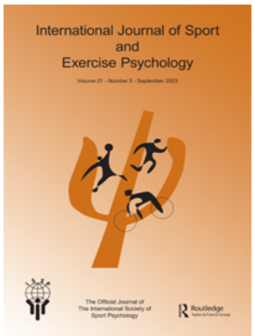

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Fundamental movement skill interventions in young children: a systematic review

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ABSTRACT

The aim of this systematic review was to provide an overview of the effectiveness of fundamental movement skill interventions in young children (2–5 years) and to identify elements that determine the effectiveness of these interventions. A systematic literature search was conducted in four electronic databases (PubMed, Academic Search Complete, Education Resources Information Centre and SPORTDiscus). First, intervention-related data (e.g., intervention length, volume, focus, and content) were extracted. Next, the methodological quality and risk of bias of the selected studies were evaluated using a 10-item checklist. Sixteen studies (13 randomised controlled trials and 3 controlled trials) met the inclusion criteria of which 9 had a high methodological quality. Fourteen studies reported statistically significant intervention effects, ranging from small negative to very strong positive effects. Four studies executed a retention test of which two showed positive effects. Elements that influence the effectiveness are: incorporating all fundamental movement skills in the intervention with a variety of activities; combining deliberate practice and deliberate play; the intervention length; the intervention volume and; providing a training programme with coaching during the intervention for the professional involved in delivering the intervention. However more studies containing retention tests are needed.

ARTICLE HISTORY

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Children; fundamental movement skills; interventions; systematic review

Introduction

The foundation for an active lifestyle is formed in early childhood (2–5 years) (Hesketh et al., 2017; Robinson et al., 2015; Tremblay et al., 2010). Regular physical activity (PA) at young age is associated with several short- and long-term positive health effects on the physiological status (Gentier et al., 2013) and the circulatory systems (Cattuzzo

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et al., 2016). Also, there seems to be a positive relationship between being physically active at young age and developing an active lifestyle in adulthood (Barnett et al., 2009; Lopes et al., 2011; Stodden et al., 2008). For being physically active, developing fundamental movement skills (FMS) in early childhood is critical (Barnett et al., 2016; Tompsett et al., 2017). FMS can be divided into three groups: i.e., object control/ manipulative skills (e.g., throwing, catching, dribbling, kicking, striking, and rolling underhand), locomotor skills (e.g., walking, running, jumping, hopping, leaping, galloping, sliding, and skipping), and balance/ stability skills (e.g., body rolling, bending, dodging, stick balancing, one-foot balancing, stretching, swinging, turning, and twisting) (Goodway et al., 2019).

A common misconception is that children learn FMS automatically (Stodden et al., 2008). A growing body of evidence suggests that an increasing number of children do not obtain proficiency in FMS (Bös et al., 2004; Hardy et al., 2012; Huotari et al., 2018; Roth et al., 2010; Tester et al., 2014; Vandorpe et al., 2011). Although these studies represent different time periods and different countries (Germany, Australia, Finland, and Belgium), in general they report declining levels of children's motor skills competence. These findings are of major concern as children with high FMS have been linked with positive health-related outcomes. Several cross-sectional studies showed a positive association between FMS and PA in youth (Kambas et al., 2012; Slykerman et al., 2016; Williams et al., 2008), and a few longitudinal studies have found evidence for the suspected causal pathways between FMS and PA (Barnett et al., 2009; Barnett et al., 2016; Jaakkola & Washington, 2013; Lima et al., 2017; Lopes et al., 2011).

The increasing number of young children with low proficiency in FMS emphasise the need to get more insight in this decline and look for working elements in changing these trends. Particularly considering that delayed FMS development at an early age does not diminish with normative growth but may increase in the absence of proper interventions (Tompsett et al., 2017). In recent years several reviews and meta-analyses have been conducted on the effectiveness of FMS interventions in young children. For example, Van Capelle et al. (2017) completed a review and meta-analyses on 20 studies to quantify the improvement in FMS after intervention in 3–5-year-old children. They stated that children should practice at least three times per week, 30 min per session. Similar recommendations were formulated by Engel and colleagues in 2018 based on their review and meta-analyses of FMS interventions for 3–12-year-old children. Results of 18 studies indicated that training the FMS in pre-schoolers at least three times a week can improve motor skill proficiency as well as increase PA intensity. Finally, Wick et al. (2017) published a review and meta-analyses about FMS enhancing intervention programmes among 2–6-year-old children. A total of 30 studies were included that provided intervention programmes that lasted at least four weeks. Although they found effects of interventions on FMS proficiency in young children, these studies need to be interpreted with care as they are limited by shortcomings in study design.

Based on earlier reviews and meta-analyses, it is important that FMS interventions start during preschool and early school years (Hardy et al., 2012; Logan et al., 2011). Next to an early intervention start, the content of an intervention also seems important (Wick et al., 2017). According to the review that Riethmuller et al. (2010) conducted, effective FMS interventions consist of a mix of deliberate play (unstructured activities) and deliberate practice (structured activities). Deliberate play is meant to increase motor flexibility and intrinsically motivate to be physically active, which maximises fun and enjoyment and provides immediate fulfilment. Deliberate practice refers to a special type of practice that is purposeful and systematic (Güllich et al., 2020). While regular practice might include mindless repetitions, deliberate practice requires focused attention and is conducted with the specific goal of improving performance (Bailey et al., 2010). Next to an early intervention start and intervention content also the professional involved plays an important role for succeeding an intervention. Riethmuller et al. (2010) concluded that staff requires substantial training and guidance to increase the effectiveness of FMS interventions.

In summary, several reviews and meta-analyses have been conducted on the effectiveness of FMS interventions. There is evidence that FMS interventions can be effective on the short term if they consist of a combination of deliberate play and deliberate practice if they are conducted at least three times per week and if they are supervised by trained staff members. However, a diverse range of study designs, intervention characteristics and assessments used were found (Engel et al., 2018; Riethmuller et al., 2010; Van Capelle et al., 2017; Veldman et al., 2016; Wick et al., 2017). Most of these studies provided limited information on the specific elements of the FMS interventions. To further increase the effectiveness of the FMS interventions a better understanding of the underlying working mechanisms is needed. For example, it is not clear which of the specific FMS (intervention focus) should be incorporated to gain the best results and how the FMS could be best instructed (deliberate practice and/or deliberate play). Also, the type of activities (intervention content) needs to be specified in order to optimise the intervention programme as well as guidelines regarding a minimum intervention length in order to be effective. In addition, also relevant for professionals might be information about the frequency and duration of each intervention session in terms of the weekly intervention volume. Besides the intervention elements, information of which assessment tools are recommended, and what kind of education or training is needed for the professionals that delivers the intervention need to be provided. In the previous reviews these elements were not described in detail. To our knowledge no studies on the effectiveness of FMS interventions have been reported since the latest review which included studies published before July 2017 (Engel et al., 2018).

