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A META-ANALYSIS OF STUDIES ON FUNDAMENTAL MOTOR SKILLS IN CHILDREN AGED 3-12 YEARS

Jiang Wenming[1,3], Ahmad Alhussin Alali[1], Nur Ikhwan Mohamad [1,2*], Mohd Hafizuddin Baki[1,4], Novadri Ayubi[5]

[1]Faculty of Sport Science and Coaching, University Pendidikan Sultan Idris, Malaysia
[2]Faculty of Teacher Training & Education, Sriwijaya University, Indonesia
[3]Children's Sports Ability Center, Chengdu, Sichuan Province, China
[4]Education Department, Anti-Doping Agency of Malaysia,
Ministry of Youth and Sports, Malaysia
[5]Universitas Negeri Surabaya, Indonesia

*Corresponding: nur.ikhwan@fsskj.upsi.edu.my

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ABSTRACT

The purpose of this study is to synthesize the recent 2019-2023 studies related to children's fundamental motor skills, and compare their assessment methods as well as intervention programs, providing a reference basis for the next choice and design. The Scopus database was used for this review. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines were used to identify relevant literature, with Cochrane Collaboration's tool for assessing the risk of bias using eligible studies critically appraised and 27 key studies were integrated for specialized analysis. The meta-synthesis revealed that 74% of studies related to the integrated development of children's fundamental motor skills used the TGMD2/3 (which does not include the assessment of fine motor skills). Ninety percent of studies designed fundamental motor skill interventions that included only gross motor skills (manipulatives and mobility) did not include fine motor skill interventions., and did not include fine motor skill intervention content design. In terms of the country of origin of the studies, the United States produced the most studies, followed by the United Kingdom. All other countries accounted for a relatively small number of studies, with 2021 seeing a peak in relevant studies.In the past five years, research on children's fundamental motor skills has revealed that most researchers tend to equate fundamental motor skills with gross motor skills (i.e., physical manipulative skills and mobility skills) and ignore actual direct fine motor skills assessment in their study. In terms of assessment tools, there is a tendency to favor the TGMD, with a lack of attempt to try more diverse tasks, and in terms of intervention program design, there is a tendency to focus on programs that promote gross motor skills and seem to ignore fine motor skills. The correlation and holistic design and research of fundamental motor skills (including gross motor skills as well as fine motor skills) is less. A comprehensive study of children's fundamental motor skill development and interventions would be more beneficial to practitioners in finding the best and most efficient approach.

Keywords: children aged 3-12 years, fundamental motor skills, gross motor skills, fine motor skills. Assessment tools, intervention programs.

INTRODUCTION

Fundamental Motor Skills as the name implies, begin from the moment the child is born to the moment they start to move. The level of Fundamental Motor Skills development is directly and indirectly related to a child's lifelong level of physical functioning, physical fitness, physical activity habits, motor interests, as well as mental health and social adjustment.

The current field of research on Fundamental Motor Skills is dominated by researchers related to physical education, who have taken great care to conduct a large number of quantitative studies (1-27) on the importance of Fundamental Motor Skills and have obtained very significant results.

A look at all the research literature on Fundamental Motor Skills for young children by physical educators reveals that almost all researchers have focused on the developmental level of Gross Motor Skills and related studies of experimental interventions, neglecting the developmental level of fine motor skills. However, no proper investigation on this has been done so far, for this to be fully confirmed.

The development of Gross Motor Skills, which is part of Fundamental Motor Skills, should be as important as the development of Fine Motor Skills in terms of young children's physical development, especially in terms of their influences on the level of physical functioning, physical fitness, and daily physical activity habits.

A simple browse through some of the articles that stated that they are performing studies on Fundamental Motor Skills seems to show a similar pattern, in which it seems like the Fundamental Motor Skills only refers to the Gross Motor Skills. However, our researchers also found no other systematic reviews that have properly investigated and confirmed this perception. Due to this, this systematic review has been performed to identify the main things, one is what is the most utilized assessment for Fundamental Movement Skills among children, and another one is how many out of those are assessing both Gross Motor Skills and Fine Motor Skills in their assessment and study.

This study aims to: i) compare the assessment instruments for fundamental motor skills and to confirm whether the assessment instruments both included assessments related to gross motor skills (Stationary performances, object control skills, and locomotor skills) and fine motor skills (Grasping, Visual-motor integration) and ii) compare the intervention design items for fundamental motor skills, it was confirmed that the intervention tools included items designed for both gross motor skills (Stationary performances, object control skills, and locomotor skills) and fine motor skills(Grasping, Visual-motor integration).

METHODOLOGY

Scopus served as the source for this synthesizing review study. This analysis identified pertinent literature by following PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) standards and utilized the Cochrane Collaboration method to assess the risk of bias. After a thorough evaluation of the eligible papers, 27 important studies were combined for specialist analysis.

Eligibility Criteria

In conducting the literature selection process, the topic chosen was fundamental motor skills, and the target audience of young children, there was no restriction on the age of young children, and the literature was chosen for the last five years of publication (2019-2023), the language of publication had to be English literature, and the research literature focused on experimental-type studies with intervention program designs and clear assessment tools.

Information Source

All literature was obtained from SCOPUS. (https://www.scopus.com/search/form.uri?display=fundamental&zone=header&origin=#fundamental).

Search Strategy

All of the article resources are from the SCOPUS academic website. Open the "SCOPUS" website. Search within "Article title, Abstract, Keywords". Enter the search documents "Fundamental and motor and skills and Children" (n=997). Articles were limited to the years of publication between 2010 and 2023, a total 14 years (n=871). The subject area was limited to Medicine, Health professions, and social sciences(n=462). The document type was limited to Article only (n=424). The source type was limited to Journal only(n=424). The publication language was limited to English only(n=397). There is no restriction on the following items: Author, Source title, Publication stage, Keyword, Affiliation, Funding sponsor, Country/territory (Table1&Figure1).

Table 1. Search Strategy

Search Strategy		
1	Open the "SCOPUS" website.	
2	Search within "Article title, Abstract, Keywords".	
3	Enter the search documents "Fundamental and motor and skills and Children" n=997	
4	Year limit	Limit to 2010-2023, n=871
5	Author limit	No limit
6	Subject area limit	Limit to Medicine, Health Professions, and Social Sciences. n=462
7	Document type limit	Limit to Article. n=424
8	Source title limit	No limit
9	Publication stage limit	No limit
10	Keyword limit	No limit
11	Affiliation limit	No limit
12	Funding sponsor limit	No limit
13	Country/territory limit	No limit
14	Source type limit	Limit to Journal. n=424
15	Language limit	Limit to English. n=397
16	Selection limit	1. the article studied the topic of fundamental motor skills 2. The target population of the articles was children aged 3-12 years. 3. The type of study was quantitative. 4. the article was an experimental study. 5. the article looks at the study of the effects of the research design intervention program on fundamental motor skills. 6. There is a clear and reliable assessment tool for fundamental motor skills in the article. n=54
17	Year limit again	Limit to 2019-2023, n=27

