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REVIEW PAPER

Fundamental Motor Skills and School-Aged Individuals with Visual Impairments: a Review

Justin A. Haegele[1] · **Ali Brian**[2] · **Jackie Goodway**[3]

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Abstract The purpose of this paper was to review the published research literature on fundamental motor skills (FMS) for school-aged individuals with visual impairment by describing study characteristics and major findings of the extant literature. Keyword searchers were used to identify articles from electronic databases published between 1982 and 2014. Eleven articles met all inclusion criteria, and relevant data were extracted from them. Of the 11 studies, six were comparative, two were correlational, two were validation studies, one was descriptive, and none were interventions. Major findings suggest that, in comparison to peers without disabilities, those with visual impairments tend to perform significantly greater delays in FMS.

Keywords Disability · Motor skills · Physical education · Physical activity · Blindness

Research indicates that individuals with visual impairments tend to be less physically active than their peers without disabilities (Haegele and Porretta 2015; Kozub 2006). Because individuals with visual impairments are less physically active than their peers without disabilities, they are at greater risk for developing health-related issues associated with sedentary lifestyles, such as obesity, cardiovascular disease, and obesity. Several factors have been identified that limit physical activity participation for those with visual impairments, such as a lack of knowledge of opportunities (Stuart et al. 2006), parental encouragement (Ward et al. 2011), and professional training of teachers (Lieberman et al. 2002).

An additional factor that must be considered is the role that fundamental motor skills (FMS) competence plays in supporting physical activity behaviors (Stodden et al. 2008). FMS are considered building blocks of more complex movements (Clark and Metcalf 2002) that require the activation of large muscle group movements (Logan et al. 2011) and are typically classified as either object control or locomotor skills (Haywood and Getchel 2009). Locomotor skills are those which propel the body from one point in space to another and include galloping, jumping, leaping, hopping, running, and sliding (Logan et al. 2011). Object control skills, also known as manipulation skills, are those that encompass the reception, propulsion, and/or manipulation of an object with either the hand or foot (Gallahue et al. 2012). Object control skills include throwing, kicking, catching, striking, rolling, and dribbling. FMS enable children to apply basic motor skills to participate in sports, games, and other physical activities that require complex movement patterns.

Unfortunately, research suggests that school-aged individuals with visual impairments tend to acquire motor skills later in life than peers without disabilities (Bouchard and Tetreault 2000; Levtzion-Korach et al. 2000). Delays in motor acquisition can be a contributing factor to differences between school-aged individuals with and without visual impairments in FMS (Houwen et al. 2007, 2010a). FMS deficiencies may relate with low levels of physical activity participation among those with visual impairments (Haegele and Porretta 2015).

Over the years, a number of literature reviews have been conducted in regard to school-aged individuals with visual impairments (Depauw 1981; Houwen et al. 2009; Skaggs and Hopper 1996). In 1981, Depauw completed a review

✉ Justin A. Haegele
jhaegele@odu.edu

[1] Old Dominion University, Norfolk, VA, USA

[2] University of South Carolina, Columbia, SC, USA

[3] The Ohio State University, Columbus, OH, USA

focusing on physical education for individuals with visual impairments. The review found six empirically based studies published between 1970 and 1980. Of those, only one focused on FMS development, suggesting that children with visual impairments self-initiate mobility and locomotion later in life than peers without disabilities (Adelson and Fraiberg 1974). Skaggs and Hopper (1996) completed a review that addressed physical fitness and motor skill performance differences between school-aged individuals with and without visual impairments. Of the 19 empirically based studies between 1950 and 1993, five dealt with motor development. Skaggs and Hopper found that individuals with visual impairments were delayed in motor development when compared to peers without disabilities. While this review categorized findings as motor development, Skaggs and Hopper did not specify what areas of motor development were reviewed within those categories (e.g., object control, locomotion).

Most recently, a published literature review by Houwen et al. (2009) addressed specific variables which influence motor skill performance of children with visual impairments. Houwen et al. (2009) defined motor skill performance as the interaction between the child's genetic predisposition and impairments, environmental opportunities, and barriers for movement, as well as task constraints. The review concluded that previous research provided weak evidence to support relationships between three areas: (a) degree of vision loss and dynamic balance, (b) amblyopia/ strabismus (e.g., misalignment of the eye) and fine motor skills, and (c) movement interventions and motor skill performance (Houwen et al. 2009). The conclusion of article suggested that, at the time of the review, inadequate evidence was available in which to inform practical decision making in this area (Houwen et al. 2009).