Therefore, there were two main objectives of this study: (1) to conduct a systematic review to provide evidence on the effectiveness of FMS interventions in young children (2–5 years); and (2) to identify elements that determine the effectiveness of these interventions.

Method

A systematic review was conducted on intervention studies that aimed to enhance FMS levels of young children aged 2–5 years. The guidelines in the Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA) statement were followed (Page et al., 2021).

Study inclusion and exclusion criteria

The review was restricted to original peer-reviewed published studies applying the following inclusion criteria: (1) published between January 2000 and December 2022; (2)

the intervention focused on typically developing children between 2 and 5 years old (interventions with a target population of 5-year old which extended in time were also included); (3) validated FMS assessments were used (studies using measurement batteries that incorporated an assessment of fine motor skills, health-related fitness or that included a focus on a skill unique to a particular sport were excluded); (4) interventions in which the main component or one of the components focused on the development of FMS (interventions that solely focused on increasing physical activity or preventing obesity were excluded). Furthermore, all settings (e.g., childcare centre, kindergarten, pre-school, primary or elementary school, sport clubs) were included and no countries were excluded in the selection process.

Studies were excluded if it was a duplicate study, if no full text was available, and if the studies were not original research (i.e., review articles, surveys, conference abstracts, or book chapters). Finally, also studies not published in English were excluded.

Information sources and search strategy

The search strategy was developed by three authors (P.K., J.H., S.d.V.). Four electronic databases were searched by two authors (P.K., J.H.), i.e., PubMed, Academic Search Complete, Education Resources Information Centre (ERIC), and SPORTDiscus. Search terms were divided into three groups: (1) population (i.e., toddler OR toddlers OR children OR child* OR youth* OR school OR primary OR elementary OR pre-school); (2) study design (i.e., random* OR clinic* OR trial OR intervention OR evaluation OR experiment OR programme* OR pilot OR feasibility); and (3) intervention type (i.e., physical activity OR exercise OR motor skill OR movement skill OR fundamental motor skill OR fundamental movement skill OR coordination OR motor competence OR motor development). To combine search terms Boolean operators (AND/OR) were used. The Boolean phrase "AND" was used between groups and the phrase "OR" was used within groups.

Both authors checked the initial results and discussed the outcomes. Studies published between January 2000 to December 2022 were included.

Study selection

After searching the databases, first, duplicate studies across databases were identified and excluded by one of the authors (P.K.) Next, two authors (P.K., J.H.) independently screened titles and abstracts of the remaining studies and divided them into two groups: yes or no. Initial consensus was reached in 91% of the screened studies, general agreement was achieved through discussion for the last 9%. Eligible studies selected from the first screening were retrieved and read in full by two authors (P.K., J.H). Additional studies were included based on reference tracking of the included studies.

Data extraction

From all included studies, the following data were extracted by two authors (P.K., J.H.): author, year and country, study design and setting, professional involved in the intervention delivery, training of the intervention professional, total sample size at baseline (boys and girls), age of the study sample (in years), intervention and control group (boys and girls), intervention length (in months), intervention name, intervention volume (duration x number of sessions per week), intervention focus (which FMS, deliberate practice and/or deliberate play), intervention content (specified content), control group information, motor skill assessment, primary outcome (post intervention and after retention), other measurements performed, and secondary outcome (post intervention and after retention). The effect size of the intervention on the primary outcome was registered. If not provided in the study, effect sizes were determined by calculating Cohen's d (Hox et al., 2017).

Assessment of methodological quality and risk of bias

The methodological quality of the included studies was assessed by two authors (P.K., J.H.) using a 10-item quality assessment checklist adapted from the Consolidated Standards of Reporting Trials (CONSORT) statement (Moher et al., 2012), and used in previous reviews of similar areas (Van Sluijs et al., 2007; Veldman et al., 2016). The checklist consisted of the following questions listed: (i) Were the key baseline characteristics reported separately for each group? (ii) Was the randomisation procedure clearly described and adequately carried out? (iii) Did the study report the sources and details of FMS assessment and did the instruments have acceptable reliability for the specific age group? (iv) Did the study report dropouts (in numbers and reasons) for participants who did not complete the intervention? (v) Has the process of concealing treatment group identity from outcome assessors, after their treatment assignment through randomisation, to minimise the occurrence of biased assessments been done properly? (vi) Did the study protocol contain a retention test more than 6 months after the pretest? (vii) Is the intention-to-treat analysis properly performed in the study? (viii) Are potential confounders be taken in account when analysing the results? (ix) Have the outcomes of the study been presented in detail? (x) Is there a power calculation reported?

Each item was scored positive (1) (i.e., criterion was met; low risk of bias) or negative (0) (i.e., criterion was not met; high risk of bias) by both authors independently. If a specific item could not be determined, the item was also considered as potentially high risk when reporting results. In cases of disagreement, consensus was reached by discussion. All positive scores were accumulated. A study was classified as of high methodological quality when it scored ≥5 points for a controlled trial and ≥6 points for a randomised controlled trial, lower scores were classified as studies of low methodological quality (Van Sluijs et al., 2007).

Next to the methodological quality assessment of each included study, the risk of bias of all included studies was assessed and accumulated. Criteria ii), (iv), (v), (vii), and (viii) were regarded as the most significant items in which bias could have an impact on results. The scoring procedure was identical as the methodology assessment. Differences in assessments were resolved via discussion or by consulting a third author.

Results

The process of identifying relevant studies is shown in the PRISMA flow diagram (see Figure 1). The initial search identified 2242 studies. After removing duplicates ($n = 9$), 2184 articles were excluded based on title and abstract. The remaining 49 articles met the inclusion criteria and were assessed for eligibility based on the full texts of these

