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CURRENT OPINION

Development of Foundational Movement Skills: A Conceptual Model for Physical Activity Across the Lifespan

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Abstract Evidence supports a positive association between competence in fundamental movement skills (e.g., kicking, jumping) and physical activity in young people. Whilst important, fundamental movement skills do not reflect the broad diversity of skills utilized in physical activity pursuits across the lifespan. Debate surrounds the question of what are the most salient skills to be learned which facilitate physical activity participation across the lifespan. In this paper, it is proposed that the term 'fundamental movement skills' be replaced with 'foundational movement skills'. The term 'foundational movement skills' better reflects the broad range of movement forms that increase in complexity and specificity and can be applied in a variety of settings. Thus, 'foundational movement skills' includes both traditionally conceptualized 'fundamental' movement skills and other skills (e.g., bodyweight squat, cycling, swimming strokes) that support physical activity engagement across the lifespan. A proposed conceptual model outlines how foundational movement skill competency can provide a direct or indirect pathway, via specialized movement skills, to a lifetime of physical activity. Foundational movement skill development is hypothesized to vary according to culture and/or geographical location. Further, skill development may be hindered or enhanced by physical (i.e., fitness, weight status) and psychological (i.e., perceived competence, self-efficacy) attributes. This conceptual model may advance the application of motor development principles within the public health domain. Additionally, it promotes the continued development of human movement in the context of how it leads to skillful performance and how movement skill development supports and maintains a lifetime of physical activity engagement.

Key Points

Replacing the term 'fundamental movement skills' with 'foundational movement skills' underpins a significant conceptual adaptation to broaden the scope of skills considered important for promoting physical activity and other positive trajectories of health across the lifespan. Examples include resistance training movements, swimming strokes, and riding a bicycle.

Foundational movement skills are defined as goal-directed movement patterns that directly and indirectly impact an individual's capability to be physically active and that can continue to be developed to enhance physical activity participation and promote health across the lifespan.

The proposed conceptual model helps examine the potential lifespan contribution between movement skill development and physical health.

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1 Introduction

Participation in physical activity is associated with an extensive range of health benefits, including increased cardiovascular fitness, increased bone strength, lower levels of body fat and improved cognitive and mental health [1–5]. Despite these benefits, most children and adolescents worldwide fail to meet physical activity recommendations [5–8].

1.1 Importance of Motor Competence

Developing appropriate levels of motor competence (i.e., degree to which an individual can perform goal-directed human movement) [9] may be a critical antecedent for promoting physical activity and other positive health trajectories across the lifespan [9, 10]. Reviews and longitudinal studies have noted evidence for the positive association between motor competence and physical activity [11–15], health-related fitness [16, 17], perceived competence [11], and weight status (inverse) [11, 18, 19]. Thus, the preponderance of evidence indicates numerous health benefits when increasing motor competence among young people.

Various measures of gross motor skills have been used for decades. Their use accelerated when research examined the importance of motor development for various aspects of health [20]. In children and adolescents, this research has focused primarily on 'traditional' fundamental movement skills [21]. These 'building blocks' for more developmentally advanced movement forms are commonly divided into categories including locomotor (e.g., running, hopping), object control (e.g., catching, kicking), and stability (e.g., balance, body roll) skills [22]. Failure to develop competency in fundamental movement skills will make learning more advanced/specialized forms of these skills more difficult [23].

With few exceptions [24, 25], research on movement skills/performance in older adults has focused on assessing 'functional capacity' (e.g., walking, supine-to-stand, timed up and go). Similarities in describing human movement, yet with different age-related terminology, demonstrates that the development of movement skills is a lifespan journey [26]. As individuals age, various factors (e.g., injury, loss of mobility/flexibility) emerge as substantive barriers to physical activity participation. While limited data has compared skill competency from childhood into adulthood [27–30], data on functional capacity in older adults highlights the importance of maintaining adequate levels of motor competence to support functional independence later in life (i.e., ability to ambulate) [31] and reduce the risk of all-cause mortality [32, 33]. Therefore, understanding movement skills that may be performed across the lifespan are important so that skill development in youth may be related to general health and quality of life into our elderly years.

