Chapter

Motor Games for Learning Fundamental Motor Skills

Valentina Biino

Abstract

Active Initiation Guidelines recommend that children up to age 5 years engage in daily physical activity to develop basic motor skills for health-related fitness. However, many entering kindergarten today have low motor skills and many more are predicted to have lower motor coordination skills tomorrow. Recent studies suggest that children who do not adequately develop their movement skills and fitness levels in early childhood will fail to progress them later in life. This chapter presents a literature review of motor competence in young children and suggests game playing as a means for preschoolers to learn fundamental motor skills in locomotor and object control skills.

Keywords: game, children, preschoolers, fundamental motor skills, MVPA

1. Introduction

Two fundamental questions lie at the core of human motor learning: how can movement skills be learned and which movement skills need to be acquired. Humans have both the capacity for skilled movement and the ability to learn it. Without essential movement skills, we would be defenseless against the dangers around us and unable to expand the spectrum of body-mind development that communication with the surrounding environment demands [1, 2]. As we learn to move, we encounter and overcome obstacles; we climb, keep our balance, and manipulate objects while doing so, thus using every opportunity to explore more and more. Besides the need to survive, we sense a fundamental need to move. Without the ability to master basic motor skills adequately, we could not satisfy our need to move.

Stodden's conceptual model [3] explains the role of motor competence in children's willingness to move according to body weight and in reaction to perceived motor competence and health-related fitness. Later studies [4–6] provided longitudinal and experimental evidence to support this conceptual model. Children will have few opportunities to participate in physical activity, play and sports later in life if they lack the basic skills for running, jumping, kicking, catching, throwing and hitting. If, instead, they are provided with the necessary skills to participate in physical and recreational activities, they are more likely to be active throughout life.

There is a reciprocal relationship between the degree of competence in fundamental motor skills and participation in physical activity: higher levels of motor

competence correspond to higher levels of participation in physical activity and play, with a consequent increase in active lifestyles. In addition, the fundamental motor skills underlying many of the diverse activities of daily life that make survival possible are acquired during growth and into maturity. Rosengren and colleagues [7] reported that children should be assigned exercises that focus on solving a movement task potentially related to survival (e.g., walking, running, climbing, grasping), so-called motor development tasks, or exercises that require expertise (e.g., riding a bicycle, dancing, rolling an object) which, albeit less concerned with survival, are more sensitive to expertise, the so-called motor learning tasks.

Young children can improve the quality, speed, and control of fundamental motor skills (FMS) to meet demands that go far beyond mere survival. The age of onset for mature models of FMS is between 2 and 6 years [8]. The development of motor skills concerns the movements used to move the body from one place to another and those that enable throwing and catching objects [9]. The period encompassing kindergarten and first grade primary school is when FMS can be best developed and refined.

As children acquire and perfect their FMS, they build their motor competence: they experience the changes in motor behavior and the processes that underlie such changes. Using the metaphor of the "motor development mountain", Clark and Metcalfe [10] suggested that FMS act as precursors of movement skills. It follows then that to reach "the top of the mountain", children must acquire a certain level of competence in FMS in order to be able to apply these skills in the various contexts of sports and motor activities of daily life. FMS can also be compared to real "building blocks" for the construction of increasingly advanced and complex movements required for playing games and sports and/or other physical activities [11, 12].

2. What kind of physical activity supports learning motor skills?

Motor development and motor/skill learning are central to successful outcomes in multiple domains. A domain is a category within which similar skills can be grouped. A motor skill can be defined as the means to successfully accomplish the goals of a particular skill. It is primarily determined by the quality of movement and is not necessarily relevant to a specific sport. One thing common to all motor skills is that they must be learned. A person may be categorized either as unskilled or highly skilled, depending on how well the skill has been learned and practiced [13]. People are not born possessing movement skills but rather acquire them so as to adapt to the demands of their environment.

Three aspects characterize motor skills: the perceptive requirements, the muscle coordination patterns involved, and the demands imposed by the environment. Furthermore, motor skills belong not only to the motor domain but are composites of all three domains: motor, cognitive, and perceptual [14]. Motor skill development engages children's perceptual and cognitive abilities and involves their social development as well (**Figure 1**) [15].

Motor activities that include learning FMS are essential for the development of motor competence in children, as they start to coordinate the muscles of the limbs with those of the body to generate the desired movement [11]. Children need to be provided with ample opportunities for structured practice starting in early childhood to improve their motor performance skills.