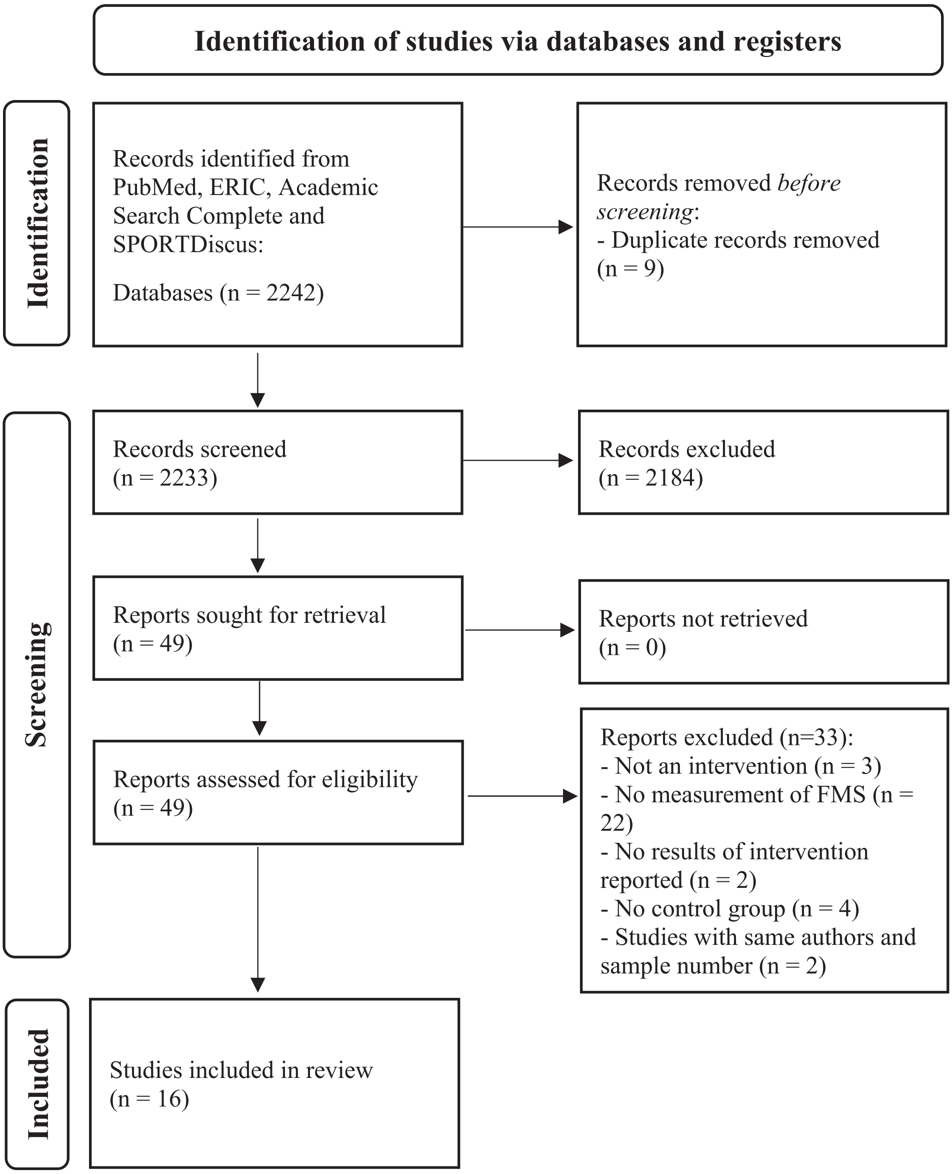

Figure 1. PRISMA flow diagram.

studies. This resulted in the exclusion of another 33 studies. Reference tracking was performed which resulted in including one more study. Two studies have been excluded because the author(s) used an identical sample in the study. In total, 16 studies were included in this review (see Appendix).

Study characteristics

Table 1 shows the characteristics of the 16 included studies. Despite the inclusion of studies from 2000 up till 2022, all studies were published between 2010 and 2022.

Table 1. Study characteristics of the 16 included studies.

Reference (author, year, country)	Design	Setting	Professional	Training professional	Total sample	Age	Int. / Con. group	Int. length	Int. name
1) Aivazidis et al., 2019, Greece	RCT	Kinder garten	- PE teachers - School teachers	- 1 day training session - weekly evaluation	N = 140 60 boys 80 girls	to 6-year-old (M = 5.1 SD ± 0.2)	INT n = 74: 30 boys 44 girls CON n = 66: 30 boys 36 girls	8-months	The Walk
2) Bardid et al., 2016, Belgium	CT	Sports-club Local council School Day care centre	- Sport leaders - School teachers - Care-givers	- 1 day training session - supervision	N = 992 511 boys 481 girls	3-to 8- year-old (M = 5.6 SD ± 1.4)	INT n = 523: 277 boys 246 girls CON n = 469: 234 boys 235 girls	6-months	Multimove for Kids
3) Brian et al., 2017, USA	RCT	School	Class-room teacher	- 6-hour training session - supervision	N = 122 55 boys 67 girls	2-to 7-year-old (M = 4.7 SD ± 2.2)	INT n = 63: 23 boys 40 girls CON n = 59: 32 boys 27girls	2-months	T-SKIP
4) Donath et al., 2015, Switzerland	RCT	Kinder garten	Experienced, certified, exercise instructor	No training reported	N = 41 24 boys 17 girls	3-to 5-year-old (M = 4.6 SD ± 1)	INT n = 22: 12 boys 10 girls CON: n = 19: 12 boys 7 girls	1.5-months	x
5) Engel et al., 2021 Australia	RCT	Childcare centre (outdoor)	- Exercise phys. researcher - fourth year students	No training reported	N = 66 36 boys 30 girls	3- to 5 year-old (M = 4.0 SD ± 0.6	INT n = 49: 26 boys 23 girls CON n = 17: 10 boys 7 girls	3- months	PLAYFun
6) Foulkes et al., 2017, UK	RCT	Childcare centre	Childcare centre staff	No training provided	N = 162 86 boys 76 girls	3-to 5- year-old (M = 4.6 SD ± 0.6)	INT n = 71: 33 boys 38 girls CON n = 91: 53 boys 38 girls	1.5-months	Active Play
7) Jones et al., 2011, Australia	RCT	Childcare centre	Childcare centre staff	4 times a 30-minute training session	N = 97 N boys/ girls: not specified	3-to 5-year-old (M = 4.1 SD: Not reported)	INT n = 52 CON n = 45	6-months	Jump Start
8) Jones et al., 2015, Australia	RCT	Childcare centre	Childcare centre staff	2 times a 90-minute training session - weekly supervision	N = 150 N boys/ girls: not specified	3-to 5-year-old (M = 4.0 SD ± 0.6)	INT n = 77 CON n = 73	6-months	Jump Start

(Continued)

Table 1. Continued.

Reference (author, year, country)	Design	Setting	Professional	Training professional	Total sample	Age	Int. / Con. group	Int. length	Int. name
9) Krneta et al., 2015, Servia	RCT	Kinder garten	Kinesiology professionals	No training reported	N = 68 68 boys	4-to 6- year-old (M = 5.9 SD ± 0.6)	INT n = 37 CON n = 31	9-months	x
10) Matvienko, 2010, USA	RCT	Kinder garten	PE teacher	No training reported	N = 70 35 boys 35 girls	Not reported	INT n = 42 CON n = 28 ? boys/girls	1-month	Nutri active
11) Navarro-Patón et al., 2021 Spain	RCT	School	PE teachers	No training reported	N = 152 82 boys 70 girls	4- to 5 year-old (M = 5.2 SD ± 0.54	INT n = 76: 40 boys 36 girls CON n = 76: 42 boys 34 girls	1.5-months	x
12) Piek et al., 2013, Australia	RCT	School	Classroom teachers	1 day training session	N = 511 257 boys 254 girls	4-to 6- year-old (M = 5.4 SD ± 3.6)	INT and CON: no information provided	2.5-months	Animal Fun programme
13) Robinson et al., 2017, Australia	RCT	School	Motor development specialist	No training reported	N = 124 s (M age = 48.14 ± 6.62 months)	3-to 5- year-old (M = 4.0 SD ± 0.6)	INT n = 81 CON n = 43 ? boys/girls	2-months	CHAMP
14) Ruiz-Esteban, 2020, Spain	CT	Childcare centre	Childcare centre staff	No training reported	N = 136 66 boys 70 girls	3-to 5-year-old (M = 3.2 SD ± 0.3)	INT n = 28: 14 boys 14 girls CON n = 106: 52 boys 56 girls	5-months	x
15) Tortella, 2016, Italy	CT	Kinder garten	Childcare centre staff	No training reported	N = 110 63 boys 57 girls	5-to 6- year-old (M = 5.6 SD ± 0.3)	INT n = 71: 41 boys 30 girls CON n = 39: 22 boys 17 girls	2.5-months	Primo Sport playground
16) Toussaint, 2019, The Netherlands	RCT	Childcare centre	Childcare centre staff	2 training session 1 coaching on the job session	N = not specified (Preschools N = 41)	2- to 4-year-old (M not reported)	N = not specified (Preschools INT n = 21 CON n = 20)	4-months	PLAYTOD