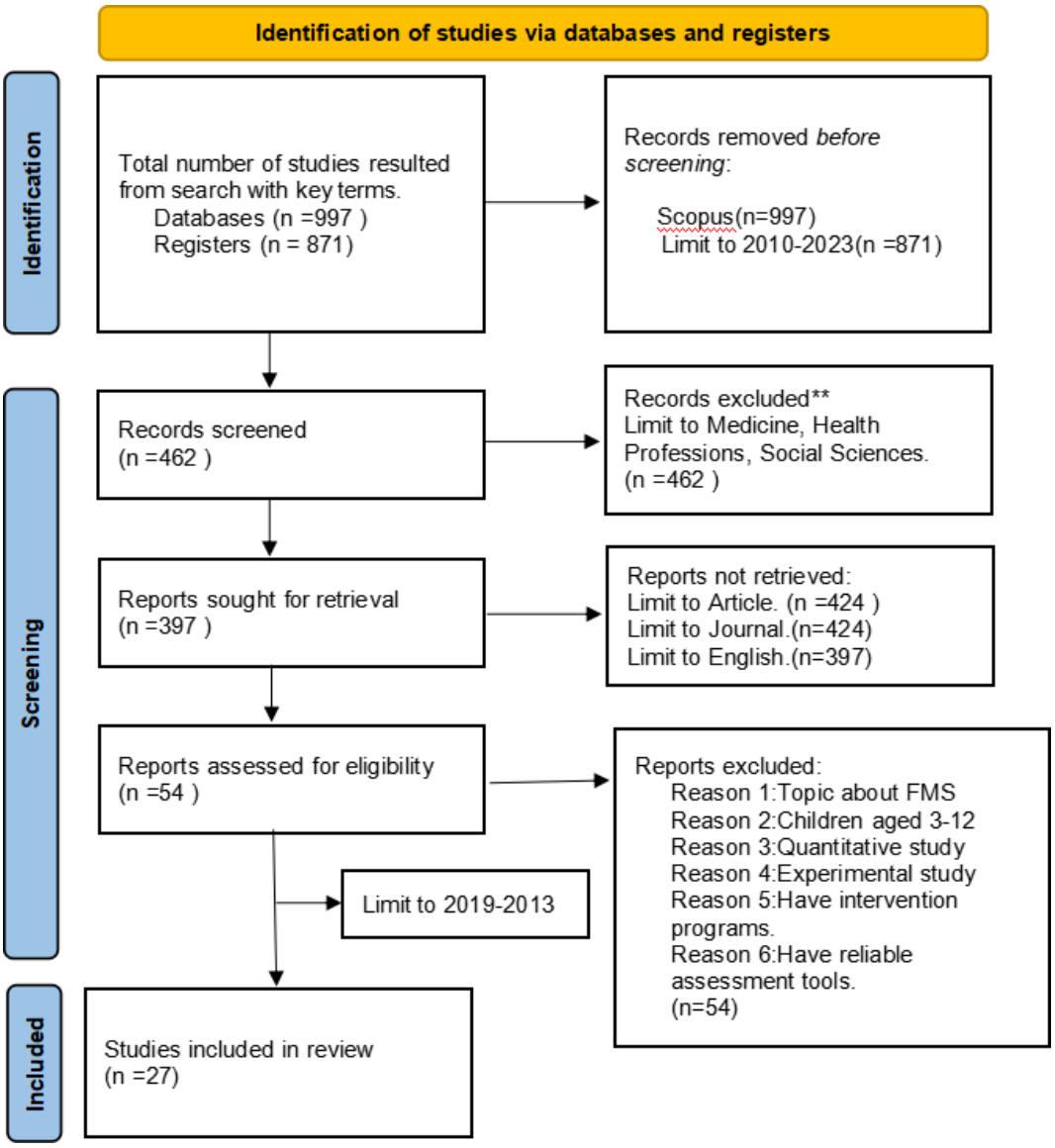

Figure 1. identification of studies via databases and registers

Selection Process

After downloading all 397 articles selected according to the restrictions, the articles were read and analyzed one by one, and those that met the following criteria were included in the subsequent analysis:

1. the article studied the topic of fundamental motor skills
2. The target population of the articles was children aged 3-15 years.
3. The type of study was quantitative.
4. the article was an experimental study.
5. the article looks at the study of the effects of the research design intervention program on fundamental motor skills.
6. There is a clear and reliable assessment tool for fundamental motor skills in the article.

Data Collection Process

After reading and analyzing the articles according to the inclusion criteria, the titles of the selected articles, basic information about the experimental study subjects and groupings, summary findings, and

general conclusions were collected and organized (Table2).

Table 2. List of articles

List of articles					
No	Study/title	Subjects (sex and means±SD, Age, Height, Weight)	Methodology (measurement)	Results	Conclusion/suggestion
1	A four-week fundamental motor skill intervention improves motor skills in eight to 10-year-old Irish primary school children (Costello & Warne, 2020)	A total of 100 primary school students, 42 girls and 58 boys, ages ranging from 9 to 1 year, were evenly divided into control and intervention groups for this study.	Using Fundamental Motor Skills Quotient (FMSQ) to test 4 motor skills.	The findings demonstrate that fundamental motor skill scores are influenced by three factors: time, group, and gender. The control group's pre-test and post-test scores showed no significant change, whereas the intervention group's post-test FMSQ scores improved dramatically. Males in the intervention group scored considerably higher on fundamental motor skills than females at the pre-test. The post-test, however, revealed no gender differences.	This study shows that in 8 to 10 year old boys and girls, a 4-week Fundamental Motor Skills intervention consisting of two 30-minute sessions each week markedly improved Fundamental Motor Skills performance.
2	An active play intervention to improve physical activity and fundamental movement skills in children of low socioeconomic status: feasibility cluster randomize controlled trial (Johnstone et al., 2019)	30 students in elementary aged 7 years in eight primary schools involved in the study.	Using the NIH Toolbox Flanker Test to test the Inhibition. Obtaining height and weight data with digital scales and a portable stadiometer. calculating physical activity with an ACTi Graph GT3X accelerometer. FMS testing using TGMD-2. Math fluency is evaluated with the One Minute Basic Number Facts Test.	The findings demonstrate that MVPA was present, along with mild physical activity. During a semester, participants spend more than 35% of their time engaging in MVPA activities in addition to sedentary entertainment. The intervention group experienced a rise in FMS, while the control group did not experience an increase. For the fish trials and arrow trials, the conflict scores of the intervention group and the control group both increased. Addition and subtraction scores increased for both the intervention group and the control group.	The article suggests that Children from lower socioeconomic backgrounds can benefit from active play interventions in terms of increased physical activity and basic motor skills. The next area of concern is how to run after-school activity clubs, involve parents in the process, and efficiently implement weekly active physical play activities for kids at school.
3	The effect of the CHAMP intervention on fundamental motor skills and outdoor physical activity in preschoolers (Palmer et al., 2019)	Two cohorts of 102 children were established. A comparison was made between the groups that received intervention (n = 64, 40 boys, 4.40 ±0.44 years) and control/outdoor free play (n = 38, 23 boys, 4.40 ± 0.41 years).	Evaluating the FMS with the third version of the Test of Gross Motor Development (TGMD-3). Assessing PA with Actigraphy GT3X accelerometers	The findings demonstrate that the intervention group's and the control group's baseline motor skill levels did not differ significantly. The group known as CHAMP experienced a significant improvement in their overall Fundamental Motor Skills, locomotor skills, and object manipulation skills following the intervention. The CHAMP group exhibited considerably higher locomotor and object manipulation skills, and a favorable correlation was found between children's motor skills and age growth.	This study shows that preschoolers benefit more from a 5-week motor skill intervention than from unstructured outdoor play when it comes to developing their motor skills. Preschoolers who receive the 5-week motor skills intervention may also be actively encouraged to develop a greater interest in and habit of engaging in low-, middle-, and high-intensity outdoor physical activities.
4	Sequencing effects of	Three groups of 140 children,	Using TGMD-2 to assess motor	The findings demonstrate that locomotor skills and Object	This study shows that children between the