Scientific research shows that motor skills interventions are effective for improving FMS and moderate to vigorous intensity physical activity (MVPA) [16, 17]. Early

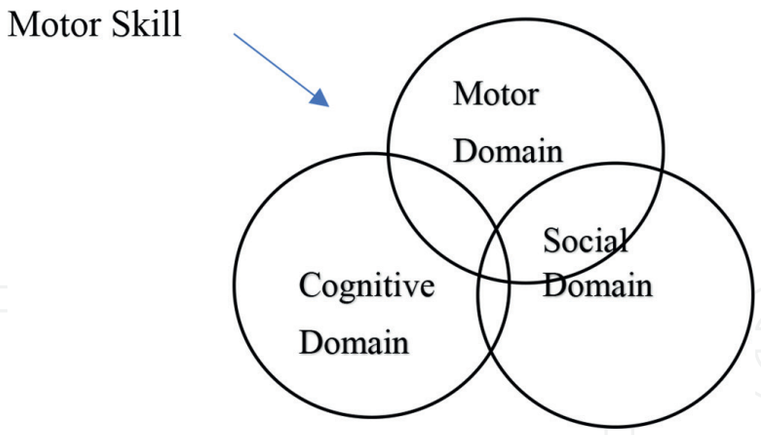

Figure 1.
Holistic approach.

childhood education centers should have planned movement programs in place as well as strategies to promote the development of motor skills in children. Implementing motor skills interventions is an effective strategy to improve FMS. Wadsworth and colleagues [18] reported that interventions based on FMS learning boosted MVPA. Girls and boys of all ages, and kindergarten schoolchildren in particular, generally preferred exercises that focus on motor skills (FMS group) learning or mixed (FMS + physical activity group) to free play and physical activity, demonstrating that interventions that combine both FMS and physical activity may reduce physical activity disparities in preschool children.

Yet, it is not sufficient to improve children's cognitive functioning by training a motor activity or practicing a game based only on promoting competence in FMS. Instead, exercise of basic motor skills needs to be expanded and progressed through fun games or goal setting strategies [19] such as "how many times can you hit the target on the wall by throwing a ball for 5 minutes'?" [20]. When considering a holistic approach to development, motor activities should challenge children's mental skills and the physical abilities needed to refine them [21]. Children enjoy themselves in a learning environment where they can explore and solve problems. Motor activities should therefore be designed to promote deliberate play [22], which refers to games and sports that are intrinsically motivating, provide immediate gratification, and maximize enjoyment [23]. However, regardless of the type of exercises practiced, children improve at problem solving when confronted with variety in the problems they encounter [21]. This is why it is important that the activities are varied in practice and continuously "destabilized" [24, 25]. Motivation to succeed in executing movement is inherent in children. It is related to what they have learned about themselves and how they perceive their abilities.

The key to successful mastering of motor skills in children is that they are taught, so it is crucial that children be provided with clearly stated instructions for learning the critical components of a movement. Teaching the key elements of movement will increase the chances of executing a movement successfully and developing that movement correctly and skillfully in the future. The bad habits that children have learned in early life will heavily influence their motor competence later on and will probably render the movement less effective and smooth [21].

Starting from an early age children should be provided with appropriately graded experiences, instruction, correction, as well as encouragement and feedback [26, 27]. Verbal encouragement provided by a competent adult motivates the child to marshal effort and stick to the task. Children learn early on the difference between enthused

encouragement that sounds authentic and believable and generic cheering with little meaning. For this reason, a physical education teacher, given his or her competence and trained eye, can more credibly provide encouragement that strongly supports children during a game.

Moreover, muscle tension, heart rate, and sweating increase during a game. Young children with limited exposure to MVPA may perceive such sensory experience as negative (fear, anxiety) or positive (novel pleasure, fun, joy). Teachers' feedback during the initial phase of teaching an exercise or a game can help the child understand and recognize the physical activation that constitutes the core of playing a game [21].

Playing games catalyzes and promotes the development and acquisition of motor skills, reduces boredom, and promotes previously learned FMS. Developing FMS improves physical literacy, increases self-confidence, and provides a more positive attitude towards exercise. The "play now or pay later" concept [28] characterizes physical activity as a means to prevent a cascade of adverse health outcomes later in life. Physical activity may be considered a primary prevention with a positive impact on promoting an active lifestyle. Physical education teachers should therefore provide meaningful opportunities for children to participate in a variety of physical activity games through programs that are developmentally appropriate, meaningful, and enjoyable [28]. Children should progress through well-known physical activity games. For example, children who play *Hide and seek, jump rope*, or play to *One, Two, Three... Star* in Italy or *One, Two, Three... Sun* in France or *One, Two, Three... Pumpkin* in Mexico and so on, learn many abilities because in this games there are locomotor skills and stability tasks such as run, jump, leap, stop and go. Children who play the various versions of *Speedy Swapper*s or try to tag and catch opponents learn how to run, to spring or to move while chasing, fleeing or dodging opponents. Looked at it this way, the motor games that children play can provide much insight into the skills they can potentially acquire. Physical growth and regular exercise have a crucial role in the ways movement patterns can change [29].

