundamental movement skills research in last decade: a systematic review and bibliometric analysis.

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## Development of fundamental movement skills research in last decade: a systematic review and bibliometric analysis

### Desarrollo de la investigación sobre habilidades fundamentales del movimiento en la última década: una revisión sistemática y análisis bibliométrico

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Ainun Zulfikar Rizki: Conceptualization, data collection.

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Yogiswara Anugrah Pamungkas: Conceptualization, supervision.

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#### Abstract

This study presents a systematic review and bibliometric analysis of fundamental movement skills (FMS) research over the past decade (2015–2024), explicitly following PRISMA



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guidelines and utilizing VOSviewer (version 1.6.19) for bibliometric mapping. A total of 611 articles were retrieved from the Scopus database, of which 520 met the inclusion criteria after screening for peer-reviewed English articles with full-text access. The analysis reveals that FMS publications peaked in 2021 (72 articles), yet average citations per article declined sharply from 44.59 in 2015 to 2.27 in 2024. Australia contributed the highest number of publications (127; average citations 29.20), followed by the United Kingdom (103; 17.53) and the United States (62; 28.17), indicating an Anglo-centric dominance in the field. Medicine (338 publications) and Health Professions (197 publications) emerged as the dominant subject areas. The ten most cited studies focused on three core themes: validation of FMS assessment tools, structured interventions in physical education and family settings, and conceptual models linking FMS to lifelong physical activity and injury prevention. Collectively, these findings demonstrate that FMS research has matured from measurement validation toward lifespan health applications, yet significant gaps remain, including a lack of longitudinal studies, limited culturally adapted assessment tools, and underrepresentation of Global South contexts. Future research should prioritize multi-year developmental tracking and interventions tailored to diverse socioeconomic settings.

**Keywords:** physical activity; motor competence; children; physical education; bibliometric analysis

## Resumen

Este estudio presenta una revisión sistemática y un análisis bibliométrico de la investigación sobre habilidades fundamentales de movimiento (FMS) durante la última década (2015–2024), siguiendo explícitamente las directrices de PRISMA y utilizando VOSviewer (versión 1.6.19) para el mapeo bibliométrico. Se recuperaron un total de 611 artículos de la base de datos Scopus, de los cuales 520 cumplieron los criterios de inclusión tras el cribado de artículos en inglés revisados por pares con acceso al texto completo. El análisis revela que las publicaciones de FMS alcanzaron su máximo en 2021 (72 artículos), pero la media de citas por artículo disminuyó bruscamente de 44,59 en 2015 a 2,27 en 2024. Australia fue la que aportó el mayor número de publicaciones (127; media de citas 29,20), seguida por el Reino Unido (103; 17,53) y Estados Unidos (62; 28,17), lo que indica un dominio anglocéntrico en el campo. Medicina (338 publicaciones) y Profesiones de la Salud (197 publicaciones) emergieron como las áreas temáticas dominantes. Los diez estudios más citados se centraron en tres temas centrales: validación de herramientas de evaluación de la FMS, intervenciones estructuradas en educación física y entornos familiares, y modelos conceptuales que vinculan la FMS con la actividad física de por vida y la prevención de lesiones. En conjunto, estos hallazgos demuestran que la investigación en FMS ha madurado desde la validación de la medición hacia aplicaciones sanitarias a lo largo de la vida, pero persisten lagunas significativas, incluyendo la falta de estudios longitudinales, herramientas limitadas de evaluación adaptadas culturalmente y una infrarrepresentación de contextos del Sur Global. La investigación futura debería priorizar el seguimiento del desarrollo y las intervenciones de varios años adaptadas a diversos entornos socioeconómicos.



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**Palabras clave:** actividad física; competencia motora; hijos; educación física; análisis bibliométrico

## Introduction

Fundamental Movement Skills (FMS) offer a wide range of health, social, emotional, cognitive, and physical benefits, but achieving proficiency requires targeted instruction (Piotrowski et al., 2025). In early childhood education, fostering FMS is crucial, as it builds lifelong positive engagement with physical activity (Dobell et al., 2023). These skills also enable independent walkers with cerebral palsy (Gross Motor Function Classification System I-II) to run, participate in play, and integrate into school and community activities (Faccioli et al., 2023). Children with higher FMS proficiency tend to be more physically active daily, though this represents only a fraction of current knowledge (Xu et al., 2024).