continued

	object control and locomotor skill during integrated neuromuscular training in 6- to 7-year-old children (Duncan et al., 2019)	aged 6-7 (77 boys and 63 females), were formed.	skills. Muscular fitness is measured by a 10-meter flying sprint time, a standing long jump, and a sitting medicine ball throw (1 kg). Children's PMSC can be evaluated by using the graphical scale of perceived movement skill competence (PMSC).	control skills exhibited greater overall locomotion compared to CON ($p = 0.001$), whereas Object First had a greater improvement in locomotion compared to Loco First ($p = 0.001$). The object priority's (10 m) sprint pace was slower than the CON's ($p = 0.024$). Locomotion skills vs. CON ($p = 0.0001$) and Object control skills ($p = 0.0001$) have longer standing long jump distances. In comparison to CON, Loco First and Object First threw seated medicine balls farther (both $p = 0.001$). Moreover, object control has superior sensorimotor capabilities. First Loco ($p = 0.005$), followed by CON ($p = 0.001$).	ages of 6-7 can benefit greatly from NIT classes in terms of their basic motor abilities, muscle function, and sensory-motor ability. Children with INT who placed a higher priority on object control skills also showed more alterations in their physical fitness, sensory-motor abilities, and fundamental motor skills.
5	Setting up girls for success in fundamental motor skills: The role of balance in 8-10 year olds (Tsiros et al., 2022)	47 girls between the ages of 8 and 10 (14 of whom were overweight or obese and 33 of whom were of a healthy weight). 3.5.7 ± 8.4 kg of physical mass, 1.4 ± 0.1 meters tall, and 9.6 ± 0.8 years old	Using the Test of Gross Motor Development , Second Edition to test the FMS. evaluating foot dominance with two attempts at kicking a ball.	The findings demonstrate a strong relationship between steady regulation of body posture and mobility skills. The capacity to manage stationary performance while keeping one's eyes closed and total Fundamental Motor Skills are significantly correlated.	This study shows that girls' postural control may be a significant predictor of both the quality of movement and the maturation of motor skills. Girls who struggle with the development of Fundamental Motor Skills require ongoing evaluation and postural control-enhancing intervention.
6	A Mediation Analysis of the Association between Fundamental Motor Skills and Physical Activity during Middle Childhood (Gu et al., 2021)	342 children in all (156 girls; Mage = 8.40; SD = 0.50).	Using PE Metrics to test FMS.Using the FITNESSGRAM test battery to examine The HRF components. (muscular endurance, cardiovascular health, and body composition). Assessing PA using Actical Accelerometers (LPA \MPA \VPA)	The findings demonstrate that while there is no direct correlation between Fundamental Motor Skills and basic physical activity, there is a strong interaction between each item of health-related physical fitness and these skills. FMS acted as a mediator between PA and HRF components.	The article suggests that HRF acts as a mediator in the relationship, which is not direct, between FMS and PA. These results imply that preserving a certain amount of HRF may aid in the development of skills and encourage PA during middle childhood.
7	A Network Perspective on the Relationship Between Moderate to Vigorous Physical Activity and Fundamental Motor Skills in Early Childhood (Bezerra et al., 2021)	204 Children ,99 males, age mean ± SD = 4.0 ±0.8 years old	Using TGMD-2 to test FMS. To evaluate the PA, use the WGT3-X model accelerometers.	The findings demonstrate that boys outperform girls in fundamental motor abilities; girls exercise more on weekends than boys do; younger children are more active; and jumping skills have the greatest impact on MVPA.	The article suggests that FMS and MVPA have a poor relationship, further research on FMS should concentrate on the function of each motor skill in its particular setting. similar to the notable influence of motor abilities for jumping.

continued

8	Development of fundamental motor skills between 2006 and 2016 in Dutch primary school children (Mombarg et al., 2021)	There were 573 girls (BMI: 18.31±2.88) and 567 boys (BMI: 17.59±2.67) in the group in 2006. There were 827 girls (BMI: 18.51±3.06) and 750 boys (BMI: 17.97±2.99) in 2016.	Utilizing the FMS exams, which are based on the standards and requirements of the Dutch PE curriculum. (Tennis, throwing and catching, roll, hop, balance, swing, and roll)	According to studies, kids from 2006 outperformed kids from the same age group in 2016. The greatest declines in total object control abilities were in tennis and throwing and catching in 2016, while vault jumping capabilities stayed constant. All tests showed lower scores for kids with higher BMIs, and in tests of balance, leaping, and tennis, the difference between them and kids with lower BMIs grew during the previous ten years. In the activities of rolling, shooting, throwing, and catching, boys performed less well than girls.	The article suggests that reductions in motor proficiency are closely linked to decreased engagement in sports and worse health consequences. In order to assist youngsters improve their FMS and lessen the detrimental effects of their deterioration, new therapies are required. Enhancing Physical Education in Schools: This will be one of the most effective approaches.
9	Effectiveness of a novel digital application to promote fundamental movement skills in 3- to 6- year-old children: A randomized controlled trial (Trost & Brookes, 2021)	Two groups of children, ages three to six, are formed. 17 children in the intervention group. 17 kids in the control group.	Using the Test of Gross Motor Development 2nd Edition (TGMD-2) to measure the FMS. using Trost et al.'s 5-item scale to measure the amount of physical exercise.	The findings demonstrate that after 8 weeks of intervention, the intervention group's level of progress in FMS—whether it be in locomotor abilities or object control—was noticeably higher than the control group's. Over the course of eight weeks, however, no discernible change in physical activity was discovered.	The article suggests that over the course of an eight-week intervention, preschoolers' FMS performance was effectively improved by Moovosity™. Nevertheless, additional validation of the findings in bigger sample size experiments is required.
10	Effects of an 8-week school-based intervention Program on Irish school children's fundamental movement skills (Kelly et al., 2021)	There are 255 Irish third- and fourth-graders (7.4 ± 0.6 years old, 50% male). Alternatively, either intervention-control (Group I-C: 2 schools, n = 134, 48% male) or control-intervention (Group C-I: 2 schools, n = 121, 2% male)	Using TCMD-3 test the FMS.	The findings demonstrate that after taking part in the FMS intervention, participants' motor abilities, ball skills, and FMS were dramatically improved. The children's eight newly acquired talents increased until it was clear that they had mastered the material.	The article suggests that a brief FMS intervention can greatly enhance children's ability to move about and manage objects. Additional research is necessary for long-term efficacy.
11	Exploring the relationships between fundamental movement skills and health related fitness components in children. (Behan et al., 2022)	2098 elementary school students (mean age 9.2 ±2.04, 47% female, ages 5–12)	Using the TGMD-2 assess FMS, as well as two additional movements: balance and vertical leap. BMI, waist, MS (hand grip), ME (plank test), flexibility (sit-and-reach), and CVE (20Mpace test) are all	According to the findings, there was an inverse relationship between body composition and FMS and a substantial positive link with MS. The dynamic link between FMS and HRF gets stronger as people age.	The article suggests that early FMS development is good for your child's development of health-related fitness and extends long into adolescence.