Reference (author, year, country)	**Int. volume per week**	**Int. focus**	**Int. content**	**Control group information**	**FMS assess-ment**	**Primary outcomes**	**Other measurements**	**Secondary outcomes**
1) Aivazidis et al., 2019, Greece	- PE sessions (4x p/w, 45-50 min) - recess (5x p/w 15 min)) - walking (1x p/w, 30 min) total: 355 min/w	FMS skills: - object control - locomotor - stability Deliberate practice (PE) Deliberate play (recess)	- PE Lessons: gross motor activities, traditional games, music activities - recess: chases, games with balls, hoops, ropes, e.d.	Received no additional practice	KTK* Product orientated	Post-test: INT > CON (P < .001) for all KTK items d = 3.45	PA: Omron HJ-720IT-E2 piezoelectric pedometers	Post-test: INT > CON (P < .001)

2) Bardid et al., 2016, Belgium	- Motor skill session (1x p/w, 60 min) total: 60 min/w	FMS skills: - object control - locomotor - stability Deliberate practice	running, climbing, swinging, gliding, rotating, jumping, catching and throwing, pushing and pulling, lifting and carrying, hitting, kicking, dribbling.	Received no additional practice	TGMD-2 Process orientated	Post-test INT > CON (p < .001) for both locomotor and object control skills d = 0.43	x	x
3) Brian et al., 2017, USA	- PE sessions (2x p/w, 30 min) total: 60 min/w	FMS skills: - object control Deliberate practice	No information provided in article	Received no additional practice	TGMD-2 Object control subscale Process orientated	Post-test INT > CON (p < .001) for object control skills d = 0.59	x	x
4) Donath et al., 2015, Switzerland	- Motor skill sessions (2x p/w, 30 min) total: 60 min/w	FMS skills: - object control Deliberate practice	ball rolling, throwing and catching, rolling or throwing balls against or into a target, dribbling scoring goals with kicking or rolling	Received instructed and supervised training twice a week	TGMD-2 Object control subscale Process orientated	Post-test INT > CON (p < .001) for object control skills d = 0.77	x	x
5) Engel et al., 2021 Australia	- Motor skill session (3x p/w, 40 min) total: 120 min/w	FMS skills: - object control - locomotor - stability Deliberate practice and deliberate play	Games, such as bull-rush (run), Jump the River (jump), Hopscotch (hop) and free play	Usual preschool curriculum	TGMD-2 Process orientated	Post-test: INT > CON (p < .001) for object control skills d = 1.06 GMQ total score d = 0.83 Retention test INT = CON	PA: GT3X + Actigraph accelerometers Anthropometry: height, weight, and waist circumference, calculated BMI	INT > CON for less sedentary behaviour
6) Foulkes et al., 2017, UK	- Motor skill session (1x p/w, 60 min) total: 60 min/w	FMS skills: - object control - locomotor - stability Deliberate practice	Not reported	Not reported	CMSP Process orientated	Post-test INT = CON Retention test INT = CON d = x	x	x
7) Jones et al., 2011, Australia	- Motor skill session (3x p/w, 20 min) - Unstructured activities, after the structured session total: 120 min/w	FMS skills: - object control - locomotor - stability Deliberate practice (structured lesson) Deliberate play (recess)	- structured lesson focusses on running, catching, jumping kicking and hopping - recess opportunity to practice the skills learnt in the structured lessons	Received no additional practice	TGMD-2 Process orientated	Post-test INT > CON (p < .001) Total outcome d = 0.42	PA: MTI 7164 Actigraph accelerometers Anthropometry: calculated BMI based on Weight and height.	PA (counts per minute): INT > CON Anthropometry: INT = CON

(*Continued*)

Table 1. Continued.

Reference (author, year, country)	Design	Setting	Professional	Training professional	Total sample	Age	Int. / Con. group	Int. length	Int. name
8) Jones et al., 2015, Australia	- Motor skill session (3x p/w 20 min) - Unstructured activities, after the structured session total: 60 min/w	FMS skills: - object control - locomotor - stability Deliberate practice (structured lesson) Deliberate play (recess)	- structured lesson focusses on running, catching, jumping kicking and hopping - recess offering an opportunity to practice the skills learnt in the structured lessons	Received no additional practice	TGMD-2 Process orientated	Post-test INT = CON Medium effect size of FMS d = 0.23	PA: GT3X + Actigraph accelerometers	Post-test Medium ES of sedentary behaviour (d = 0.42) small ES of time in light-intensity PA (d = 0.39) and light-, moderate- and vigorous-intensity PA (d = 0.23).	
9) Krneta et al., 2015, Servia	Motor skill session (2x p/w, 60 min) total: 60 min/w	FMS skills: - object control - locomotor - stability Deliberate practice	perceptual-motor activities, creative movements, rhythms and dances, stunts, tumbling, and apparatus activities, running, jumping, throwing, games	Received no additional practice	No validated MC assessment tool was described	Post-test INT > CON (p = .001) Total outcome d = 3.54	x	x	
10) Matvienko, 2010, USA	- daily walk (15 min) - daily motor skill session (30 min) - daily non-structured active play (30 min) - daily classroom activities (30 min) total: 525 min/w	FMS skills: - object control - locomotor - stability Deliberate practice (structured lesson) Deliberate play (unstructured activity)	motor skills including throwing for distance, kicking for accuracy, and various rope-jumping steps. fitness-enhancing activities	Received no additional practice	No validated MC assessment tool was described	Post-test INT > CON (p = .001) Retention test INT > CON (p = .001) d = 0.85	Anthropometry: calculated BMI based on Weight and height Body Strength: Push Up, Pull Up and Stranding long jump Endurance: Shuttle run	Post-test BMI: INT = CON Pull Up: INT = CON Push Up: INT > CON Standing long jump: INT > CON Shuttle run INT = CON (p = .001)	
11) Navarro-Patón et al., 2021 Spain	Motor skill session (1x p/w, 40 min) total: 40 min/w	FMS skills: - object control - stability Deliberate practice	Warm-up (5 min), three or four tasks related to the skill to be developed (manual dexterity, pointing and chatting or balance; 30 min) and a cool-down or goodbye activity (5 min).	Received no additional practice (regular programme was given i.e., the body and body image, play and movement, daily activity, and personal care and health)	MABC-2 Product orientated	Posttest INT > CON for manual dexterity (p=<0.05) d = 0.30 for aiming and catching (p < 0.001) d = 0.84 for balance (p < 0.001) d = 0.61 total eight test score (p < 0.001) d = 0.88	x	x	
12) Piek et al., 2013, Australia	Not reported	FMS skills: - object control	Trunk and Lower Limb Static Balance, Dynamic Balance,	Not reported	BOT-2SF Product	Post-test: INT > CON (p	x	x	