1.2 Models and Metaphors of Motor Development

Seefeldt originally presented a model depicting the progression of movement skills across developmental time [34], which has been further developed and promoted by Gallahue and colleagues' Hourglass of Motor Development [22] and Clark and Metcalfe's metaphor of the Mountain of Motor Development [23]. All three of these contributions were based on the general presumption that reflexes and/or rudimentary movements provide a neurological basis for the development of movement skills [22, 23, 34]. The importance of the 'fundamental movement skills' phase is highlighted as a time to create a broad base of skill competencies and promote the greatest potential for skill transfer. Those with a stronger base will have a greater repertoire of skills to apply to a greater variety of physical activities [35]. As individuals learn more advanced or 'transitional skills,' the levels of competency needed are higher due to additional constraints and demands of specific activities [36]. Transitioning to the most advanced levels of movement skill development demonstrates the cumulative and sequential nature of skill development across time [22, 23, 34]. Thus, these novel contributions have stimulated discussion about which skills should be taught to individuals of different developmental levels.

Developing a wide variety of movement skill competencies has been proposed by numerous authors [22, 23, 34]. Indeed, sampling for skill development is reinforced by the Mountain of Motor Development [23], Developmental Model of Sport Participation [37, 38], the Stodden et al., conceptual model [9, 10], and the Long-Term Athlete Development model [39]. Potential consequences of early specialization include greater risk of acute and overuse injuries, burn out, decreased motivation, and limited long-term physical activity participation due to a limited movement skill set [40–42].

Stodden and colleagues created a conceptual framework, which accounted for the potential recursive effects between the development of motor competence and participation in physical activity [10]. This relationship was hypothesized to be mediated by perceived competence and health-related fitness [10]. Reviews have provided cross-sectional and longitudinal support for this framework spanning from childhood to young adulthood [9, 11, 13, 15, 16, 43, 44].

These models and metaphors have provided an important context related to the progression of skill development and/or how skill development is related to physical activity

participation and positive trajectories of health. Similarly, Burton and Miller's taxonomy of skills has provided classifications for the variety of skills that can be assessed [45]. To advance the application of motor development principles within the public health domain, it is important to examine the potential lifespan development of motor competence to various aspects of physical health. Therefore, a critical question to be asked is *what types of movement patterns would be most beneficial to develop to facilitate participation in physical activity across the lifespan?*

2 The Lifelong Physical Activity Model

Our proposed conceptual model (Fig. 1) illustrates the development of movement skills from reflexive movements to specialized movement skills. We acknowledge that previous models, metaphors, and taxonomies have contributed towards the current model (denoted by black arrows) [9, 10, 22, 23, 45]. However, our model extends previous motor development work by (1) broadening the classification of movement skills important for physical activity participation, referred to as 'foundational movement skills' (see Table 1), (2) recognizing the potential cultural and geographic specificity of movement skills, and (3) acknowledging attributes such as health-related fitness, weight status, and psychological constructs (perceived competence and self-efficacy) which affect lifespan movement skill development. These aspects of the proposed model are signified by white arrows and dotted boxes.

2.1 Reflexes and Rudimentary Movements

Reflexes and rudimentary goal-directed movements are important for providing the basis for further development of more complex movement skills. Briefly, reflexes are innate to children upon birth (e.g., the Moro reflex where a child stretches out arms in response to being startled) as a means of survival and learning information about their environment. As one develops physically, these reflexes disappear and rudimentary, volitional movements (e.g., reaching, grasping) emerge. From these movements, more advanced movement patterns develop in response to individuals being able to explore their environment more effectively (i.e., locomotion). However, this progression of development is not a focus of this paper as these stages are addressed more comprehensively elsewhere [22, 23, 46].