continued

			included in HRT.		
12	Movement skills, perception, and physical activity of young children: a mediation analysis (Capio & Eguia, 2021)	230 kids between the ages of 4-6 made up the sample (109 boys and 121 girls; mean age in months: 67.41±8.46).	Using TGMD-2 to assess FMS. the measurement of perceived physical proficiency using the Pictorial Scale of Perceived proficiency's physical skills domain. Using pedometers over a 5-day period to analyze the physical activity.	According to the findings, children's ability to perceive their bodies is greatly influenced by their object motor abilities, which also have a major positive impact on their physical activity levels.	This study shows that it becomes clear that object control abilities influence physical activity levels most directly and indirectly through body awareness, which gives us a useful guide for creating goal-oriented motor exercises for kids.
13	Physical activity during school-time and fundamental movement skills: a study among preschoolers with and without physical education classes (da Silva et al., 2022)	201 children (102 females, 50.7%), aged 3–5 years old (mean age 4.51 ± 0.79).PE group (n=129). NPE group(n=72)	Using TGMD-2 to assess FMS. Assessing PA with an accelerometer.	According to the findings, MVPA and object control motor abilities were significantly correlated in the PE group.	This study shows that given the beneficial relationship found between MVPA and object control abilities, structured physical education opportunities ought to be a key component of any preschool program aimed at fostering motor development.
14	SKIPping With PALS: Exploring Parental Engagement in a Motor Intervention for Their Preschool Children (Brian et al., 2022)	60 Children , Mean age = 60.86±6.57.	Using TGMD-3 to assess the GMS of FMS. Using the Mov band 4 which is a wrist-worn physical activity tracker to record the PA.	According to the findings, in terms of physical activity, every increase in attendance for the school portion of the intervention increased the average weekly steps to 1455 steps. For every additional school-based course that parents take, the child's locomotor skills and objective control skills improve by 1.87 and 1.95 points, respectively.	This study shows that is evident that parental support and involvement had a major influence on kids' gross motor skill development. Furthermore, parents' involvement in sports and attention on them can greatly boost their kids' physical activity levels.
15	Accelerometer-based physical activity levels, fundamental movement skills and weight status in British preschool children from a deprived area. (Roscoe et al., 2019)	185 children aged 3-4 years old. (99 boys, 86 girls).	Using TGMD-2 to test the FMS. testing the PA over a period of four days with a triaxial accelerometer.	According to the findings, between body weight and PA and the level of FMS competence, there is no discernible difference. Additionally, no significant correlation was seen between moderate to vigorous PA on weekdays or weekends and FMS mastery.	It was shown that boys scored higher on object control skills and girls did better on locomotor skills. FMS mastery was not significantly different from PA or body weight at this age (3-4 years).
16	Assessing the impact of a physical	120 children (63 girls and 57 boys, mean age	Using TGMD-2 to test the FMS. Using the	According to the findings, the low-level group scores, locomotor skills, and gross motor	The study was shown that the youngsters with FMS continue to

continued

	education project based on a games approach on the actual motor competence of primary school children (Sgro et al., 2019)	10 years, mean height one meter, mean weight 38.05 kg)	Children's Leisure Activities Study Survey (CLASS) to record the children's PA.	development quotient were all positively impacted by boys. It is beneficial for the girls in the high-level group when their motor abilities develop.	deteriorate and decline, and neither the exercise program's limited effect nor the participants' generally improved performance will be sufficient to stop this. We must continue to consider tactics and fixes.
17	Association between Physical Activity and Fundamental Movement Skills in Preschool-Aged Children: Does Perceived Movement Skill Competence Mediate This Relationship ? (He et al., 2021)	148 children, 43% of whom were female, and a mean age of 4.52 ± 0.67 years.	Testing the FMS with the TGMD-2. Assessing the perceived FMS with the Pictorial Scale for Perceived Movement Skill Competence Using an accelerometry to record the PA.	The findings demonstrate that a noteworthy association was observed between MVPA and FMS level. However, there was no significant correlation found between FMS and MVPA and perceived FMS.	The article suggests that we need to provide consistent attention and efficient intervention in these two areas in early childhood since there is a strong association between FMS in early childhood and MVPA in young children. It is unclear, therefore, how sensorimotor skills relate to one another throughout this time.
18	Associations between body composition and fundamental motor skill competency in children (Webster et al., 2021)	There were 244 children (mean±SD = 6.05±2.01 years; 53.3% male).	Testing the FMS with the TGMD-2. Testing the body composition with the Tanita SC-331S Body Composition Analyzer	The findings demonstrate that lean body mass ($p<.001$) was a significant predictor of locomotor skills and total gross motor skills. Additionally, BMI was a significant predictor ($p <.001$) for both the total motor abilities and the locomotor skills.	The article suggests that there are various ways in which varying body compositions impact basic motor abilities. While body composition does not seem to be a clear predictor of object control skills, fat-free body mass does have some directionality in its capacity to predict movement skills. Furthermore, basic motor skills are more interpretively predicted by body composition bioimpedance tests than by BMI.
19	Connection between Social Relationships and Basic Motor Competencies in Early Childhood (Herrmann et	There are 548 preschoolers (51% females; M = 68.0 months; SD = 6.8).	Using the MOBAK KG test instrument to test the children's core motor competencies. Measuring the kids' social integration with their parents and teachers using the relevant subscale	The findings demonstrated a strong correlation between young children's motor development and skill and their early social ties; this correlation is particularly evident in the data pertaining to boys.	The article suggests that is frequently pertinent to focus on a child's development from both a developmental and health perspective. This study also demonstrated the strong interdisciplinary relationship between the healthy development of children's early

continued

	al., 2021)		of the Perception of Inclusion (PIQ) Questionnaire.		psychology and the health of their bodies.
20	Differences in motor competence, enjoyment, and weight status of young children (4-6 years) (PIM et al., 2022)	1708 children (mean age: 5.34 ± 0.73 years; 50.4% male)	Assessing the AMC with the Athletic Skills Track (AST-1) testing the PMC with the Pictorial Scale of Perceived Movement Skill Competence for Young Children. Using the Visual Analogue Scale to capture the children's enjoyment of physical activities.	According to the findings, there were no discernible interactions between age, sex, and weight status and AMC or PMC. Age and weight status showed a statistically significant two-way interaction with physical activity like. Children vary widely in their preference for physical activity, especially when it comes to different weight states.	The findings indicate that there is no discernible difference between a child's actual and potential athletic ability in the age group of 4-6 years old, regardless of the child's age, gender, weight, or other characteristics. However, a child's enjoyment of physical activity at this age might be influenced by their body weight.
21	Do Fundamental Movement Skills, Physical Activity, And Enjoyment Among Inactive Student During The Covid-19 Era Improve After Exergame? (Juliantine et al., 2022)	There were 26 children in all, 13 of whom played the exercise game. They were 1.38±2.38 cm tall, 31.60±4.50 kg in weight, and 7.20±1.30 years old. group of control: 13 individuals, height: 1.36±3.08 cm, weight: 28.40±3.43 kg, and age: 7.40±1.14 years.	Testing the FMS with the TGMD-2 and recording the PA with the Acti Graph GT9X Link accelerometer To gauge the level of enjoyment, use the Physical Education Curriculum Enjoyment Scale.	According to the findings, the sports game intervention group significantly improved in Fundamental Motor Skills, physical activity, and love for physical activities, according to the results. The control group did not experience any notable changes.	The findings indicate that, for future, we should make active use of sports games as a useful instrument to enhance children's FUN, physical activity, and Fundamental Motor Skills in the wake of the new crown epidemic.
22	Effects of a Need-Supportive Motor Skill Intervention on Children's Motor Skill Competence and Physical Activity (Lee et al., 2020)	36 children, 17 girls and 8 boys, made up the intervention group (63.8% females, Mage = 6.52 ± 0.97).	Using TGMD-2 to test FMS. gathering the PA with a water-resistant accelerometer.	According to the findings, there were no discernible gender differences in the FMS and MVPA scores between the intervention and control groups. The timing of the intervention did not change much.	The article suggests that a need-supportive FMS program that effectively promotes FMS development and everyday physical activity in boys and girls during the early childhood years.
23	Effects of Different Multi-Year Physical Exercise Programs on Motor Skills in Preschool Children	There were 161 children, 76 boys and 85 girls, ages 5.8 ± 0.7 years. four groups.GI(n=38 ,2018–2019).G2(n=36, 2016-2019), G3(n=38,2015-	Using Bruininks-Oseretsky Test of Motor Proficiency (BOT-2) to assess FMS.	The findings demonstrated that a one-year multilateral exercise program improved preschoolers' motor ability levels. A sustained degree of motor skill acquisition can be attained with extra years of participation in an exercise program. Furthermore, preschool females were more impacted by the fitness program than boys	The study was shown that the physical education curriculum has the potential to greatly enhance preschoolers' motor skills multilateral development, as well as their capacity to manipulate objects and