		- locomotor - stability Deliberate practice	Climbing, Locomotion Walking, jumping, Hopping, Skipping, Throwing, Catching, Kicking		orientated MABC-2 Product orientated	= .001) d = −0.10		
13) Robinson et al., 2017, Australia	Motor skill session (2x p/w, 30 min) total: 60 min/w	FMS skills: - object control Deliberate practice	targeted six ball skills - throw, catch, strike off a tee, kick, dribble, and roll.	Received no additional practice	TGMD-2 Object control subscale Process orientated	Post-test: INT > CON (p = .005) Retention test INT > CON (p = .005) d = 1.88	x	x
14) Ruiz-Esteban, 2020, Spain	Motor skill session (2x p/w, 45 min) total: 90 min/w	FMS skills: - object control - locomotor - stability Deliberate practice	walking, running, jumping, rolling, sliding, galloping, leaping, striking, dribbling, kicking, throwing, and catching	Received no additional practice	MSCA Product orientated	Post-test: INT > CON (p = .001) for both leg and arm coord. d = 0.99	x	x
15) Tortella, 2016, Italy	- Motor skill session (1x p/w, 30 min - Unstructured activities session (1x p/w, 30 min) total: 60 min/w	FMS skills: - object control - locomotor - stability Deliberate practice (structured lesson) Deliberate play (unstructured activities)	- structured lessons focus on manual dexterity, mobility and balance - unstructured activities: free play at playground	No activities at the playground	Subscales of M-ABC KTK TMC Product orientated	Post-test: INT > CON (p = .001) d = −0.43	Test of Physical Fitness: Putting a Medicine Ball	Post-test: INT > CON (P < .001)
16) Toussaint, 2019, The Netherlands	Not reported	FMS skills: - object control - locomotor - stability Deliberate play (unstructured activities)	zone 1: cycling, zone 2: obstacle course with jump, climb, crawl, walk, balance and turn. zone 3: experience sensory materials. zone 4: free play	Not reported	SOPLAY protocol Observation Process orientated	INT > CON based on observation d not reported	Physical activity observation	INT > CON based on observation

* KTK = Körper- Koordination Test für Kinder, TGMD-2 = Test of Gross Motor Development-2, SLJ = Standing Long Jump, TMR = Twelve Metre Run, CMSP = Children's Activity and Movement in Preschool Study Motor Skills Protocol, BOT-2SF = Bruininks–Oseretsky Test of Motor Proficiency-version 2 Short Form, MABC-2 = Movement Assessment Battery for Children-version 2, MSCA = McCarthy Children's Psychomotricity and Aptitude Scales, TMC = Test of Motor Competence, SOPLAY = System for Observing Play and Leisure Activity in Youth.

Nine studies were conducted in Europe (studies: 1, 2, 4, 6, 9, 11, 14–16), five studies were conducted in Australia (studies: 5, 7, 8, 12, and 13), and two studies were conducted in the USA (studies 3 and 10). Thirteen studies conducted a randomised controlled trial (studies: 1, 3–13, and 16) and three studies a controlled trial (studies: 2, 14, and 15). The sample size of the studies varied from 41 children (study 4) up to 992 children (study 2). Ten studies had a sample size > $n = 100$ children (studies: 1–3, 6, 8, 11–15). One study didn't report the number of included children in the study (study 16). The age range of the study samples varied between studies, with the most frequent age range between 3-and 5-year-old (studies: 4–8, 11, 13, and 14), two studies focused on 4-to 6-year-olds (studies 9 and 12), two studies on 5-to 6-year-olds (studies 1 and 15), and one study on 3-to 8-year-olds (study 2), 2- to 7-year-old (study 3), and 2- to 4-year-old (study 16). One study didn't report the exact age of the included children (study 10).

Intervention setting

Most interventions took place in settings such as kindergarten (studies: 1, 4, 9, 10, and 15), childcare centre (studies: 5–8, 14, and 16) or school (studies: 3, 11, 12, and 13). Only one intervention had a community-based approach (e.g., sports-club, local council, school, and day care centre) (study 2). There were no studies that focused on FMS development in the home setting. All interventions were conducted by professional staff of that setting. For example, in the school setting the teacher conducted the intervention. Specialised training for professional staff was offered in seven of the 16 studies prior to the interventions (studies: 1–3, 7, 8, 12, and 16). In one study no training was provided (study 6). The remaining eight studies didn't report about a professional training session prior to intervention delivery (studies: 4, 5, 9–11, 13–15) (see Table 1).

Interventions

In Table 1 the intervention length, volume per week, focus, and content of the interventions are reported. The length of the intervention period varied from one month (study 10) up to nine months (study 9) with an average length of four months. The volume per week (duration x number of sessions per week) was 60 min per week in most studies (studies: 2–4, 6, 8, 9, 13, and 15), except for six studies (studies: 1, 5, 7, 10, 11, and 14) which reported a volume of respectively 355, 120, 120, 525, 40, and 90 min per week. Two studies did not report the volume of the intervention per week (studies 12 and 16).

If not specified in the selected studies, the deliberate practice and/or deliberate play intervention focus was deduced by terms as structured lessons and/or unstructured activities (e.g., recess or free play). In nine studies a deliberate practice programme was evaluated (studies: 2–4, 6, 9, 11–14). The intervention content of the deliberate practice programme focused on all FMS in five studies (studies: 2, 6, 9, 12, and 14). In four studies the deliberate practice programme focused solely on object control and/or stability skills (studies: 3, 4, 11, and 13). There was one study that consisted of a deliberate play condition to improve FMS (study 16). Six studies were based on a mix of deliberate practice and deliberate play conditions (studies: 1, 5, 7, 8, 10, and 15) with one or more structured activities and one or more supervised free play or unstructured activities per week. In all six studies, the programme consisted of activities to improve all FMS.