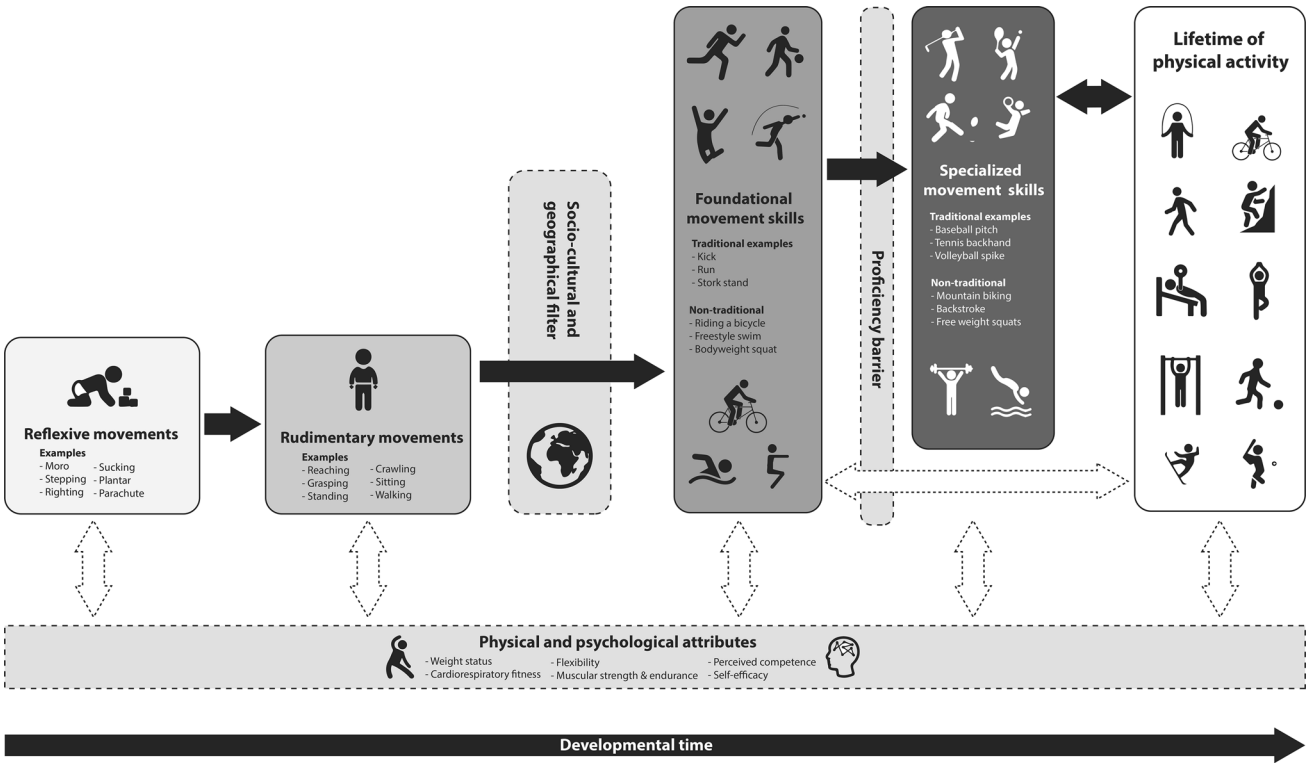

Fig. 1 Development of foundational movement skills for physical activity across the lifespan. *Black arrows* indicate previously hypothesized pathways; *white arrows* and *dotted boxes* indicate newly hypothesized pathways/components unique to this conceptual model

Table 1 Extended list of foundational movement skill examples

Foundational movement skill examples
Bouncing/dribbling a ball
Catching a ball
Cycling[a]
Freestyle swimming stroke[a]
Galloping
Hopping
Horizontal jumping
Kicking
Leaping
Lunge[a]
One-handed strike
Overhand throw
Overhead press[a]
Push-up[a]
Running
Rolling a ball
Scootering[a]
Skipping
Sliding
Squat[a]
Treading water[a]
Two-handed strike
Underhand throw

List is not all-inclusive

[a]Skills not previously classified as 'fundamental'

2.2 Foundational Movement Skills

Research related to fundamental movement skills has been and continues to be an important research focus [21]. A more contemporary view is that the term 'fundamental' is too narrow and does not encapsulate the full range of skills that may promote continued physical activity participation across the lifespan. Skills involved in activities such as resistance training, swimming, or cycling, require competency in specific coordinative movement patterns (e.g., swimming strokes, bodyweight squat, push-up) that do not easily fit into the traditional classifications of fundamental movement skills (i.e., locomotor, object control, stability skills) and therefore have not been widely addressed in the literature base [47]. We suggest that the term 'foundational movement skills' better reflects the wide variety of skills an individual should develop competency in. Foundational movement skills are defined as goal-directed movement patterns that directly and indirectly impact an individual's capability to be physically active and can be developed to enhance physical activity participation and promote health across the lifespan. The term 'foundational movement skills' and the adaptations of our proposed model promote the notion that there is no pre-determined set of 'foundational' movement skills. This allows for greater flexibility to consider other types of skills. Therefore, foundational movement skills are proposed to encapsulate both traditionally noted 'fundamental' movement skills, as well as other movement skills important for physical activity across the lifespan.