continued

	(Plazibat et al., 2021)	2019), and CG(n=49).		were.	maintain balance. As a result, practitioners can think about incorporating multinational preschool programs into the kindergarten curriculum.
24	Examining Relationships among Chinese Preschool Children's Meeting 24-Hour Movement Guidelines and Fundamental Movement Skills (Li et al., 2022)	There were 322 children ,181 boys and 141 girls, ages 3–6 years old.	Using TGMD-2 to test FMS. To gather the PA, we use accelerometry, screen time, and sleep time.	According to the findings, the majority of participants followed the advice about screen time and sleep, according to the data. Of the PA suggestions, just 22% were put into practice. Four percent of the subjects did not follow any of the guidelines' recommendations. Subjects' FMS significantly improves when they fulfill the PA standards. The degree to which locomotor skills were associated with PA and sleep instructions was positive.	The study was shown that very few preschoolers followed the three recommendations of the guidelines. The amount of physical activity plays an important role in promoting children's FMS, and screen time and sleep time also affect the development of Fundamental Motor Skills in preschool children.
25	Foundational Movement Skills and Play Behaviors during Recess among Preschool Children: A Compositional Analysis (Foweather et al., 2021)	There were 133 children, 55% male, with a mean age of 4.7 ± 0.5 years.	Testing the FMS with Activity and Movement Assessment Study (CHAMPS) Motor Skill Protocol (CMSP). Testing the kids' play behaviors with an altered version of the System for Observing Children's Activity and Relationships during Play (SOCARP).	According to the findings, total skill and displacement skill were positively connected with the amount of time spent on non-equipment tasks. There was a negative correlation between total motor abilities and displacement skills and the amount of time spent on them. The amount of physical activity and the size of the gaming group did not significantly affect FMS.	The study was shown that play behaviors akin to those of playtime significantly impacted children's FMS. Preschoolers benefited more from a richer playground environment that included a range of permanent and moveable equipment, while active play without equipment was more helpful in encouraging FMS play-based development.
26	Long-term effectiveness of a fundamental motor skill intervention in Belgian children: A 6-year follow-up. (Coppens et al., 2021)	There were 399 children, 228 in the intervention group and 171 in the control group.	Utilizing the TGMD-2 motor compacity (MC) test collecting the PA by using portions of the Flemish Physical Activity Questionnaire (FPAQ)26.	According to the findings, compared with the control group, the improvement in motor abilities after 6 years in the intervention group 6 years ago was not significant. Children who had received the intervention had considerably higher involvement in object control motor abilities in the ensuing physical activity.	The study was shown that after six years, the effect of thirty weeks of focused motor skills training did not result in continued skill improvement; rather, over time, children who received targeted, structured instruction participated in physical activity at a considerably higher rate, which had a favorable effect.
27	The Effects of an Integrative, Universally Designed Motor Skill Intervention for Young Children	There were 111 children, aged 3 to 6 (Mage = 5.15, SD = 0.82 years, 58 girls, 53 boys, 24 impairments, 87 individuals	Testing FMS-GMS with TGMD-2 Assessing motor proficiency in people with and without the majority of impairments using	According to the findings, when compared to their peers with and without disabilities in the control condition, children with and without disabilities who received a complete exercise intervention demonstrated significantly higher levels of motor ability and proficiency.	The article suggests that to address motor skill deficiencies in children with and without impairments, early childhood schools and institutions should think about developing integrated generic

continued

With and Without Disabilities (Miedema et al., 2022)	without disabilities). control condition (n = 58), integrated motor intervention (n = 53).	the BOT-2 brief form.	interventions that target several elements of motor development.

RESULTS

Article year of publication

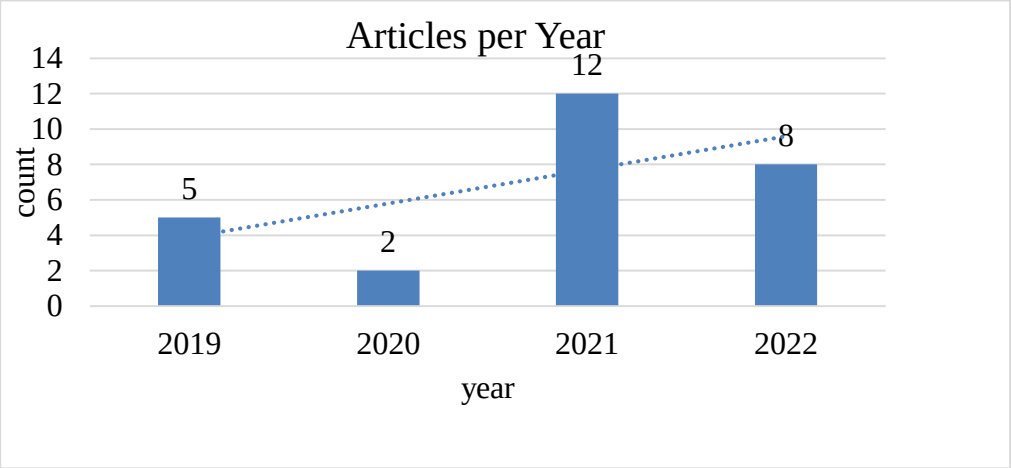

Figure 2. Article year of publication

From 2019 to 2023, there were a total of 27 articles on Children's Fundamental Motor Skills that meet the selection criteria, of which 5 articles were published in 2019, two articles were published in 2020, 12 articles were published in 2021, and eight articles were published in 2022, not yet in 2023 (Figure 2).

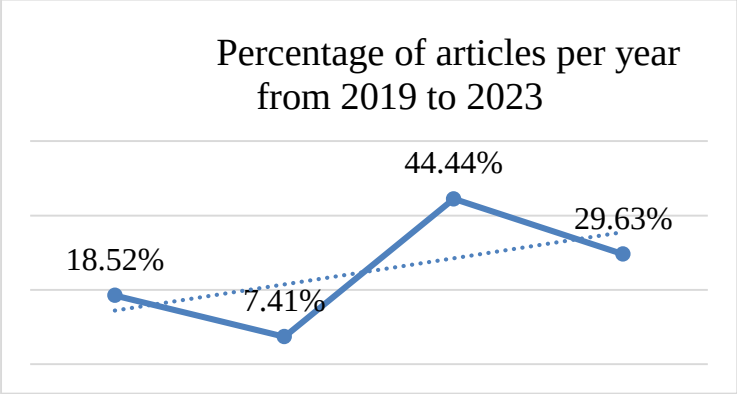

Figure 3. Percentage of articles per year from 2019-2023

19% of articles published in 2019, 7% of articles published in 2020, 44% of articles published in 2021, and 30% of articles published in 2022. Notable among these is the least number of relevant articles published in 2020 and high number of articles published in 2021.

Overall, there was an upward trend in the number of articles published in Basic Motor Skills for Children from 2019 through 2023 (Figure 3).

Article Origin

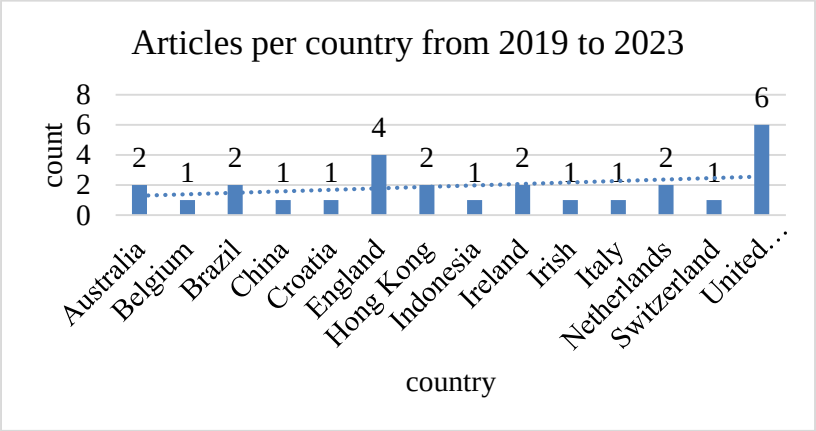

Figure 4. Articles per country from 2019-2023

In terms of the country distribution of articles （2019-2023）related to Children's Fundamental Motor Skills， the United States published 6 articles, ranking first, the United Kingdom published four articles, ranking second, Australia and Ireland published two articles, ranking third, China and Italy published only 1 related article in the past five years (Figure 4).