Motor skill assessment

The tools that were used to measure FMS can be divided into process- and product-orientated measurement tools. A process-orientated assessment evaluates how the skill is being performed while a product-orientated approach evaluates the outcome of a skill performance (Palmer et al., 2021). From the selected studies, eight interventions were evaluated with a process-oriented assessment whereas five studies used a product-orientated assessment. Of the eight studies that measured FMS with a process-orientated tool, the Test of Gross Motor Development-2 (TGMD-2) (Ulrich, 2000) was the most common one (studies: 2–5, 7, 8, and 13). One study used the System for Observing Play and Leisure Activity in Youth (SOPLAY) (McKenzie, 2002) (study 16), and one study used the Children's Activity and Movement in Preschool Study Motor Skills Protocol (CMSP) (Williams et al., 2009) (study 6). Five studies measured FMS with a product-orientated tool or a combination of tools: Bruininks–Oseretsky Test of Motor Proficiency-version 2 Short Form (BOT-2SF) (Simons, 2008) (study 12), McCarthy Children's Psychomotricity and Aptitude Scales (MSCA) (McCarthy, 1972) (study 14), Körper Koordination Test für Kinder (KTK) (Kiphard & Schilling, 2007) (studies 1 and 15), Movement Assessment Battery for Children-version 2 (MABC-2) (Henderson et al., 2007) (studies 11 and 12), and the Test of Motor Competence (TMC) (Sigmundsson et al., 2016) (study 15). In two studies motor competence assessments were used which were well described but lacked references to validation studies considering these assessment tools (studies 9 and 10). Six studies explicitly reported test-retest reliability scores ranging from moderate to high ($r = .61–.94$) (studies: 1, 2, 4, 6, 9, and 12). One study reported a "high" test-retest reliability score without reporting actual coefficient scores (study 11). Other studies did not report test-retest reliability scores.

Intervention effects

Fourteen studies reported a statistically significant positive effect of the intervention on children's FMS in the post-test (studies: 1–5, 7, 9–16), and two studies reported no statistically significant effect (studies 6 and 8). Four studies executed a retention test (studies 5, 6, 10, and 13). Two of these studies showed a statistically significant effect after retention (studies 10 and 13). In the other studies the effect was no longer statistically significant (study 5 and 6). Effect sizes ranged from small but negative ($d = -0.43$) to very strong ($d = 3.54$) with 12 studies showing a positive effect size (studies: 1–5, 7–11, 13, and 14) (Hox et al., 2017; Van Sluijs et al., 2007; Veldman et al., 2016).

Next to FMS, seven studies reported a secondary outcome. Five studies reported secondary outcomes on PA, which all showed a statistically significant effect of the intervention on PA (studies 1, 5, 7, 8, and 16). Three studies measured children's body mass index (BMI). These studies showed no effect on BMI (studies 5, 7, and 10). Two studies showed a significant effect on physical fitness of the intervention (studies 10 and 15).

Table 2. Criteria and scoring of methodological quality and risk of bias.

Reference (author, year, country)	i) Key baseline charac–teristics reported separately for each group	ii) Randomi–zation procedure clearly described	iii) Valid measure of FMS	iv) Dropout ≤20% for <6 months follow-up, ≤ 30% for ≥6 months follow-up	v) Assessor blinding	vi) Motor develop-ment assessed a min of 6 months after pre-test	vii) Intention-to-treat analysis	viii) Potential confound-ders accounted for in analysis	ix) Summary outcomes presented + treatment effect + precision	x) Power calcul–ation reported	Total score	Classified as high quality (≥5 for controlled trial and ≥6 for a randomised controlled trial
1) Aivazidis et al., 2019, Greece	1	1	1	0	0	1	1	1	1	0	7	**High**
2) Bardid et al., 2016, Belgium	1	0	1	0	0	1	1	1	1	0	6	**High**
3) Brian et al., 2017, USA	0	0	1	0	0	1	0	1	0	0	3	**Low**
4) Donath et al., 2015, Switzerland	1	1	1	0	1	0	1	1	1	0	7	**High**
5) Engel et al., 2021, Australia	1	1	1	1	1	0	1	0	1	1	8	**High**
6) Foulkes et al., 2017, UK	1	1	1	0	0	1	1	0	1	0	6	**High**
7) Jones et al., 2011, Australia	0	1	1	1	1	0	1	0	1	0	6	**High**
8) Jones et al., 2015, Australia	1	1	1	0	1	1	0	0	1	0	6	**High**
9) Krneta et al., 2015, Servia	1	0	0	0	0	1	1	0	1	0	4	**Low**
10) Matvienko, 2010, USA	0	0	0	0	0	1	0	1	1	0	3	**Low**
11) Navarro-Patón et al., 2021, Spain	1	1	1	1	0	0	1	0	1	0	6	**High**
12) Piek et al., 2013, Australia	0	0	1	0	0	1	1	0	1	0	4	**Low**
13) Robinson et al., 2017, Australia	1	1	1	1	1	0	1	0	1	0	7	**High**
14) Ruiz-Esteban, 2020, Spain	1	1	1	0	0	0	0	0	1	0	4	**Low**
15) Tortella, 2016, Italy	0	0	1	0	0	0	0	0	0	0	1	**Low**
16) Toussaint, 2019, The Netherlands	0	1	0	1	0	0	0	0	1	0	3	**Low**
Risk of bias (%)	**28%**	**28%**	**19%**	**69%**	**69%**	**50%**	**38%**	**69%**	**13%**	**94%**		

Quality assessment

Table 2 summarises the criteria and scoring of methodological quality and risk of bias of the 16 studies included in the review. Nine of the 16 studies (56%) had a high methodological quality with a total score ranging from 6 to 8 points on a 10-point scale (studies: 1, 2, 4–8, 11, and 13). The other seven studies had a low methodological quality with scores ranging from 1 to 4 points (studies: 3, 9, 10, 12, 14–16).

Risk of bias

Study risk of bias shows that 29% of the included studies had some baseline imbalances due to the randomisation process, although bias related to controlling for potential confounders scored high (69%) and was of serious risk. The intention-to-treat analysis in most studies was well documented and relatively low of risk (38%), while the process of concealing treatment group identity from outcome assessors and the reporting of dropouts during the intervention scored high (69%).

Discussion

This systematic review examined literature published between January 2000 and December 2022 on FMS interventions in young children (2–5 years). In the majority of the included studies, beneficial effects were found of general FMS interventions mainly focusing on object control skills, combined with either locomotion or stability. This suggests that significant increases in FMS proficiency can be achieved through an intervention. This is in line with previous reviews (Eddy et al., 2019; Engel et al., 2018; Iivonen & Sääkslahti, 2014; Riethmuller et al., 2010; Van Capelle et al., 2017; Veldman et al., 2016; Wick et al., 2017). However, there were differences between the intervention studies.