Over the years, the preconception has been dismissed that FMS are important only for participating in sports or physical activity in general and achieving the recommended dose of daily physical activity. Neuroscience has made substantial advances in linking physical activity to cognitive performance, as well as brain structure and function [30]. Throughout growth and development, close links exist between brain activity and movement [31]. Donnelly and colleagues [32] found that participation in sports and physical activity boosts mental acuity, skills and strategies that are vital for coping with life's challenges. Previous studies have shown that regular exercise alters higher brain functions, i.e., the executive system, by improving the switching from one type of task to another, regulating the updating and tracking of representative information in working memory, and inhibiting strong habitual responses [24, 25, 33]. Furthermore, studies involving preschool children have shown that those with higher proficiency in FMS and physical activity have better working memory, attention, and inhibitory control [34]. Mastering FMS is crucial for holistic development in the physical, cognitive-perceptual and relational domains [12].

Regular participation in aerobic physical activity with a good mastery of FMS can induce lasting improvement in executive functions via three pathways: the cognitive engagement required in challenging motor activities, complex coordination tasks, and the physiological changes in the brain that aerobic exercise induces [33]. In their literature review, Donnelly and colleagues [32] reported an association between physical activity, physical fitness, cognition, and academic achievement. For instance, improvement in executive function was associated with acute bouts of physical

activity and physical fitness and improvement in academic performance was associated with both acute and chronic physical activity in general [14]. In brief, providing instruction in physical education can lead to improvement in academic performance. In their review, Macdonald et al. [35] found that refinement of motor skills is positively associated with academic achievement in mathematics and reading, especially during early school years. Positive associations also emerged between academic achievement and components of gross motor competence, particularly speed and agility, upper limb coordination, and FMS proficiency levels.

Mastery of FMS is not only the starting point for any form of motor development but also for cognitive development: a real structure that progressively becomes logical, mental, thought and verbal organization. A holistic approach defines physical and mental domains not only as complementary but also as indivisible and interdependent. Children master the majority of FMS by age 6 years [36]. This skills set is a key aim in the national primary school curriculum (Department for Education. Early Years Foundation Internship Statutory Framework; Department for Education: London, UK, 2014). Despite the aim of the program and the potential for development, however, many children fail to master these skills.

Recent research [5, 22] suggests that nearly half of children leave school without having mastered the basic motor skills for successful participation in sports and physical activity. Some studies have reported a non-linear trend for motor competence across time [37, 38], with peak performance at 8–9 years of age and a plateau in locomotor skills occurring as early as 10 years Vandorpe et al., [37]. Why? What happens or what does not happen during the so-called "sampling years" [38] when children should participate in a wide range of activities centered on deliberate play for fun [23]? How is this time spent in the "hungry for skills" stage when children learn to enjoy exercising and developing movement skills?

It is far from proven that skills levels naturally reach the threshold that encourages, motivates or facilitates participation in motor games [16, 21, 39]. Stodden et al. [3] suggested that physical activity during early childhood can guide children's growth in motor competence. Children with higher levels of motor skill proficiency in FMS in middle and late childhood will more likely maintain physical activity for longer periods of time and continue to improve their motor skills. An increase in physical activity can mean more opportunities to promote motor development. From infancy onwards, depending on the level of participation in physical activity, a sort of positive spiral can be created for developing high motor competence, with more time devoted to daily physical activity to achieve higher health-related fitness levels. Chronically low motor competence levels indicate a negative attitude towards physical activity and physical fitness, with a greater predisposition to weight gain and obesity.

Furthermore, motor performance influences how a child is viewed by peers [9]. Less skilled children will generally be chosen last to join a team in group games during recess and extracurricular activities. Being chosen last or not at all can have a negative impact on a child's physical self-concept and motivation to get active and play with peers.

2.1 What are the fundamental motor skills?

Clark [10] defined FMS as the "principal patterns of coordination that underlie later movement skillfulness" (p. 251). Motor skills rely on the coordination of arms or legs and the body. Depending on speed and strength parameters, a motor skill is a learned, goal-directed activity accomplished by muscle action. This classic definition of motor skills contains the word "learned", which means that motor skills can be improved.

Three macro categories of skills are distinguished [12, 17]:

- Locomotor skills. Skills that allow you to move your body from one point in space to another using mainly the muscles of the lower limbs (e.g., walking, running, jumping, hopping, galloping).