With a greater emphasis being placed on physical activity participation and the role that FMS play in the ability of school-aged individuals to participate in those activities, more empirical work in this area is being conducted. Aside from the Houwen et al. (2009) review, little attention has been given to a comprehensive review of FMS literature for school-aged individuals with visual impairments. Further, the Houwen et al. review utilized a definition of motor skill performance which is broader than the contemporary use of the term FMS. Thus, the purpose of this paper was to review the published research literature on FMS for school-aged individuals with visual impairment by describing study characteristics and major findings of the extant literature. For the purposes of this review, FMS were defined as either object control or locomotor skills (Haywood and Getchel 2009). Studies pertaining to dynamic or static balance, while some may argue also constitute FMS, were not considered. Suggestions for future research in this arena are provided.

Method

The following databases were searched for relevant studies: (a) Academic Search Complete, (b) Education Full Text, (c) Education Research Complete, (d) ERIC, (e) Masterfile, (f) MEDline, (g) Physical Education Info, (h) PsycINFO, and (i) Sportdiscus. Article references were searched for additional eligible studies. Studies were identified by searching electronic databases and scanning reference lists of articles identified. The search strategy included three lines of search words, truncated whenever possible: (a) visual impairment, blindness, low vision, and sensory impairment; (b) physical activity, physical education, recreation, motor skills, gross motor activities, mobility, sport, psychomotor, fine motor skills, motor competence, and fundamental motor skills; and (c) children, youth, youngster, and adolescent.

Inclusion and Exclusion Criteria

The inclusion criteria for this review were published studies in (a) peer-reviewed journals between 1981 and 2014, (b) the English language, (c) which school-aged (<22 years) participants whose primary disability was visual impairment or blindness, and (d) which full text was available. The exclusion criteria were being studies (a) published in non-English language, (b) published before 1981, (c) in which participants were 22 years or older, and (d) in which participants were identified in mixed disability categories. Additional exclusion criteria included unpublished dissertations or theses and studies published in conference proceedings. Studies were limited to those published after 1981 because of the findings discussed by DePauw (1981), which found no studies focusing specifically on FMS competence.

After the initial search was completed, an additional inclusion criterion was introduced. Articles were then searched for those which pertained to FMS competence including object control or locomotor skills. Articles pertaining to other topics (e.g., physical activity, exercise, balance) were excluded.

Article Selection

The full search process produced a total of 215 articles; 162 were excluded due to failure to meet all of the initial inclusion criteria. Common reasons for studies exclusion included mixed disability populations, mixed age populations, and practical application papers. After the initial search was completed, the authors searched the qualifying articles (N=53) for studies focusing on FMS competence. Eleven articles were identified with all inclusion criteria. See Fig. 1 for the procedures in which articles were selected.

The first and second authors independently evaluated each study to identify essential study characteristics and major findings. Inter-observer agreement (100 %) was reached on each