Interventions that consisted of a combination of deliberate practice and deliberate play or solely of deliberate practice seem to be more effective than only deliberate play. Deliberate practice is beneficial because of the provision of immediate feedback, time for problem-solving and evaluation, and opportunities for repeated performance to refine behaviour (Anders Ericsson, 2008) whereas a deliberate play setting can be characterised by flexibility and enjoyment (Pesce et al., 2016). A combination of deliberate practice and deliberate play seems effective (Baker & Côté, 2006) although at young age varied practice with a focus on deliberate play, fun, and enjoyment should be a bigger part of an intervention than structured and effortful training. Examples of combining deliberate practice and deliberate play in our selected high-quality studies were activities like ball rolling, throwing, and catching, against or into a target, dribbling scoring goals with kicking or rolling during the structured part of the lesson and later (or during recess) offering an opportunity to practice these skills on the playground. Also, a great variety in activities like music activities, traditional games, climbing, swinging, gliding, rotating, jumping, pushing and pulling, lifting and carrying were more often found in the more effective interventions.

Weekly volumes ranged from 40 to 525 min per week, with the number of sessions ranging from 1 to 5 times a week, and intervention lengths varying from 1 to 9 months. However, for gaining significant results, a minimum of three sessions a week for 30–45 min per session is recommended from the high-quality studies. Also, longer intervention lengths (≥6 months) seem to generate better results compared with interventions shorter in length (<2 months). Similar findings were found in previous studies (Engel et al., 2018; Van Capelle et al., 2017) however in this review a tendency was noticed with more, slightly shorter intervention sessions (three or four times a week for 30 min) being more effective than one (longer) session a week. However, inconsistency in reported intervention characteristics, for example, according to the F.I.T.T (Frequency, Intensity, Type, and Time) principle of exercise prescription (American College of Sports Medicine, 2012) makes it difficult to extract the ideal dose–response relationship for the best intervention programme.

Professionals (e.g., childcare centre staff, PE teachers, classroom teachers) delivered the interventions in almost all studies. According to Tompsett et al. (2017) specialist-led interventions, taught in conjunction with at-home practice and parent involvement, appeared to be more efficacious in enhancing FMS proficiency than school PE alone. Although one study had a community-based approach (e.g., sports-club, local council, school, and daycare centre) remarkably in our studies no parents were involved.

Methodological quality of the included studies

Since only nine of the 16 studies were of high methodological quality, caution is required when interpreting individual study results. Well-described study designs and well-described intervention programmes are essential for the assessment of RCT's. The CONSORT guidelines were presented in 2010 to improve the reporting of RCT's. However, some studies have been conducted before the guideline was published and thus may have influenced the quality and bias evaluation due to missing information. A lack of high methodological quality studies was also found in previous reviews (Riethmuller et al., 2010; Veldman et al., 2016; Wick et al., 2017). More high-quality research is needed, with more heterogeneous samples, that explore directly which determinants moderate an intervention's efficacy in young children (Van Sluijs & Kriemler, 2016). Regarding the study design, 81% of the included studies were RCT's which is positive, given the fact that a RCT study is the desirable research design to gain objective results.

This review revealed that only four studies performed a retention test after the post-test. One of the desired outcomes when conducting an intervention is a long-term effect on FMS proficiency. A research design including a retention test is needed to reveal those long-term effects on FMS proficiency.

Another notable aspect of the included studies is the alignment of FMS measurement tools used to evaluate the interventions. In this review 10 different assessment tools were used (i.e., process-, product-orientated, and/or observations). According to Palmer et al. (2021) and Tompsett et al. (2017) the type of assessment used should be taken in consideration when interpreting the results of the evaluated studies, since product- and process-oriented tools assess different elements of FMS. In line with differences between type of assessment used, most severe lagging behind on FMS can be found in intervention studies (van Beurden et al., 2003; Ré et al., 2018) that used process-oriented measurements (e.g., opposite leg in front position during overarm throw), while better results are presented in intervention studies which directed their attention towards product-oriented measures (e.g., the amount of positive hits when throwing at a target (Bös et al., 2004)).

Strengths and limitations of this review

This systematic review has certain strengths. It used a sensitive search strategy to ensure all relevant studies were captured. In addition, a proper review methodology, including full paper assessment and methodological evaluation of the studies was done in an independent standardised way. Furthermore, a unique in-depth-analysis of the intervention elements (e.g., intervention length, volume, focus, and content) was performed to explain possible causes of intervention results.

There are a few limitations of this review. Although this review was comprehensive (e.g., no countries were excluded), only studies published in English were included and publication bias related to selective reporting of only positive associations may be possible. Additionally, most studies were conducted in well developed countries, where sedentary lifestyles are rather common among young children and where overweight and obesity rates in children are also high (Lopes et al., 2021). Pooling intervention data and outcomes from existing studies across the world would provide an insight on the global prevalence and possibly trends of motor development.

The partially inadequate description of the studies according to the CONSORT guidelines influenced the risk of bias. A detailed study protocol regarding the randomisation process, reporting of dropouts and controlling for potential confounders would have been beneficial. Regarding the lack of assessor blinding, it should be noted that it is difficult to blind PE teachers, childcare centre staff in relation with participants when a FMS intervention is given. Either way, lack of assessor blinding may have led to bias in the outcome of assessment results, particularly those of a subjective nature.

In the included studies there was a limited amount of information on demographic, biological, environmental, social, and psychological confounders that might have influenced the effects of the FMS interventions on young children's FMS. For example, information regarding the type and amount of leisure PA (e.g., playground activity, sport club activities, community programmes) the participants displayed before, and during, the intervention was limited. This information could be valuable for group assignment, but also for looking at confounding. Five studies reported changes in PA levels as a result of the intervention provided. One study (study 8) mentioned increased levels of moderate to vigorous PA, however this was not statistically substantiated. Once PA is objectively measured and becomes a more consistent outcome it will be possible to explore the relationship between mastery in FMS and higher levels of PA participation (Cliff et al., 2009; Graham et al., 2021; Jones et al., 2020). PA may also act as a confounder for the intervention outcome (Engel et al., 2018). One study (study 1) reported that the study population was not allowed to perform activities outside of the intervention programme. Another study (study 5) reported that during the intervention the control population was asked to refrain from any changes in their daily physical and sportive activities during the intervention. Some studies reported no changes in the daily routines of the control group. There was one study which suggested that sport club activities of participants in the control group during the summer could have influenced the results of the control group. However, none of the included studies reported to use physical activity assessment tools such as accelerometers of parental report to check for activities outside the FMS intervention. In future studies, it is recommended to assess and report potential confounders of effects on FMS.

Furthermore, no distinction is made in intervention effects between boys and girls because the included studies did not report differences between boys and girls. However, there is growing body of evidence indicating that FMS are better performed by boys than girls in manipulative skills (Bardid et al., 2016; Bolger et al., 2018). On the other hand, girls are performing better in balancing and locomotor tasks compared with boys (Iivonen & Sääkslahti, 2014). Iivonen and Sääkslahti (2014) suggested in their review that gender differences in motor skills at a young age (2–6 years) are likely to be influenced by environmental rather than biological factors. Therefore, it seems advisable when aiming at FMS improvement to strive for a multi-disciplinary approach including environmental aspects.