- Interaction and object control/manipulation skills. Skills that involve a muscle sequence that allows you to interact and control/manipulate objects with your body (e.g., catching and throwing, hitting or kicking objects).

- Postural skills. Skills that stabilize certain body segments in relation to other segments, to the whole body or to external objects, while holding a body position for best executing a specific task in static and dynamic balance (**Figure 2**).

FMS are typically categorized as object control and locomotor skills [9, 32]. Some authors define balance and stability skills as the locomotor skills underlying FMS considered independently and essential for learning motor literacy [11].

Motor skills emerge and mature during preschool and primary school years. While children continue to develop these skills as they grow, focused instruction, guidance, appropriate feedback, and encouragement are essential for the acquisition of motor skills [22]. Young children in particular need to learn how to execute and correct their movements so that they can progress in developing their skills.

And in order for that to happen, teachers should illustrate the technique and state clearly how to execute a movement from the start. They should express themselves using a vocabulary shared with the children so that the technique can be described and memorized. For example, effective instruction on the execution of skipping could be given as follows:

- "*Now take a step forward and hop on the spot with the same leg, then take a step with the other leg and hop. And so on: step and hop on one leg, step and hop on the other leg*".

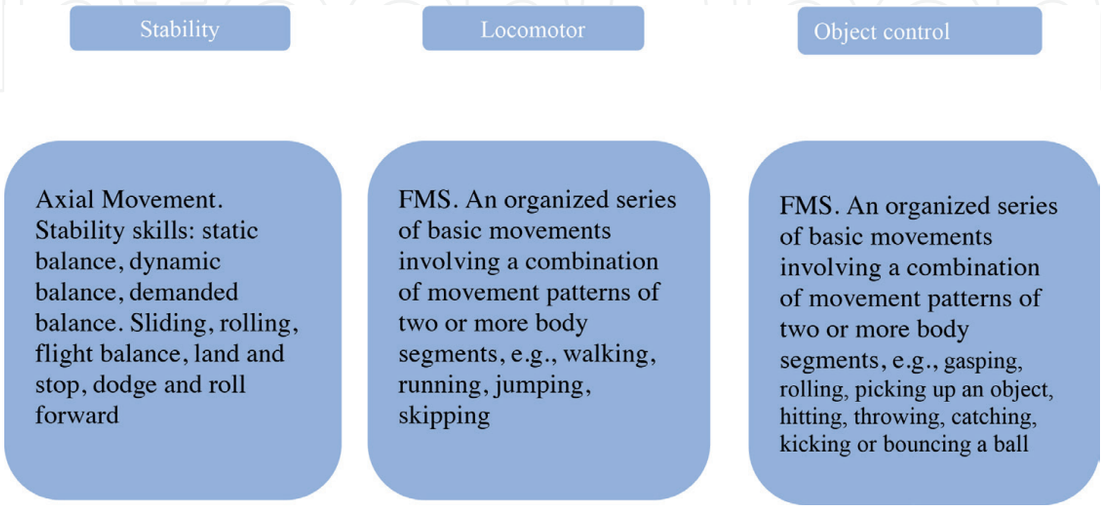

Figure 2.
Fundamental motor skills scheme.

Given that instructions can also be given during the execution of a movement, the teacher will need to keep explanation to a minimum and simplify it with keywords that accompany the movement rhythmically:

- *step-hop/step-hop*

In brief: step and hop on the same foot while moving the arms in opposition. After stepping, both feet are temporarily off the ground. The body moves forward in a rhythmic motion.

Since teaching and assessment are inseparable, the level of FMS learning is monitored to inform exercise programming. Well designed assessments are not perceived as tests but rather as part of progression through a program. As FMS emerge and mature between age 3 and 10 years, they are categorized as locomotor skills, among which gross motor skills require smooth, coordinated movements of the body in space. For example:

- *running.* The ability to advance steadily with springing steps so that both feet leave the ground for an instant with each stride.
- *galloping*. The ability to maintain a fast, natural, three-beat gait.
- *hopping.* The ability to hop a minimum distance on the preferred foot.
- *skipping.* The ability to skip in continuous, rhymical, alternating steps.
- *horizontal jumping.* The ability to take a horizontal jump from a standing position.
- *sliding*. The ability to slide sideways in a straight line from one point to another.

FMS include common ball handling skills:

- *Two-hand strike of a stationary ball. S*trike a stationary ball with a plastic bat.
- *One-hand forehand strike while-bouncing a ball.* Strike a bouncing ball with a plastic paddle.
- *Two-hand catch*. Catch a ball that has been thrown underhand.
- *Kick a stationary ball.* Kick a stationary ball with the preferred foot.
- *Overhand throw.* Throw a ball with the preferred hand while aiming at a point on a wall.
- *Underhand throw.* Throw a ball with the preferred hand while aiming at a point on a wall [9].