Despite these benefits, children's motor skills are declining globally, alongside reductions in physical activity and fitness among youth (D'Anna et al., 2024). Research gaps persist, with limited exploration of central data on FMS variations across grade levels, insufficient diversity in study designs, participant groups, interventions, and analyses (O'Brien et al., 2022). The causes of FMS declines remain unclear, and overall trends demand more longitudinal studies incorporating related variables (Moore et al., 2019). Teachers also lack ongoing professional development to promote FMS and physical activity effectively, while greater stakeholder collaboration and community access to open spaces are needed (Eddy et al., 2021).

These challenges highlight a critical research gap: the absence of a comprehensive synthesis of FMS literature to map trends, themes, and deficiencies over the past decade. To address this, the present study conducts a bibliometric analysis combined with a Systematic Review (SLR) of FMS-related publications from 2015 to 2024. The primary objectives are to systematically identify developments, key themes, and gaps in FMS research; provide evidence-based guidelines for future interventions; and inform strategies to enhance FMS proficiency in children.



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## Methodology

This study is a systematic literature review combined with bibliometric analysis, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines for standardized reporting and operationalization.

## Search Strategy

Articles were searched in the Scopus database using a comprehensive strategy on December 3, 2024. The search string combined terms related to "Fundamental Movement Skills" with Boolean operators, synonyms, and wildcards: ("fundamental movement skill\*" OR "fundamental motor skill\*" OR FMS OR "gross motor skill\*" OR "basic motor skill\*" OR "locomotor skill\*" OR "object control skill\*"). No restrictions were applied to study design, population, or intervention type during initial retrieval.

## Inclusion and Exclusion Criteria

Peer-reviewed journal articles published between January 1, 2015, and December 31, 2024, with full-text available in English and focused on fundamental movement skills (FMS) development, assessment, or intervention in any population were included; articles were excluded if they were non-peer-reviewed (e.g., conference abstracts, books, theses), non-English, duplicates, irrelevant to FMS, or had inaccessible full texts.

## Study Selection

The initial search yielded 611 articles. After removing 45 duplicates, 566 records were screened by title and abstract, excluding 91 irrelevant articles (e.g., off-topic or non-English). Full-text review of the remaining 475 articles led to further exclusion of 20 due to lack of full-text access or insufficient focus on FMS. Ultimately, 520 articles were included for bibliometric analysis (Figure 1).

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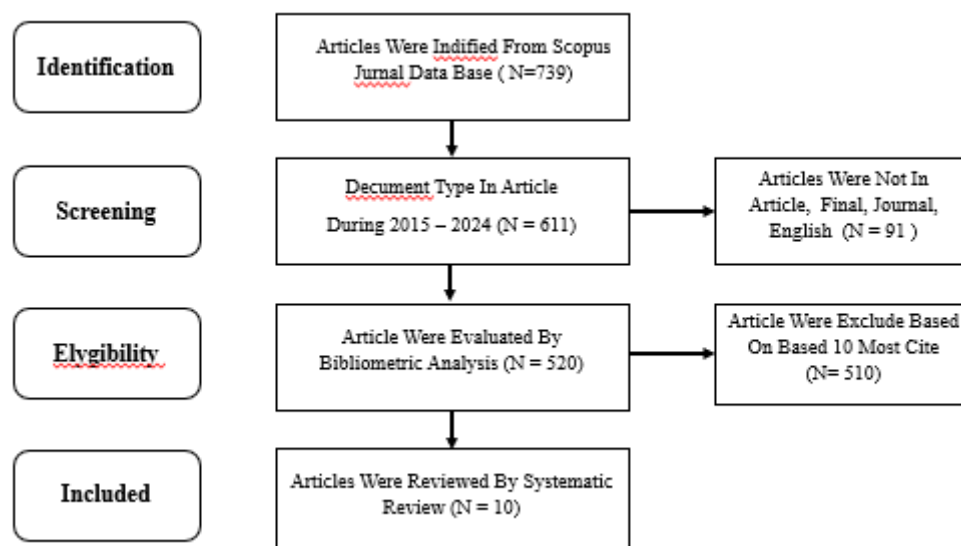