Recommendations

Based on this review several recommendations can be done for practitioners improving FMS at young age. First, incorporating all FMS (locomotor-, object control-, and balance skills) with a great variety of activities provided in a practice and play setting is recommended. Second, results indicate that longer interventions (6 months) divided into weekly volumes of at least three relative short sessions of 30–45⍰ training generate better results. Third, implementing a proper motor assessment is useful to objectively determine the results of the intervention.

To be able to compare interventions, future studies should provide more information on the content of the interventions. Intervention characteristics such as deliberate practice and deliberate play should be specified since this can be of influence in the outcomings of the intervention programme for young children (Pesce et al., 2016). Also, general F.I.T.T. principles should be well documented since this can give direction for setting up new interventions and to improve translation of evidence into practice. Besides the specifications of the intervention there is need for alignment on the exact goal of the intervention and the type of assessments used to measure FMS improvement on the short- and, even more important, on the long-term (Logan et al., 2018). For measuring the long-term effects, future effect studies of FMS interventions should incorporate a retention test to investigate if the results found are sustainable. Information on potential confounders is also required.

Besides the alignment between intervention goal and type of assessment there is also a need for more international agreement regarding the implementation of FMS assessment tools (Lopes et al., 2021). In 2016, Malina and colleagues stated that studies are largely based on youth in economically better-off, developed countries in the Western culture context. Reaching movement proficiency can be difficult when there is a lack of opportunities for (non-) organised play or when participating in sports is culturally less tolerated. According to Lopes et al. (2021) an international field-based assessment tool of FMS would ensure comparability between populations with respect to socio-cultural diversity.

Finally, the included high-quality studies reported training sessions for the professionals that delivered the interventions ranging from either a 1-day workshop or a series of brief workshops. It is however remarkable to notice that eight of the included studies did not report any information regarding the content of the training for the professionals. There seems to be no clear consensus about the skills and competences a professional needs to effectively improve young children's FMS levels through interventions. Most likely to have effect, and therefore recommended based on the results of this review, professionals should be trained prior, and coached during, the interventions to gain maximal intervention results.

Conclusion

Although effective FMS intervention for young children exists, results from this population should be interpreted with caution because of limited data, variance in research design, and lack of retention. Intervention elements which seem to lead to significant results are characterised by incorporating all FMS with a variety of activities provided in a combination of deliberate practice and deliberate play delivered by trained professionals.

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Appendix: Included articles

1. Aivazidis, D., Venetsanou, F., Aggeloussis, N., Gourgoulis, V., & Kambas, A. (2019). Enhancing motor competence and physical activity in kindergarten. *Journal of Physical Activity and Health, 16*(3), 184-190.
2. Bardid, F., Lenoir, M., Huyben, F., De Martelaer, K., Seghers, J., Goodway, J. D., & Deconinck, F. J. (2017). The effectiveness of a community-based fundamental motor skill intervention in children aged 3–8 years: Results of the "Multimove for kids" project. *Journal of Science and Medicine in Sport, 20*(2), 184-189.
3. Brian, A., Goodway, J. D., Logan, J. A., & Sutherland, S. (2017). SKIPing with head start teachers: Influence of T-SKIP on object-control skills. *Research Quarterly for Exercise and Sport, 88*(4), 479-491.
4. Donath, L., Faude, O., Hagmann, S., Roth, R., & Zahner, L. (2015). Fundamental movement skills in preschoolers: A randomized controlled trial targeting object control proficiency. *Child: Care, Health and Development, 41*(6), 1179-1187.
5. Engel, A., Broderick, C., van Doorn, N., Hardy, L., Ward, R., Kwai, N., & Parmenter, B. (2021). Effect of a Fundamental Motor Skills Intervention on Fundamental Motor Skill and Physical Activity in a Preschool Setting: A Cluster Randomized Controlled Trial. *Pediatric Exercise Science*, *34*(2), 57-66.
6. Foulkes, J. D., Knowles, Z., Fairclough, S. J., Stratton, G., O'Dwyer, M., Ridgers, N. D., & Foweather, L. (2017). Effect of a 6-week active play intervention on fundamental movement skill competence of preschool children: A cluster randomized controlled trial. *Perceptual and Motor Skills, 124*(2), 393-412.
7. Jones, R. A., Okely, A. D., Hinkley, T., Batterham, M., & Burke, C. (2016). Promoting gross motor skills and physical activity in childcare: A translational randomized controlled trial. *Journal of Science and Medicine in Sport, 19*(9), 744-749.
8. Jones, R. A., Riethmuller, A., Hesketh, K., Trezise, J., Batterham, M., & Okely, A. D. (2011). Promoting fundamental movement skill development and physical activity in early childhood settings: A cluster randomized controlled trial. *Pediatric Exercise Science, 23*(4), 600-615.
9. Krneta, Ž, Casals, C., Bala, G., Madić, D., Pavlović, S., & Drid, P. (2015). Can kinesiological activities change» pure «motor development in preschool children during one school year? *Collegium Antropologicum, 39*(Supplement 1), 35-40.
10. Matvienko, O., & Ahrabi-Fard, I. (2010). The effects of a 4-week after-school program on motor skills and fitness of kindergarten and first-grade students. *American Journal of Health Promotion, 24*(5), 299-303.
11. Navarro-Patón, R., Brito-Ballester, J., Villa, S. P., Anaya, V., & Mecías-Calvo, M. (2021). Changes in Motor Competence after a Brief Physical Education Intervention Program in 4 and 5-Year-Old Preschool Children. *International Journal of Environmental Research and Public Health*, *18*(9), 4988.
12. Piek, J. P., McLaren, S., Kane, R., Jensen, L., Dender, A., Roberts, C., … Straker, L. (2013). Does the animal fun program improve motor performance in children aged 4–6 years? *Human Movement Science, 32*(5), 1086-1096.
13. Robinson, L. E., Veldman, S. L., Palmer, K. K., & Okely, A. D. (2017). A ball skills intervention in preschoolers: The CHAMP randomized controlled trial. *Medicine and Science in Sports and Exercise, 49*(11), 2234-2239.
14. Ruiz-Esteban, C., Terry Andrés, J., Méndez, I., & Morales, Á. (2020). Analysis of motor intervention program on the development of gross motor skills in preschoolers. *International Journal of Environmental Research and Public Health, 17*(13), 4891.
15. Tortella, P., Haga, M., Loras, H., Sigmundsson, H., & Fumagalli, G. (2016). Motor skill development in italian pre-school children induced by structured activities in a specific playground. *PLoS One, 11*(7), e0160244.
16. Toussaint, N., Streppel, M. T., Mul, S., Fukkink, R. G., Weijs, P. J., & Janssen, M. (2020). The effects of the PLAYTOD program on children's physical activity at preschool playgrounds in a deprived urban area: A randomized controlled trial. *International Journal of Environmental Research and Public Health, 17*(1), 329.