3. Relation between fundamental motor skill and cardiorespiratory fitness

Many studies suggests that motor competence (MC) and cardiorespiratory fitness (CRF) have declined in children and adolescences [38, 40–42]. This fact has made

the current generation less able and fit to participate in various physical and daily life activities than previous generations. These changes in MC, CRF and Physical activity in children and adolescences have been suggested to lead to a negative circle leading to an increase risk overweight and obesity [43, 44]. MC is widely recognized as an important correlate of physical activity (PA), weight status and of a psychological and social physical benefits. It is understood that MC is a precursor to PA as learning to move is necessary for participation in PA [3]. The development of MC that includes FMS begins at birth through the acquisition of locomotor, object manipulation and stability skills, before becoming a central pillar of lifetime education. Mastery of FMS influences children's BMI and time spent sedentary already at preschool age [45]. Wadsworth et al. [18] showed that FMS learning focus even improves MVPA in younger boys and girls.

While a longitudinal study [46] has explained that a greater lean body mass could be associated to more suitable Gross Motor Coordination levels.

The question that arises is understandable: do the decline in MC and CRF levels could depend on the percentage of fat mass in children and adolescences?

Several allometric approaches [43, 46] have shown that MC is an important determinant of body composition; many batteries test used to assess MC are highly dependent on fat mass, as well as CRF scaled by BMI it depends on adiposity. But there is a positive association between MC and CRF as a function of the percentage of fat mass? The results of the Haapala study et al. [43], showed that children with poor MC levels had low CRF levels scaled by BMI, and fat mass is included in BMI; instead children with lower and higher levels of MC had similar CFF levels, scalded by lean mass. Therefore the association between MC and fat mass, in this case, is not depended on CRF.

In the educational context this evidence opens the possibility of not precluding coordination or VPA aerobic activities The aerobic exercise when it consist of running and jumping games of the rope, basketball and football modified to one heart rate was set at an average above 150 beats per minute, can represent an effective means of jointly achieving good levels of both MC and CRF.

Cardiovascular fitness, resistance, strength and flexibility are essential in developmental age as in all ages [28, 46]. Advances in studies on the cardiovascular system have made it clear how children respond and adapt to aerobic training. Today, pediatricians and educators, while continuing to be wary towards physical stress and effort in children, prescribe moderate to vigorous intensity physical activity (Moderate – to – Vigorous Physical Activity, MVPA). However, children are not little adults and cannot enjoy the same exercise routine as adults. The activity patterns of children differ greatly from those adults [21]. This is to be kept in mind in sports and school settings as appropriate or inappropriate programs can influence children's motivation to be active. To train physical efficiency in children, the scientific community suggests systematically encouraging fundamental motor skills in a playful and cooperative way. Physical activity games represent a suitable and effective means of developing coordination and physical fitness in children.

FMS need to be learned, practiced, and reinforced [47]. Improvement in motor proficiency have been attributed to FMS applied to a variety of games and sports. For example, you need to be able to run, jump, pitch and hit a ball in order to play baseball.

Unfortunately, children are sometimes more motivated by what they are capable of doing than by learning how to do a skill correctly. Prekindergarten children can hit, roll or kick a ball even when the move is made with the wrong step. Without correction, a poor motor pattern becomes a habit that is very difficult to unlearn [48]. It should be

Figure 3.
Morra game.

remembered therefore that the constructs of motor enjoyment and self-efficacy are essential precursors of long-term engagement in play and physical activity. If children know how to do things correctly, they feel better about themselves and make progress. To foster this sense of satisfaction, the correct execution of FMS must be clearly illustrated as needed while playing a game. In this way, the game situation allows for introducing increasingly complex coordination tasks. Modifying game rules to challenge children cognitively can be a daunting and demanding task, even for the most experienced teacher. This is illustrated in three modified traditional games to which a specific locomotor element is added (**Figure 3**).

The Week

A grid of small and large rectangles is drawn with chalk on the ground.

The children jump and hop in the grid or a mix inside the rectangles, depending on size or distance.

One, Two, Three…Skip

Players spread out in scatter formation. They choose one of the locomotor skills; keeping it in mind, they stand still like statue in the starting position of that locomotor skill. When the game leader calls the players, must move and perform that locomotor skill correctly.

Paper, Rock…Six

Players challenge each other in pairs in a game of *Morra*, a traditional game that trains the ability to calculate while calling out the number of the players' fingers shown in a flat hand. The player that manages to count first, grabs a handkerchief and runs away, and the other tries to catch it.