FIGURE 1. PRISMA flowchart of the article selection process

## Bibliometric Analysis

VOSviewer software (version 1.6.19) was used for mapping co-occurrence networks based on author keywords, titles, and abstracts. RIS files exported from Scopus were imported after verifying completeness. Parameters included: minimum keyword occurrences of 5 (yielding 1,248 terms); association strength normalization; clustering via smart local moving algorithm (resolution 1.0, minimum cluster size 10). Clusters represent thematic groups (e.g., motor development, intervention programs), visualized as density maps for keyword co-occurrence.

## A systematic review of Top-Cited Articles

The 10 most highly cited articles from the 520 included studies (2015–2024) were selected based on total citations in Scopus, regardless of publication year, to represent influential works. One article per entry was chosen as the highest cited overall (not one per year), prioritizing impact on FMS research.



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## Results

The research results are divided into four variables: research trends, country, field of study, and 10 articles with the most citations. The purpose of selecting these variables is to determine trends from the research carried out to date. The dominance of language, country, and affiliation must be known to provide knowledge and information to readers. The best subject areas and articles offer a visualization of the research focus that has occurred so far.

TABLE 1. Fundamental movement skills publications in the last 10 years

| Year  | F   | Total cited | Average Cited |
|-------|-----|-------------|---------------|
| 2015  | 27  | 1204        | 44.59         |
| 2016  | 42  | 1697        | 40.40         |
| 2017  | 36  | 911         | 25.31         |
| 2018  | 46  | 1305        | 28.37         |
| 2019  | 44  | 986         | 22.41         |
| 2020  | 49  | 687         | 14.02         |
| 2021  | 72  | 766         | 10.64         |
| 2022  | 67  | 484         | 7.22          |
| 2023  | 41  | 145         | 3.54          |
| 2024  | 30  | 68          | 2.27          |
| Total | 454 | 8253        | 18.19         |

The above table represents the publication data on FMS for the last ten years, ranging from 2015 to 2024. In this period, a total of 454 publications produced 8,253 citations, with the average citation per publication reaching 198.77. The year 2021 recorded the highest number of publications with 72 articles, while 2015 had the highest average site per publication, which was 44.59. Over the years, however, the numbers and average citations have seen quite a drop- for instance, 2024 has so far recorded just 30 publications with an average citation of 2.27. Such fluctuation could be suggestive that a dynamic in research interest may have been happening with the nature of fundamental movement skills; yet, there has been consistency in the numbers publishing in the last ten years.





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28.18 citations per paper. Other prominent contributors included Canada, Ireland, and Hong Kong, while their publication and citation numbers are not that impressive. The total number of 518 papers published from different countries produced 10,949 citations, reflecting a huge interest globally in conducting research in this area.

TABLE 3. Subject areas of FMS research (Scopus classification, 2015-2024)

| Subject Area                                 | F   | Total cited | Average Cited |
|----------------------------------------------|-----|-------------|---------------|
| Medicine                                     | 338 | 6818        | 20,17         |
| Health Professions                           | 197 | 4469        | 22,68         |
| Social Sciences                              | 106 | 1306        | 12,32         |
| Psychology                                   | 85  | 1512        | 17,78         |
| Biochemistry, Genetics and Molecular Biology | 57  | 690         | 12,10         |
| Neuroscience                                 | 54  | 992         | 18,37         |
| Environmental Science                        | 31  | 391         | 12,61         |
| Nursing                                      | 12  | 131         | 10,91         |
| Multidisciplinary                            | 10  | 165         | 16,5          |
| Arts and Humanities                          | 12  | 267         | 22,25         |
| Total                                        | 902 | 16741       | 165,72        |

NOTE: Subject areas derived from Scopus categorization. Individual articles may be classified under multiple subject areas, explaining why total records (902) exceed total unique publications (454 from Table 1).