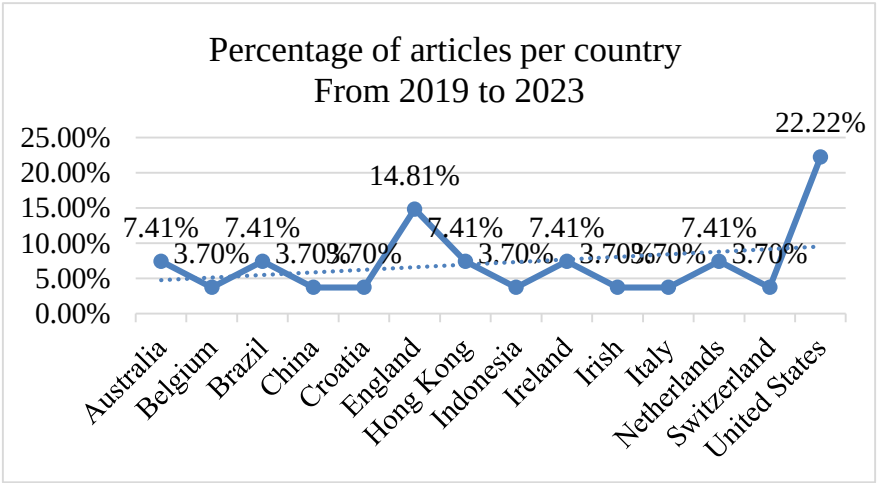

Figure 5. Percentage of articles per country from 2019-2023

In terms of the proportion of articles related to children's basic motor skills published by each country, in the past five years, the United States accounted for the largest proportion with 22% of articles published, followed by the United Kingdom with 15%, Australia and Ireland with 7% each, and countries such as China and Italy accounted for the smallest proportion with 4% of articles published together (Figure 5).

Data collection location

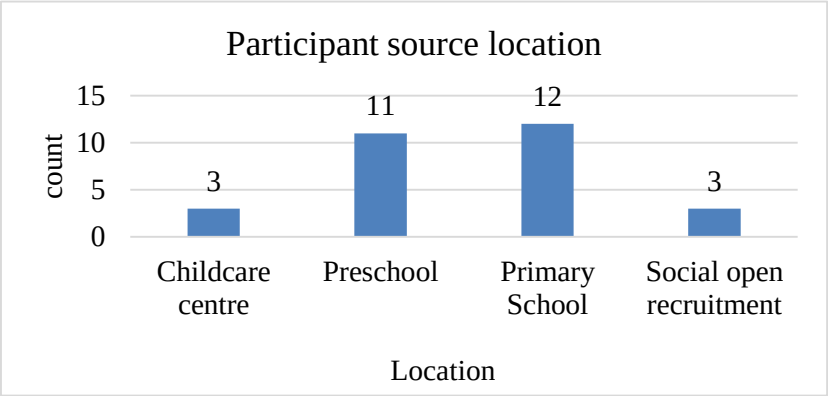

Figure 6. Participant source location

It can be seen from the analysis of the source location data of the participants of the experimental subjects that relevant researchers focused on specific elementary schools and kindergartens when collecting data. 12 articles collected data in primary schools, 11articles collected data in kindergartens, three articles collected data in child care centers, and three articles collected data in random participants through social recruitment in their cities. There are just two articles collected data in both Childcare Center and Preschool (17) (18) (Figure 6).

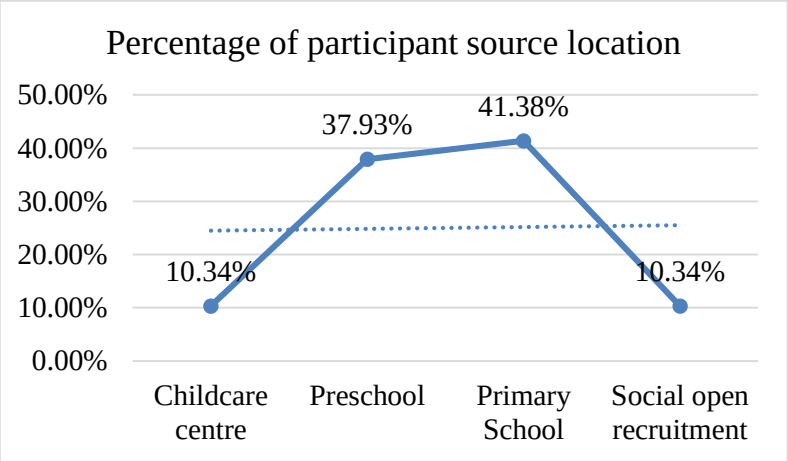

Figure 7. Percentage of participant source location

Of all the articles, 42% of the articles collected data in elementary school, 38% in kindergartens, 10% in daycare centers, and 10% randomly in their cities.

It can be seen from the data that the researchers involved prefer to collect data from schools. However, it is necessary to pay attention to the representativeness of the data. This type of data may only be representative of the school from which it was collected and not of the region, city or even country in question. And there will be a lack of data from elementary school or kindergartens, children's centers, etc. that were not selected (Figure 7).

Risk of Bias in Studies

Regarding the risk of study bias, 6 criteria were selected, including (A) Random sequence Generation , (B)Allocation concealment, (C) Binding of participants and personnel*, (D) Binding of outcome assessment* ; (E)Incomplete outcome data*, (F)Selective reporting (Table3).

Table 3. Risk of Bias in Studies-Systematic Literature Review of Fundamental Motor Skills of Children

Risk of Bias in Studies-Systematic Literature Review of Fundamental Motor Skills of Children							
NO.	Study	Random sequence generation	Allocation concealment	Blinding of participants and personnel*	Blinding of outcome assessment*	Incomplete outcome data*	Selective reporting
1	(Costello & Warne, 2020)	Y	Y	Y	Y	Y	Y
2	(Johnstone et al., 2019)	Y	Y	Y	NA	N	Y
3	(Palmer et al., 2019)	Y	Y	Y	Y	Y	Y
4	(Duncan et al., 2019)	Y	Y	Y	Y	Y	Y
5	(Tsiros et al., 2022)	Y	Y	Y	Y	N	N
6	(Gu et al., 2021)	Y	Y	Y	Y	N	Y
7	(Bezerra et al., 2021)	Y	Y	Y	Y	N	Y
8	(Mombarg et al., 2021)	Y	Y	Y	Y	N	Y
9	(Trost & Brookes, 2021)	Y	Y	Y	Y	Y	Y
10	(Kelly et al., 2021)	Y	Y	Y	N	Y	Y
11	(Behan et al., 2022)	Y	Y	Y	Y	Y	Y
12	(Capio & Eguia, 2021)	Y	Y	Y	NA	N	Y
13	(da Silva et al., 2022)	Y	Y	Y	Y	N	Y
14	(Brian et al., 2022)	Y	Y	NA	Y	Y	Y
15	(Roscoe et al., 2019)	Y	Y	Y	NA	Y	Y
16	(Sgro et al., 2019)	Y	Y	Y	Y	NA	Y
17	(He et al., 2021)	Y	Y	Y	Y	N	N

continued

18	(Webster et al., 2021)	Y	Y	Y	Y	N	Y
19	(Herrmann et al., 2021)	Y	Y	Y	Y	N	Y
20	(PIM et al., 2022)	Y	Y	Y	Y	Y	N
21	(Juliantine et al., 2022)	Y	Y	Y	Y	Y	Y
22	(Lee et al., 2020)	N	Y	Y	Y	N	Y
23	(Plazibat et al., 2021)	N	Y	Y	Y	Y	Y
24	(Li et al., 2022)	Y	Y	Y	Y	N	Y
25	(Foweather et al., 2021)	Y	Y	Y	Y	Y	Y
26	(Coppens et al., 2021)	Y	Y	Y	Y	N	Y
27	(Miedema et al., 2022)	Y	Y	Y	Y	Y	Y

*Grading System: low risk of bias “Y”; high risk of bias “N” ； unclear risk of bias “NA”.