4. Conclusion

Motivating kindergarten and primary school children to engage in motor activity can be quite easy. For small children, any call to move is perceived as an invitation to play. Whether making a basket, jumping rope or knocking down cones, just doing it can be a remarkable new discovery. However, once children discover they can hit a target, score a basket or kick a ball, it's hard to get them to go back and work on the critical elements of those skills.

What is important is to remember that FMS incorporate not only the actual competence to perform physical skills but also the psychological and behavioral skills that enable engagement in physical activity. Quality early physical experiences, appropriately graded, can ensure optimal development of FMS so that children can refine their actual and perceived skills. In light of the above, the syllabus of physical activity programs needs to be examined as regards quality physical education and early childhood sports instruction to ensure can be fully developed in pre- and school-age segments of the population.

Conflict of interest

The author declare no conflict of interest.

Author details

Valentina Biino
University of Verona, Italy

*Address all correspondence to: valentina.biino@univr.it

References

[1] National Association for Sport and Physical Education. Active Start: A Statement of Physical Activity Guidelines for Children Birth to Five Years. 2nd ed. Oxon Hill, MD: AAHPERD; 2009

[2] Bernstein NA. On dexterity and its development. In: Latash ML, Turvey MT. Dexterity and Its Development, translated by Latash ML. London, New York: Routledge Taylor and Francis Group; 1996

[3] Stodden DF, Langendorfer SJ, Goodway JD, Roberton MA, Rudisill ME, GarciaC, et al. A developmental perspective on the role of motor skill competence in physical activity: An emergent relationship. Quest. 2008;**60**(2):290-306. DOI: 10.1080/00336297.2008.10483582

[4] Battaglia G, Giustino V, Tabacchi G, Lanza M, Schena F, Biino V, et al. Interrelationship between age, gender, and weight status on motor coordination in Italian children and early adolescents aged 6-13 years old. Frontiers in Pediatrics. 2021;**9**(September):1-10. DOI: 10.3389/fped.2021.738294

[5] Barnett LM, Webster EK, Hulteen RM, De Meester A, Valentini NC, Lenoir M, et al. Through the looking glass: A systematic review of longitudinal evidence, providing new insight for motor competence and health. Sports medicine (Auckland, N.Z.). 2022;**52**(4):875-920. DOI: 10.1007/s40279-021-01516-8

[6] Gallotta MC, Zimatore G, Falcioni L, Migliaccio S, Lanza M, Schena F, et al. Influence of geographical area and living setting on Children's weight status, motor coordination, and physical activity. Frontiers in Pediatrics. 2022;**9**:794284. DOI: 10.3389/fped.2021.794284

[7] Rosengren KS, Geert JP, Savelsbergh GJ. Development and learning: ATASC-based perspective of the acquisition of perceptual-motor behaviors. Infant Behavior and Development. 2003;**26**:473-494. DOI: 10.1016/j.infbeh.2003.08.001

[8] Gallahue D, Cleland-Donnelly F. Developmental Physical Education for all Children. 4th ed. Champaign, IL: Human Kinetics; 2007

[9] Dale U. Evaluation of the psychometric properties of the TGMD-3. Journal of Motor Learning and Development. 2019;**5**(1):4

[10] Clark JE, Metcalfe JS. The mountain of motor development: A metaphor. In: Clark JE, Humphrey J, editors. motor development: Research and reviews. Vol. Vol. 2. Reston, VA: NASPE Publications; 2002. pp. 163-190

[11] Logan SW, Ross SM, Chee K, Stodden DF, Robinson LE. Fundamental motor skills: A systematic review of terminology. Journal of Sports Sciences. 2018;**36**(7):781-796. DOI: 10.1080/02640414.2017.1340660

[12] Bolger LE, Bolger LA, O'Neill C, Coughlan E, O'Brien W, Lacey S, et al. Global levels of fundamental motor skills in children: A systematic review. Journal of Sports Sciences. 2021;**39**(7):717-753. DOI: 10.1080/02640414.2020.1841405

[13] Ericsson KA. The Road to Excellence: The Acquisition of Expert Performance in the Arts and Sciences, Sports, and Games. Mahwah, NJ: Lawrence Erlbaum; 1996

[14] Biino V, Bertinato L, Rossini P, Giuriato M. Influence of highly

motivational games on the executive function in adolescence. Journal of Physical Education and Sport. 2020;**20**((3)):1386-1391. DOI: 10.7752/jpes.2020.03191

[15] Edwards WH. Motor Learning and Control: From Theory to Practice. Wadsworth Cengage Learning; 2010, California State University, Sacramento. Copyright 2010 Cengage Learning, Inc. All Rights Reserved. Library of Congress Control Number: 2010922549, ISBN-13: 978-0-495-01080-7, ISBN-10: 0-495-01080-4Wadsworth, 20 Davis Drive Belmont, CA 94002-3098 USA