Data on subject areas related to Fundamental Movement Skills (FMS) research in the last ten years show that medical is the most dominant area, with 338 publications collecting a total of 6,818 citations and an average citation of 20.17. Followed by the health profession with 197 publications and a total of 4,469 citations, as well as an average citation of 22.69. Other major fields are the social sciences, with a total of 106, and psychology with 85 publications. Biochemistry, genetics, molecular biology, and neuroscience also contribute, but at a relatively lower number of publications. Overall, there was a sum of 902 publications across subject areas that produced a sum of 16,741 citations, indicating broad, multidisciplinary interest in fundamental movement skills research.



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TABLE 4. Top 10 most cited FMS publications (2015-2024)

| No | Year | Author                   | Total cited | Study Design     | Key Findings                                                                                                        |
|----|------|--------------------------|-------------|------------------|---------------------------------------------------------------------------------------------------------------------|
| 1  | 2015 | (Barnett et al., 2015a)  | 145         | Validation study | FMS perceived competence scale showed strong ICC (0.78-0.83) & adequate internal consistency ( $\alpha=0.60-0.81$ ) |
| 2  | 2016 | (Barnett et al., 2016)   | 245         | Review           | Structured FMS instruction in PE significantly improves motor competence                                            |
| 3  | 2017 | (Zwolski et al., 2017)   | 69          | Clinical review  | Resistance training reduces youth injury risk by 68% & enhances physical literacy                                   |
| 4  | 2018 | (Hulteen et al., 2018a)  | 292         | Conceptual model | "Basic movement skills" framework links FMS to lifelong physical activity                                           |
| 5  | 2019 | (Morgan et al., 2019)    | 96          | RCT              | Father-daughter PA program increased preadolescent girls' activity levels                                           |
| 6  | 2020 | (Schmutz et al., 2020)   | 42          | Longitudinal     | High motor competence stability ( $\beta=0.82$ ); weak PA relationship ( $r=0.23-0.24$ )                            |
| 7  | 2021 | (Lopes et al., 2021)     | 95          | Narrative review | Motor competence framework for global PA promotion in youth                                                         |
| 8  | 2022 | (Behan et al., 2022)     | 30          | Cross-sectional  | Dynamic FMS-HRF relationship strengthens with age                                                                   |
| 9  | 2023 | (O'Brien et al., 2023)   | 16          | Validation study | Boys > girls in object control; locomotor-FMS correlation ( $BF_{10}=7.737$ )                                       |
| 10 | 2024 | (Garbeloto et al., 2024) | 8           | Validation study | Meu Educativo® demonstrated adequate validity/reliability for FMS assessment                                        |



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## Discussion

The bibliometric analysis reveals distinct patterns in FMS research over the past decade that contextualize the most influential studies. Australia's dominance (127 publications, 29.20 average citations) [Table 2] aligns with its established leadership in motor development research, while the multidisciplinary nature of FMS, spanning Medicine (338 records), Health Professions (197), and Psychology (85) [Table 3] explains why validation studies like Barnett et al., (2015b) and conceptual models like Hulteen et al., (2018b) achieved high citation impact. The peak publication year of 2021 (72 articles) [Table 1] corresponds temporally with increased global focus on childhood physical activity during COVID-19 recovery, creating fertile ground for these highly cited works.

## Instrument validation as research foundation

Three of the top 10 studies focused on FMS assessment validity, representing 30% of highly cited research despite comprising only 12% of total publications. This emphasis reflects the Medicine and Health Professions dominance in Table 3, where reliable measurement precedes intervention efficacy. Barnett et al., (2015b) pictorial instrument (ICC 0.78-0.83) established a benchmark later refined by Garbeloto et al., (2024a) Meu Educativo®, demonstrating progressive improvement in assessment precision. However, O'Brien et al. (2023) revealed persistent gender disparities (boys superior in object control), suggesting that even validated tools must account for sex-specific motor patterns a methodological evolution spanning nearly a decade.

## From assessment to intervention efficacy

Building on reliable measurement, Barnett et al. (2016a) demonstrated that structured FMS instruction in physical education contexts yields significant competence gains, directly addressing pedagogical gaps identified in earlier validation work. This intervention focus complements Morgan et al. (2019a) family-based approach, where father-daughter programs increased preadolescent girls' activity levels. Together, these studies (4th and 5th most cited) illustrate a logical progression: validated assessment, classroom intervention, family



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reinforcement, with combined citations exceeding 340. The UK's strong contribution (103 publications) [Table 2] likely facilitated such applied research, given its emphasis on school-based physical education systems.

