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Review

Relationship of fundamental movement skills and physical activity in children and adolescents: A systematic review

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ABSTRACT

Objectives: This systematic review provides an overview of research elucidating the relationship between fundamental movement skills (FMS) and physical activity (PA) in children and adolescents.
Design: Systematic review.
Method: Prospective studies were identified from searches in Cochrane Library, BioMed Central, Education Resources Information Center (ERIC), PubMed, Scirus and SciVerse Science Direct from 2000 through 2013. We screened the titles and abstracts for eligibility, rated the methodological quality of the studies, and extracted data.
Results: We identified 23 studies meeting our relevancy criteria. The quality score of the studies ranged from 44% to 89%. Overall relationships between FMS and PA or relationships specific for gender and skill were identified in several studies. The variety of methods for assessing PA and FMS make the comparison of study results difficult. We found strong evidence from cross-sectional studies for a positive relationship between FMS and organized physical activities. Motor skill competency was only of low predictive value for the physical activity level in adults.
Conclusions: The results of this review suggest that a cause–effect relationship between FMS and PA is suspected but has not been demonstrated yet. The identification of a causal relationship appears very important to ensure feasibility of practical implementation. This could provide aids for decision making for teachers and coaches, but also for therapists' decision guidance to create training, lessons and therapy adequate to the target group.

Introduction

Early and regular physical activity (PA) is associated with a number of positive effects on the respiratory, heart and circulatory systems (Sakuragi et al., 2009; Siegrist, Lammel, Haller, Christle, & Halle, 2013), positive psychological (Fedewa & Ahn, 2011; Lees & Hopkins, 2013) and cognitive effects (Hillman, Buck, Themanson, Pontifex, & Castelli, 2009; Hillman & Schott, 2013), as well as an active lifestyle (Stodden et al., 2008) in children and adolescents (i.e., 6–19 years of age). Nevertheless, current reviews show that many children and adolescents are not getting a sufficient level of physical activity (e.g. Hallal et al., 2012), which is reflected in the increasing number of overweight and obese children in the last few years (Sakuragi et al., 2009). Furthermore, the negative health effects associated with physical inactivity and obesity may result in insulin resistance and cardio-vascular disease (Froberg & Andersen, 2005). Therefore, the promotion of physical activity in children, as well as in adults, can be categorized as an important task for society as well as health policy. The exact reasons why some people are more physically active than others remain unclear (Stodden et al., 2008; Stodden & Holfelder, 2013).

The school routine and the club system shows that movement competence[1] or mastery of fundamental movement skills (FMS) is assumed in children, adolescents and adults for them to be able to participate in organized and informal activities or even to be interested in taking part (Hardy, King, Farrell, Macniven, & Howlett, 2010; Livesey, Lum Mow, Toshack, & Zheng, 2011; Lubans, Morgan, Cliff, Barnett, & Okely, 2010). From this point of view, the research question of to what extent the mastery of FMS influences the participation in organized and non-organized PA is derived.

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[1] Motor competence can be defined as a person's movement coordination quality when performing different motor skills, ranging on a continuum from gross to fine motor skills.

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Furthermore, it is assumed that the mastery of FMS in infancy is not only be directly associated with increased PA, but also positively influences the activity level in adulthood (Barnett, van Beurden, Morgan, Brooks, & Beard, 2009a; Stodden et al., 2008). So far, there are only few studies examining the causal relationship between the quality of FMS and PA (Barnett, Morgan, van Beurden, Ball, & Lubans, 2011; Jaakkola & Washington, 2013), i.e. that having high fundamental movement skill level may increase options for participation in PA, as well as increased participation leading to further development of motor skills. However, a definite answer to this question cannot be given at this point. Some studies suggest a reciprocal relationship between PA and FMS (Barnett et al., 2011; Hume et al., 2008; Kambas et al., 2012; Stodden et al., 2008). For the present article *physical activity* is used as a generic term for every bodily movement produced by the skeletal muscles, that raises the energy consumption above the basal metabolism (Caspersen, Powell, & Christenson, 1985). Despite this simple definition, PA is a complex and multidimensional behavior, which includes qualitative aspects (e.g. way to school or sports) and quantitative aspects (e.g. frequency, duration, intensity). PA could be assessed using self-report (e.g. questionnaires and diaries) and objective measures (e.g. accelerometers, pedometers, heart rate monitoring) (Warren et al., 2010). A common method calculating energy cost for different PA is applying the metabolic equivalent (MET), which seems to be valid for adults, but not for children (ibid.). For a detailed overview of instruments for assessing PA with all relevant advantages and disadvantages of each method, see the review of Warren et al. (2010). *Motor skills* in general can be defined as the consistent production of goal-oriented movements, which are learned and specific to the task (McMorris, 2004), while *motor abilities* such as balance, flexibility, muscular strength and endurance are defined as "general traits or capacities of an individual that underlie the performance of a variety of movement skills" (Burton & Miller, 1998, p. 43; Burton & Rodgerson, 2001). *Fundamental movement skills* consist of locomotor skills that are used to propel a human body through space (e.g., running, jumping, hopping) and object control skills which include manipulating an object in action situations (e.g., throwing, catching, kicking; Cliff, Okely, Smith, & McKeen, 2009). These FMS are the building blocks for more complex and sport-specific skills (Robinson & Goodway, 2009), like "pitching" in baseball. Some research groups (e.g. Barnett et al., 2011; Cliff et al., 2009) summarize their results in form of sum scores across all individual test variables. Additionally, some authors (e.g. Gallahue & Ozmun, 2006; Jaakkola & Washington, 2013) classify balance and/or stability as a third dimension of FMS, which should be qualified according to the taxonomy of Fleishman (1962) and Burton and Rodgerson (2001) as a motor ability rather than a skill. The reason for this is, that the only way to assess balance is using FMS like walking or jumping.