[16] Logan SW, Robinson LE, Wilson AE, Lucas WA. Getting the fundamentals of movement: A meta-analysis of the effectiveness of motor skill interventions in children. Child: Care, Health and Development. 2012;**38**(3):305-315. DOI: 10.1111/j.1365-2214.2011.01307.x

[17] Webster EK, Martin CK, Staiano AE. Fundamental motor skills, screen-time, and physical activity in preschoolers. Journal of Sport and Health Science. 2019;**8**(2):114-121. DOI: 10.1016/j.jshs.2018.11.006

[18] Wadsworth DD, Johnson JL, Carroll AV, Pangelinan MM, Rudisill ME, Sassi J. Intervention strategies to elicit MVPA in Preschoolers during outdoor play. International Journal of Environmental Research and Public Health. 2020;**17**(2):650. DOI: 10.3390/ijerph17020650

[19] Lee J, Zhang T, Chu T, Gu X, Zhu P. Effects of a fundamental motor skill-based afterschool program on Children's physical and cognitive health outcomes. International Journal of Environmental Research and Public Health. 2020;**17**(3):733. DOI: 10.3390/ijerph17030733

[20] Tomporowsky P, McCullik B, Pesce C. Enhancing Children's Cognition with Physical Activity Games. Human Kinetics Publishers; 2015, Printed in the United State of America. United States: Human Kinetics, P.O. Box 5076, Champaign, IL 61825-5076 800-747-4457

[21] MacNamara Á, Collins D, Giblin S. Just let them play? Deliberate preparation As the Most appropriate Foundation for Lifelong Physical Activity. Frontiers in Psychology. 2015;**6**:1548. DOI: 10.3389/fpsyg.2015.01548

[22] Côté J, Baker J, Abernethy B. Play and practice in the development of sport expertise. In: Tenenbaum G, Eklund RC, editors. Handbook of Sport Psychology. Hoboken, NJ: John Wiley & Sons; 2007. pp. 184-202

[23] Pesce C, Croce R, Ben-Soussan TD, Vazou S, McCullick B, Tomporowski PD, et al. Variability of practice as an Interface between motor and cognitive development. International Journal of Sport and Exercise Psychology. 2019;**17**(2):133-152. DOI: 10.1080/1612197X.2016.1223421

[24] Biino V, Tinagli V, Borioni F, Pesce C. Cognitively enriched physical activity may foster motor competence and executive function as early as preschool age: A pilot trial. Physical Education and Sport Pedagogy. 2021. pp. 2-19. DOI: 10.1080/17408989.2021.1990249

[25] Altunsoz IH, Goodway JD. SKIPing to motor competence: The influence of project successful kinesthetic instruction for preschoolers on motor competence of disadvantaged preschoolers. Physical Education and Sport Pedagogy. 2016. pp. 3-17. DOI: 10.1080/17408989.2015.1017453

[26] Brian AS, Goodway JD, Sutherland SL. Training teachers to SKIP:

A motor skill intervention pilot study. Research Quarterly for Exercise and Sport. 2014;**85**(S1):A42

[27] Faigenbaum AD, Myer GD. Exercise deficit disorder in youth: Play now or pay later. Current Sports Medicine Reports. 2012;**11**:196-200. DOI: 10.1249/JSR.0b013e31825da961

[28] Griffiths A, Toovey R, Morgan PE, Spittle AJ. Psychometric properties of gross motor assessment tools for children: A systematic review. BMJ Open. 2018;**8**:e021734. DOI: 10.1136/bmjopen-2018-021734

[29] Diamond A. Executive Functions. Annual Review of Psychology. 2013;**64**:135-168. DOI: 10.1146/annurev-psych-113011-143750

[30] Galdi M, D'Anna C, Pastena N, Paloma FG. Gross-motor skills for potential intelligence descriptive study in a kindergarten. Procedia - Social and Behavioral Sciences. 2015;**174**(February):3797-3804. DOI: 10.1016/j.sbspro.2015.01.1115

[31] Donnelly JE, Ed D, Co-chair F, Hillman CH, Co-chair PD, Ph D, et al. Physical activity, fitness, cognitive function, and academic achievement in children: A systematic review. In Medicine and Science in Sports and Exercise. 2017;**48**(6):1-36. DOI: 10.1249/MSS.0000000000000901.Physical

[32] Best JR. Effects of physical activity on children's executive function: Contributions of experimental research on aerobic exercise. Developmental Review. 2010;**30**:331-351. DOI: 10.1016/j.dr.2010.08.001