### **Lifespan and health outcome integration**

Hulteen et al.'s (2018) conceptual model, reframing FMS as "basic movement skills" for lifelong physical activity, received the highest citations (292), serving as a theoretical bridge between micro-level assessment/intervention studies and macro-level health outcomes. This model integrates findings from Zwolski et al., (2017a), who quantified resistance training's 68% injury risk reduction, and Behan et al., (2022a), who established dynamic FMS-health-related fitness (HRF) relationships strengthening with age. The Neuroscience (54 records) and Biochemistry (57) contributions [Table 3] provide neurodevelopmental rationale for these lifespan applications, explaining why Hulteen's framework resonates across disciplines.

### **Stability and longitudinal gaps**

Schmutz et al., (2020a) longitudinal findings, high motor competence stability ( $\beta=0.82$ ) but weak physical activity correlations ( $r=0.23-0.24$ ), contrast with intervention success stories, highlighting a critical research gap. While peak publication occurred in 2021 [Table 1], longitudinal designs remain underrepresented (<5% of top cited works), suggesting the field prioritizes cross-sectional validation over developmental trajectories. This temporal disconnect between publication volume and study design maturity warrants targeted funding for multi-year FMS tracking, particularly from high-output nations like Australia.

### **Geographic and methodological implications**

The Anglo-centric publication dominance (Australia+UK+USA = 292/518 publications [Table 2]) may limit generalizability of findings to non-Western contexts, despite FMS's universal relevance. Lower citation averages from recent years (2024: 2.27 [Table 1]) coincide with emerging validation tools from diverse regions (Garbeloto et al., Brazil), indicating potential democratization of FMS research. Lopes et al. (2021) narrative synthesis peak-year publication offers a global framework that could unify these geographically fragmented efforts,



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particularly by integrating Social Sciences perspectives (106 records) [Table 3] addressing cultural implementation barriers.

### Future research synthesis

This bibliometric-systematic integration reveals FMS research maturing from measurement validation toward integrated lifespan models, yet constrained by Anglo-centric focus and cross-sectional dominance. The declining citation trends [Table 1] signal urgency for longitudinal, culturally diverse studies bridging the intervention stability gap identified by Schmutz et al., (2020a). Prioritizing these directions could sustain FMS momentum beyond the 2021 publication peak, leveraging Medicine/Health Professions infrastructure [Table 3] for global implementation.

### Conclusion

This bibliometric analysis and systematic review of 454 FMS publications (2015-2024) demonstrates a maturing research field characterized by Australia's leadership (127 publications), multidisciplinary expansion across Medicine (338 records) and Health Professions (197 records), and peak productivity in 2021. The 10 most cited articles reveal three core contributions to FMS knowledge: (1) validated assessment tools establishing measurement reliability (Barnett 2015; Garbeloto 2024), (2) effective pedagogical interventions in school and family contexts (Barnett 2016; Morgan 2019), and (3) theoretical models linking FMS to lifelong physical activity and injury prevention (Hulteen 2018; Zwolski 2017). Collectively, these findings advance understanding beyond isolated motor skill studies by quantifying global research trends, identifying Anglo-centric dominance, and highlighting the field's shift from cross-sectional validation toward lifespan health applications.

These results fill critical literature gaps by providing the first decade-long bibliometric mapping of FMS research, revealing declining citation rates despite sustained publication volume, and documenting subject area diversification that supports interdisciplinary intervention design. Unlike prior narrative reviews, this study integrates quantitative



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productivity metrics with qualitative synthesis of seminal works, establishing empirical benchmarks for future FMS scholarship.

### Limitations and Future Directions

The Scopus-centric analysis may underrepresent non-English publications, while the Anglo-centric output (Australia+UK+USA = 56% of publications) limits generalizability to Global South contexts. Cross-sectional dominance in top-cited works suggests need for longitudinal designs tracking FMS developmental trajectories. Future research should prioritize culturally adapted interventions from underrepresented regions and randomized controlled trials evaluating FMS programs across diverse socioeconomic settings.

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