Risk of Bias

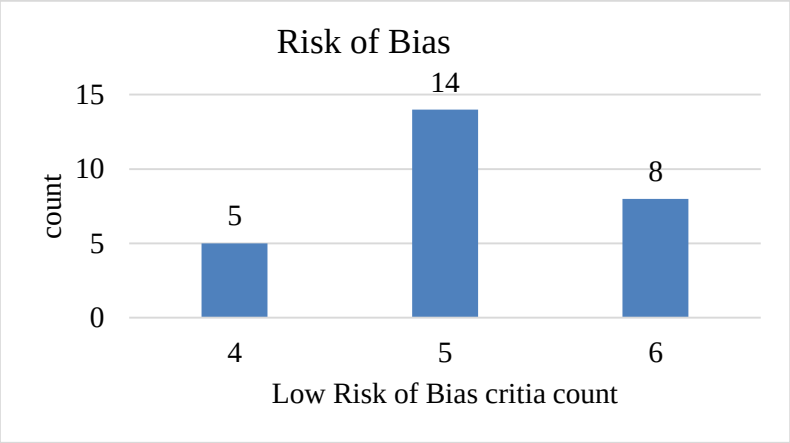

Figure 8. Risk of Bias

According to （Figure 8）, there were eight articles with zero risk, and 14 articles with one out of six risk, and 5 articles with two out of six risks. Which means all of the articles are accepted according to the risk of bias.

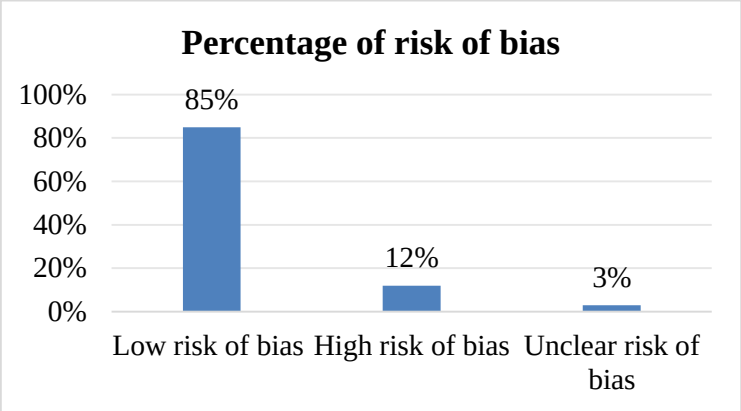

Figure 9. Percentage of Risk of Bias

In Figure 9, it shows 85% of the articles have a low risk of bias, 12% of articles have a high risk of bias, and 3% of the articles have unclear risk of bias. The certainty of the evidence is high due to the low risk of bias and the imprecision of applying the methods of all subjects.

Assessment tool for Fundamental Motor Skills of children

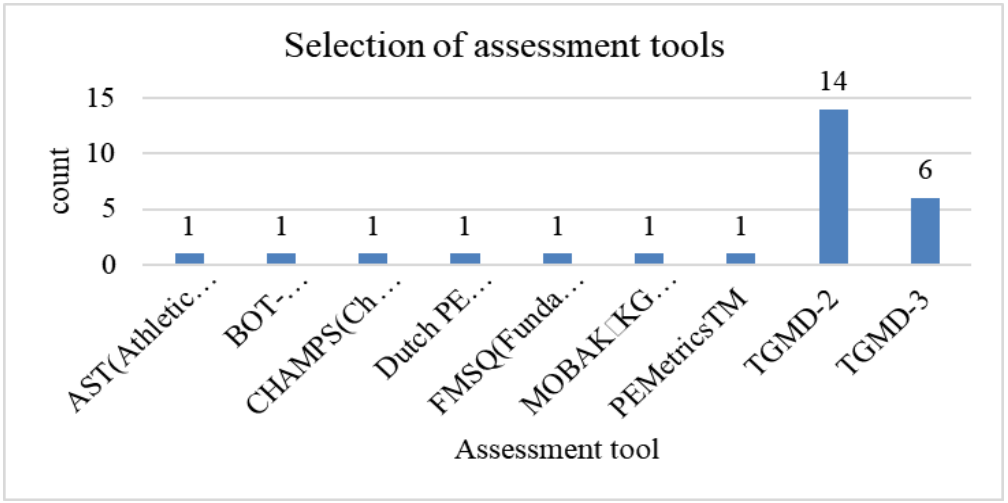

Figure 10. Assessment tool for Fundamental Motor Skills of children

Among the 27 articles related to Children's Fundamental Motor Skills from 2019 to 2023, 20 articles used the American TGMD test (14 articles used TGMD-2, 8 articles used TGMD-3), one article used BOT-2 test, one articles used AST test, one article used FMSQ test, one article used MOBAK test, one article use CHANMPS test, one article used PEMetrics test (Figure 10).

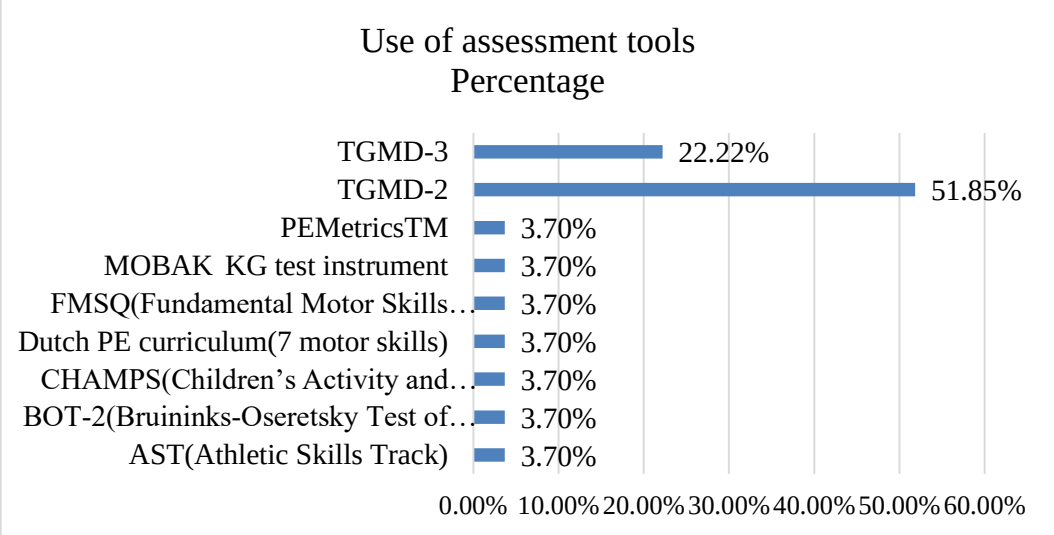

Figure 11. Use of Assessment Tools Percentage

From （Figure11）, it can be seen that 52% of the articles used the TGMD-2 test, 22% used the TGMD-3 test, and totally 74% chose to use the TGMD test as the assessment for Children's Fundamental Motor Skills. Evaluation tools such as BOT-2 and others accounted for only 26%.

However, from the analysis of evaluation items, TGMD-2 only includes 12 gross motor skills evaluation actions (The locomotor subtest consists of six skills: running, galloping, hopping, leaping, horizontal jump, and sliding. The object control subtest also includes six skills: striking a stationary ball, stationary dribble, catching, kicking, overhand throwing, and underhand rolling), there is no fine motor skills assessment action.

Therefore, we must pay attention to the comprehensiveness and effectiveness of the evaluation tools used by researchers because Fundamental Motor Skills include not only gross motor skills but also fine motor skills.