There are potential implications for future physical activity participation resulting from changing the term 'fundamental' to 'foundational'. When something is 'fundamental', that means it is of, or relating to, *necessary* structure or function. Thus, the capability to competently kick, catch, run, or jump can be implied to mean *necessary* for physical activity participation. While developing competency in these skills certainly would facilitate physical activity participation, a lack of competency in one skill (e.g., kicking) doesn't necessarily result in inactivity. Rather, that individual may have fewer physical activity options compared with someone who demonstrates competency in that particular skill. Meanwhile, 'foundational' refers to 'an underlying base or support'. Thus, the development of foundational movement skill competency will, just as motor development models show, *support* and maximize opportunities for participation in physical activity.

Foundational skills that do not fit within the traditional definitions of 'fundamental' skills include riding a bicycle, aquatic skills, and resistance training skills (e.g., squat, push-up, lunge). Consistent with the study of motor development, foundational skills can be advanced or adapted to more context-specific applications across the lifespan. For example, developing the skill of riding a bicycle would allow for the application of that skill in other contexts (e.g., mountain biking, bicycle motocross or road riding). This could similarly be done with resistance training skills, such as the squat, lunge or shoulder press (e.g., bilateral or unilateral, machines or free weights) to promote increased strength and physical function.

Another unique aspect of this model is the pathway from foundational movement skills to a lifetime of physical activity. In essence, some skills may not need to be further developed to be used in physical activity pursuits. This bidirectional arrow is based on hypotheses made by Stodden and colleagues [10], such that in early childhood, physical activity promotes movement competency and that, as an individual develops, the antecedent/consequent nature of this relationship may change.

2.3 Socio-Cultural and Geographical Filter

The cultural or geographic relevance of movement skills has been questioned previously [21]. Evidence indicates that participation in specific leisure-time physical activities differs according to age (i.e., childhood, adolescence, adulthood) and/or geographic region [48]. Therefore, we suggest foundational movement skills should be viewed through a 'socio-cultural and geographical' filter. Thus, geographic location may, in part, determine which relevant foundational movement skills to develop. For example, learning various swimming skills would allow an individual to participate in many water-based activities (e.g., surfing, paddle boarding). The perceived importance of learning these skills may be greater in a society or culture where there is warmer weather, as well as access to a pool or bodies of water (e.g., lake, ocean). We acknowledge that socio-cultural and geographic constraints influence the timing and onset of rudimentary movements. However, our socio-cultural and geographical filter is not concerned with the timing of onset of skills. Rather, the filter is concerned with the exposure of individuals to skills and the importance placed on learning a specific skill in different cultures.

2.4 Proficiency Barrier

Competence in foundational movement skills is also hypothesized to develop into more specialized/context-specific forms to be used in a variety of physical activities. However, a proficiency barrier still exists in our conceptual model. Although first hypothesized over three decades ago [34], evidence to support the existence of such a barrier is limited to two studies. A study from the US in a sample of 325 children (Mean age = 9.5 years) reported nearly 90% of individuals with 'average' or 'below average' skill levels also failed to meet physical activity guidelines [49]. A second study in 187 young adults (18–25 years) reported that only 3.1% of participants with low skill levels (i.e., throw, kick, jump) demonstrated 'good' composite fitness levels [50]. In the context of our model, individuals who do not develop sufficient competence in foundational movement skills will have greater difficulty developing and maintaining health-enhancing physical activity habits across the lifespan.

2.5 Modifiable Factors

Apart from the promotion of foundational skills from a physical development perspective, the parallel and synergistic development of physical (i.e., health-related fitness, weight status) and psychological (i.e., perceived competence, self-efficacy) attributes play a critical role in the continued development of movement skills across the lifespan.

Health-related fitness has been hypothesized as a mediator of the relationship between physical activity and motor competence [10]. Two recent reviews provide support for the positive association between motor competence and aspects of health-related fitness including cardiorespiratory fitness and musculoskeletal fitness [16, 51]. Both cardiorespiratory fitness ($r = 0.32$ to 0.57) and muscular strength/endurance ($r = 0.27$ to 0.68) are consistently linked to various aspects of motor competence [16]. The positive association between motor competence and health-related fitness also has been noted in adults (18–60 years) [24, 50]. Thus, high or low levels of health-related fitness may either enhance or diminish the time spent in and intensity levels of physical activity [24].