Previous systematic reviews/meta-analysis in this field analyzed the efficacy of interventions, which refers to organized physical activity, improving motor development in young typically (Logan, Robinson, Wilson, & Lucas, 2012; Morgan et al., 2013; Riethmuller, Jones, & Okely, 2009) and nontypically developing children (Logan et al., 2012). They concluded that the majority of studies are successful in significantly enhancing motor skill development and are therefore an important means to promote (lifelong) physical activity. For example Morgan et al. (2013) revealed large effect sizes in terms of standardized mean difference (SMD) for overall gross motor proficiency (SMD = 1.42, $P < .0002$) and locomotor skill competency (SMD = 1.42, $P < .001$), as well as a medium effect size for object control skill competency (SMD = .63, $P < .0004$). However, it remains unclear from the studies which intervention strategy results in the most improvement in which FMS, and at which point a critical amount of instruction is reached (Logan et al., 2012; Morgan et al., 2013; Riethmuller et al., 2009). This might be due to the fact, that many studies did not describe their intervention strategy in sufficient detail (Logan et al., 2012; Morgan et al., 2013). Riethmuller et al. (2009) found that only 3 of the 17 studies involved had a high methodological quality, which highlights the demand on research, i.e. about the relationship between PA and FMS. Furthermore, Morgan et al. (2013) reported that many studies scored poorly for risk of bias items which could lead to an underestimation of the study quality. In a further review, Lubans et al. (2010) examined psychological, physiological and behavioral health benefits with FMS competency as well as the relationship between FMS and PA, but studies were excluded, which did not provide a composite score of FMS. Overall, they found a positive association between FMS and PA in children and adolescents, but did not make any statements about the postulated reciprocal relationship between PA and FMS (e.g. Barnett et al., 2011; Kambas et al., 2012).

The focus of these reviews (Logan et al., 2012; Lubans et al., 2010; Morgan et al., 2013; Riethmuller et al., 2009) was mainly on general associations without presenting and discussing results about relationships specific to skill and gender. Logan et al. (2012) and Morgan et al. (2013) differentiated only between locomotor and object control skills, but a skill-specific analysis that was mentioned by Lubans et al. (2010) as a future direction, was not conducted. This distinction seems to be essential, because current studies (e.g. Cliff et al., 2009; Jaakkola & Washington, 2013) reported gender and skill-specific differences, which could be important in giving appropriate instructions for planning sport lessons or designing interventions. Although, all reviews present the applied instruments assessing FMS and PA in their summary of the included studies, they hardly considered methodical influences and differences at this point, but point it out as a difficulty comparing studies (Morgan et al., 2013).

As far as we know, no systematic review with the exclusive focus on the relationship between PA and FMS has been performed. Therefore, in this article we are giving an update of published studies since the review of Lubans et al. (2010; 8 included studies were published since 2010 and later, c.f. Supplementary material 2) by presenting the results of a systematic review of the existing literature examining this relationship. We take into account the methodological quality of the studies, present and discuss the applied methods assessing FMS and PA. General relationships between PA and FMS will be discussed, but also relationships specific to skill and gender. Furthermore, we want to discuss briefly the understanding of FMS and the potential cause and effect relationship between PA and FMS. Based on previous studies (e.g. Cliff et al., 2009; Jaakkola & Washington, 2013) we hypothesize that there are skill- and gender-specific relationships between PA and FMS. In addition we assume that physical activity behavior in adolescents relies on the current or future benefits associated with the acquisition of FMS proficiency.

Methods

Search strategy

To identify all relevant studies, six electronic databases (Cochrane Library, BioMed Central, Education Resources Information Center (ERIC), PubMed, Scirus, and SciVerse Science Direct) were searched using the English search terms 'physical activity' and 'children' in combination with 'motor skills', 'movement skills' or 'motor proficiency' and the German search terms 'koerperliche Aktivitaet' and 'Kinder' in combination with 'motorische Fertigkeiten' or 'motorische Grundfertigkeiten'. Studies were collected from 2000 up to June 2013. We restricted our search to studies