Intervention program of study for Fundamental Motor Skills of children

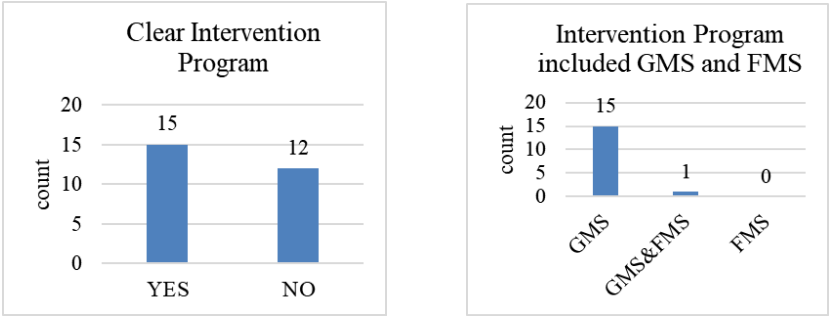

Figure 12. Clear Intervention Program & Intervention Program included GMS and FMS

15 articles had a clear and explicit intervention program design for basic motor skills, and 12 studies had no explicit intervention program. Of the 15 articles with descriptions of explicit intervention programs, all included an intervention content design for gross motor skills, but of these, only one article included an intervention content design for both gross and fine motor skills. No article focused on intervention content design for fine motor skills alone (Figure12).

DISCUSSIONS

This will be followed by a discussion of the participants, the method of assessing fundamental motor skills, the intervention program, results, and conclusions.

Participants

In the 27 studies on fundamental motor skills over the last five years, the participant set varied. The differences were mainly in the age, number, gender, and origin of the participants.

In the 27 articles examining fundamental motor skills, the age range of participants was 3-12 years. Fifteen articles had participants aged 3-6 years (3,7,9,10,12-15,17,19,20,23,24,27), with only three articles covering ages 3-6 years (9,24,27). Relatively few studies were conducted on children aged 3-6 as a whole. There were 12 articles with participants aged 6-12 years (1,2,4,5,6,8,11,16,18,21,22,26). There were 7 articles with 10-100 participants (1,5,9,14,16,21,22), 7 articles with 101-200 participants (3,4,15,17,23,25,27), 5 articles with 201-300 participants (7,10,12,13,18), and 8 articles with more than 300 participants (2,6,8,11,19,20,24,26).

19 of the 27 articles examined gender (1,3-8,11-13,15-18,22-25,27), while the other 8 studies did not differentiate between the genders of the children.

In 8 of the 27 articles, the participants in the studies were from elementary schools (2,4,8,10-12,16,20), in 12 of the studies the participants were from kindergartens (6,7,13,15,17-19,21,22-25), and in 8 of the studies the participants were from early childhood centers in the community (1,3,5,14,17,27). In 2 studies, the participants were not known to be of unknown origin (9,26).

Assessment instrument

27 articles, the assessment tools used differed for the measurement of fundamental motor skills. Fourteen of the studies used the TGMD-2 to analyze the fundamental motor skill abilities of young children (2,4,5,7,9,12,13,15-18,22,26,27). Six of the studies used the TGMD-3 to analyze fundamental motor skill competencies in young children (3,10,11,14,21,24). One study used the AST to assess fundamental motor skill competence in young children (20). Four studies used the BOT-2 to assess fundamental motor skill competence in young children (11,21,23,27). One study used the CMSP to assess fundamental motor skill competence in young children (25). One study used the assessment of Dutch PE to assess fundamental motor skill competence in young children (8). One study used the FMSQ to assess fundamental motor skill competence in young children (1). One study used the MOBAK test instrument to assess fundamental motor skill competence in young children (19). One study used the PE Metrics TM to assess fundamental motor skill competence in young children (6). Of these assessment tools, only the BOT-2 includes fine motor assessment. The rest of the assessment tools all focused primarily on measuring the gross motor skills of locomotor skills and object manipulation motor skills.

Intervention Program

Fifteen of the 27 articles had studies with explicit motor skill intervention programs. The items in the intervention plans of 15 of these studies all included gross motor skills mobile motor skills and object manipulation skills (1-4,9,10,13,14,16,21-24,26,27). Only 1 of these studies included an intervention component for fine motor skills (27). The remaining 12 studies did not have an explicit intervention program or did not implement an intervention (5-8,11,12,15,17-20,25). What we do know is that fundamental motor skills include both gross and fine motor skills. Gross motor skills consist of three categories, namely, stationary performance, locomotor skills, and object manipulation skills. Fine motor skills consist of two categories, grasping motor skills and visuomotor integration skills. As can be seen from the design of the intervention program above, many studies have only focused on two types of gross motor skills, namely, locomotor skills and object manipulation skills, while ignoring the other three types of motor skills.

Results

The results of 27 articles showed that, by 15 studies, children's motor skills improved significantly after the implementation of a developed fundamental motor skills intervention program, with the main improvements being in 2 types of gross motor skills, namely, mobile motor skills and object manipulation skills (1,2,3,4,9-11,14,16,21,22,23,24,26,27). Only 1 of the studies showed no significant improvement (25). One article shows a significant correlation between mobility skills and stable control of body posture. And, it said that there is a significant correlation between overall Fundamental Motor Skills and Stationery performance control ability with eyes closed (5).
Gu et al., 2021 said that Fundamental Motor Skills have a significant interaction with each item of health-related physical fitness, but there is no direct relationship with basic physical activity (6). Bezerra et al., 2021 said that Boys are better than girls in Fundamental Motor Skills, and, girls have more physical activity than boys on weekends. (7). The results of the study by Mombarg et al., 2021 showed that children's overall motor skills were on a downward trend as the years progressed from 2006-2016 (8). Mombarg et al., 2021 also show that boys showed lower levels of ability than girls in rolling, shooting, throwing, and catching. Girls' performance in tennis tests has declined more than boys' over the past decade (8). Capio & Eguia, 2021 show that object motor skills have an important impact on children's body perception ability, and have a significant positive effect on children's physical activity (12).

He et al., 2021 show that there was a significant correlation between FMS level and MVPA. However, perceived FMS was not significantly associated with FMS and MVPA (17). However, Roscoe et al., 2019 said that there was also no significant association between FMS mastery and moderate to vigorous PA on weekdays or weekends (15). Webster et al., 2021 said that Lean body mass and BMI was a significant predictor of locomotor skills and total gross motor skills (18). Herrmann et al., 2021 showed that children's early social relationships have a significant relationship with children's motor development and motor ability, which is more obvious in the data of boys (19). Foweather et al., 2021 showed that time spent on activities without equipment was positively correlated with total skill and displacement skill (25).

CONCLUSIONS

Over the past five years, research on children's fundamental motor skills has shown that the vast majority of researchers tend to equate fundamental motor skills with gross motor skills (i.e., locomotion and object control) and ignore the stationary performance and fine motor skills (grasping and visual-motor integration skills). In terms of assessment tools, there is a tendency to use the TGMD (about 74% use the TGMD test) with weak efforts to try more varied tasks, and in terms of intervention program design, there is a tendency to focus on programs that promote gross motor skills at the expense of fine motor skills. About 99% of intervention programs only included the two types (locomotion and object control Gross Motor Skills, without fine motor skills included. and almost every intervention program is short-term (4-10 weeks), only one researcher is using 36 weeks from the total articles. There was less design and research on the relevance and holistic nature of fundamental motor skills (both gross and fine motor skills). From the results of the study, it can be seen that the researchers focused on two types of gross motor skills, i.e., locomotion skills as well as object manipulation skills. The focus on the other three types of motor skills (stationary performance skills, grasping motor skills, and visual-motor integration skills) has been neglected. A holistic study on the development of children's fundamental motor skills and interventions would be more beneficial for practitioners to find the best and most effective approaches.

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