[33] Malambo C, Nová A, Clark C, Musálek M. Associations between fundamental movement skills, physical fitness, motor competency, physical activity, and executive functions in preschool age children: A systematic review. Children. 2022;**9**(7):1-14. DOI: 10.3390/children9071059

[34] Macdonald K, Milne N, Orr R, Pope R. Relationships between motor proficiency and academic performance in mathematics and reading in school-aged children and adolescents: A systematic review. International Journal of Environmental Research and Public Health. 2018;**15**(8):1-23. DOI: 10.3390/ijerph15081603

[35] Eyre ELJ, Walker LJ, Duncan MJ. Fundamental movement skills of children living in England: The role of ethnicity and native English language. Perceptual and Motor Skills. 2018;**125**(1):5-20. DOI: 10.1177/0031512517745437

[36] Vandorpe B, Vandendriessche J, Lefevre J, Pion J, Vaeyens R, Matthys S, et al. The KörperkoordinationsTest für kinder: Reference values and suit ability for 6-12-year-old children in Flanders. Scandinavian Journal of Medicine & Science in Sports. 2011;**21**(3):378-388. DOI: 10.1111/j.1600-0838.2009.01067

[37] Giuriato M, Biino V, Bellafiore M, Battaglia G, Palma A, Baldari C, et al. Gross motor coordination: We have a problem! A study with the Körperkoordinations test für kinder in youth (6-13 years). Frontiers in Pediatrics. 2021;**9**(December):1-12. DOI: 10.3389/fped.2021.785990

[38] Kirk D. Physical education, youth sport and lifelong participation: The importanceof early learning experiences. European Physical Education Review. 2005;**11**:239-255. DOI: 10.1177/1356336X05056649

[39] Vandoni M, Carnevale Pellino V, Gatti A, Lucini D, Mannarino S, Larizza C, et al. Effects of

an online supervised exercise training in children with obesity during the COVID-19 pandemic. International Journal of Environmental Research and Public Health. 2022;**19**(15):9421. DOI: 10.3390/ijerph19159421

[40] Sember V, Đurić S, Starc G, Leskošek B, Sorić M, Kovač M, et al. Secular trends in skill-related physical fitness among Slovenian children and adolescents from 1983 to 2014. Scandinavian Journal of Medicine & Science in Sports. 2023. pp. 1-12. DOI: 10.1111/sms.14456

[41] Fühner T, Kliegl R, Arntz F, Kriemler S, Granacher U. An update on secular trends in physical fitness of children and adolescents from 1972 to 2015: A systematic review. Sports medicine (Auckland, N.Z.). 2021;**51**(2):303-320. DOI: 10.1007/s40279-020-01373-x

[42] Haapala EA, Gao Y, Lintu N, Väistö J, Vanhala A, Tompuri T, et al. Associations between cardiorespiratory fitness, motor competence, and adiposity in children. Translational Sports Medicine. 2021;**4**(1):56-64. DOI: 10.1002/tsm2.198 http://hdl.handle.net/10138/334831

[43] Lima RA, Pfeiffer KA, Bugge A, Møller NC, Andersen LB, Stodden DF. Motor competence and cardiorespiratory fitness have greater influence on body fatness than physical activity across time. Scandinavian Journal of Medicine & Science in Sports. 2017;**27**(12):1638-1647. DOI: 10.1111/sms.12850

[44] Duncan MJ, Hall C, Eyre E, Barnett LM, James RS. Pre-schoolers fundamental movement skills predict BMI, physical activity, and sedentary behavior: A longitudinal study. Scandinavian Journal of Medicine & Science in Sports. 2021;**31**(Suppl. 1):8-14. DOI: 10.1111/sms.13746

[45] Giuriato M, Lovecchio N, Carnevale Pellino V, Mieszkowski J, Kawczyński A, Nevill A, et al. Gross motor coordination and their relationship with body mass and physical activity level during growth in children aged 8-11 years old: A longitudinal and allometric approach. PeerJ. 2022;**10**:e13483. DOI: 10.7717/peerj.13483

[46] World Health Organization. Global Action Plan on Physical Activity 2018-2030: More Active People for a Healthier World. Geneva: World Health Organization; 2018

[47] Brian A, Goodway JD, Logan JA, Sutherland S. SKIPing with teachers: An early years motor skill intervention. Physical Education and Sport Pedagogy. 2017;**22**(3):270-282. DOI: 10.1080/17408989.2016.1176133

[48] Colvin AV, Markos NJ, Walker PJ. Teaching Fundamental Motor Skills. 3rd ed. IL, USA: Human Kinetict; 2023