Similarly, weight status trajectory has been hypothesized as both an outcome and a contributor to an individual's level of motor competence [9, 10]. Reviews on the relationship between weight status and motor competence show that there is an inverse relationship. Thus, individuals with an unhealthy weight status tend to have poorer motor competence than their healthy weight peers [9, 11, 16, 44]. A recent review reported that 27 out of 33 studies in youth populations noted an inverse association ($r = -0.16$ to -0.54) between weight status and motor competence [16]. Further, in a cross-sectional sample of 188 young adults, moderate to high correlations ($r = -0.56$ to -0.73) were found between performance in throwing, kicking, and jumping and body composition [52]. Increased fat mass may change the way demands of each movement are met (e.g., force production needed, segmental movement) [16]. Essentially, more inefficient movement forms are used compared with healthy weight peers. As a result, successful completion of movement skills may be more difficult. Overweight and obese individuals tend to have poorer fitness, which in conjunction with low motor competence has shown to lead to lower motivation and opportunities for physical activity [18, 19, 53, 54].

As noted by Stodden et al. [10], a number of psychological models [55–61] have promoted the importance of 'competence'. However, these models speak to how perceptions of competence affect persistence in physical activity participation, as opposed to addressing how perceptions drive the development of actual motor competence. A significant contribution of Stodden and colleagues' model was the notion that inflated perceptions of competence in early childhood may, in part, positively drive the development of actual motor competence [10]. Yet, actual competence may effectively drive continued development of skill later in childhood (via more accurate perceptions of competence) [10].

Psychological factors, such as self-efficacy (i.e., belief in ability to be successful) and perceived competence (i.e., perceptions of actual capability) contribute to the broader 'self-concept' construct and are critical factors linked to physical activity participation [43, 62]. Perceived competence is the strongest aspect of self-concept that has been linked to physical activity in childhood and adolescence [43]. Perceived competence has also been shown to mediate the association between motor competence and physical activity in adolescents [63, 64].

Perceived competence and self-efficacy are hypothesized to become even more important in early adulthood and beyond, with high levels of self-concept driving confidence to try new physical activity endeavors [62]. Thus, if individuals perceive themselves as competent, are good at a particular task (i.e., a specific skill), or feel based on prior experiences that they can modify their skills [58], they will be more willing to try and persist at that task and try new activities [55–57]. This persistence leads to further development of motor competence and hopefully greater physical activity. For example, an individual with high self-concept, who played tennis as a child, may be more willing to try other striking/racquet activities (e.g., cricket, softball, badminton, squash), despite never having played. As many of the biomechanical attributes of striking with a racket, throwing and other variations of striking skills are quite similar [36], transferring success in tennis to activities where striking is important will be easier to attain. Therefore, individuals that develop multiple foundational skills may successfully modify skill-specific attributes for other context-specific applications.

3 Future Directions

Replacing the term 'fundamental movement skills' with 'foundational movement skills' may generate debate. However, expanding the number of movement skills classified as 'foundational' may further promote participation in a greater range of physical activities. This terminology change reinforces the need to answer previously raised questions [21], including the following: *does foundational movement skill competency allow for a lifetime of physical activity? If so, what minimal level of capability is needed? Are some foundational movement skills universally important? Does foundational skill competency track into adulthood?* Finally, *what are the implications of skill level at each life stage for health outcomes?*

4 Conclusions

Skill development across time should be viewed in the context of how it leads to skillful performance and in terms of how various movement forms support and maintain a lifetime of physical activity. This paper helps to expand the range of movement skills that are important for physical activity across the lifespan. Further, movement skills are hypothesized to vary in importance and popularity based on cultural and geographic location. Our proposed model also recognizes the synergistic and reciprocal role of physical and psychological factors that influence the development of movement skills. We aimed to answer *what types of movement patterns would be most beneficial to develop to facilitate participation in physical activity across the lifespan?* Therefore, continued debate of this topic may help to advance the application of motor development principles within the public health domain.

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Compliance with Ethical Standards

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Conflict of interest Ryan Hulteen, Lisa Barnett, Philip Morgan, David Stodden, and David Lubans declare that they have no conflict of interest.

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