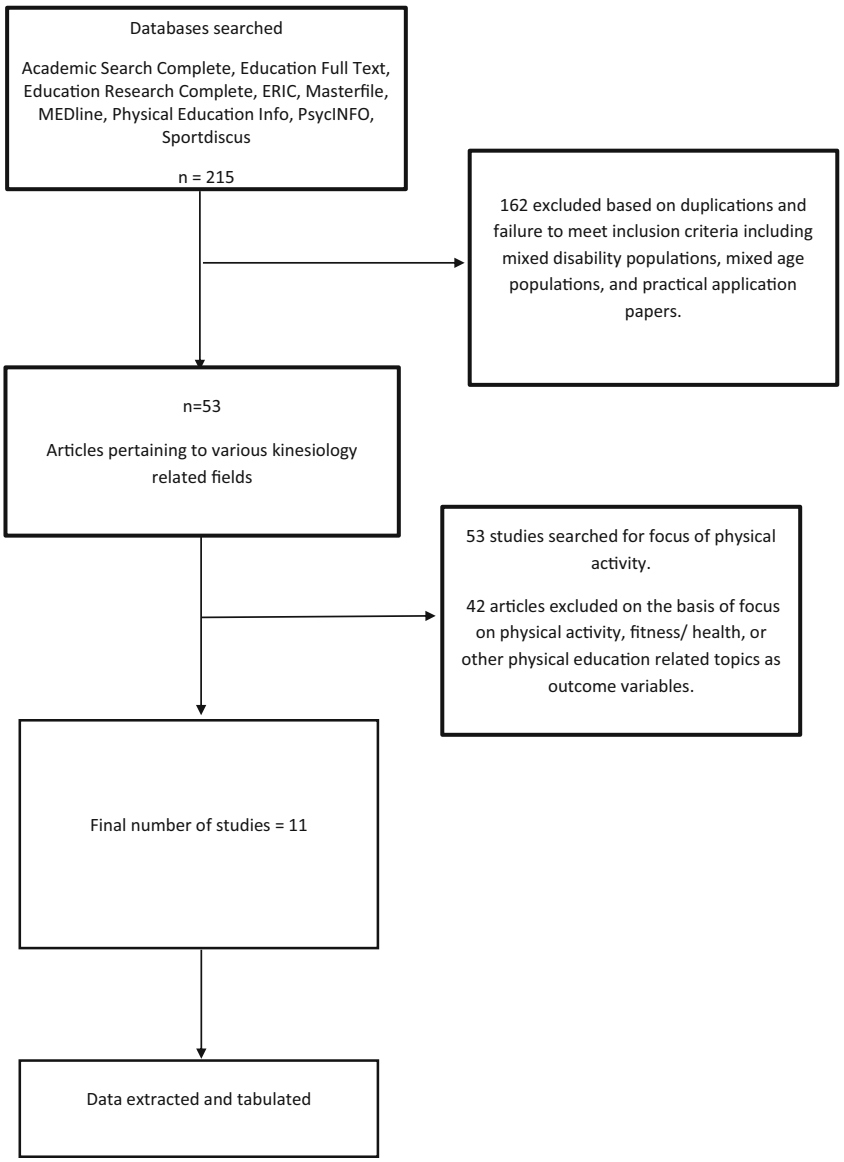

Fig. 1 Flow chart describing article selection process

categorization. Study characteristics are displayed in Table 1 and major findings are displayed in Table 2.

Results

Study Characteristics

Research Design

When categorizing the research designs of studies included in this review, five categories were utilized: (a) descriptive, (b) correlational, (c) comparative, (d) intervention, and (e) validation. Studies were considered descriptive if they described a given state of affairs without describing relationships or differences between groups (Fraenkel et al. 2012). Correlational explored relationships among variables (Thomas et al. 2005). Comparative utilized techniques to test differences among different groups of participants (Thomas et al. 2005). Those studies that included an attempt to establish a causal relationship were considered intervention studies (Thomas et al. 2005). Lastly, studies describing an attempt to validate an instrument were categorized as validation studies.

Six of the 11 studies included in this review (55 %) were considered comparative studies. Within the comparative studies (n=6), five contrasted individuals with visual impairments with peers without visual impairments, and one compared scores acquired by those with visual impairments to age-based norms (Brambring 2006). There were two correlational studies (Fotiadou et al. 2014; Haibach et al. 2014), two validation studies (Houwen et al. 2010b; Sellers et al. 2001), and one was categorized as descriptive (Celeste 2002). Of

Table 1 Participant characteristics, visual impairment classification, dependent measure, and research design across studies

Study	Participants	Visual impairment	Dependent measure	Research design
Bouchard and Tetreault (2000)	30 children; aged 8–13 years	Moderate low vision[a]	Bruininks-Oseretsky Test of Motor Proficiency	Comparative
Brambring (2006)	2 male, 2 female; aged 4–6 years	3 completely blind, 1 light perception	Bielefeld Observation Scale	Comparative
Celeste (2002)	39 male, 45 female; aged 4 months to 4 years	11 no light perception, 20 minimal light perception, 25 partial vision	Parent report	Descriptive
Fotiadou et al. (2014)	22 male, 15 female; aged 8–14 years	19 total vision loss, 18 partial vision loss	Bruininks-Oseretsky Test of Motor Proficiency	Correlational
Haibach et al. (2014)	61 male, 39 female; aged 6–12 years	23 B1, 25 B2, 52 B3[b]	Test of Gross Motor Development-2	Correlational
Houwen et al. (2007)	11 males, 9 females; aged 6–11 years	7 severe visual impairment, 13 moderate visual impairment[a]	Test of Gross Motor Development-2	Comparative
Houwen et al. (2010a)	40 males, 20 females; aged 6–12 years	16 severe visual impairment, 44 moderate visual impairment[a]	Test of Gross Motor Development-2	Comparative
Houwen et al. (2010b)	46 males, 29 females; aged 6–12 years	Severe visual impairment[a]	Test of Gross Motor Development-2	Validation
Levtzion-Korach et al. (2000)	40 participants; under the age of 5 years	No light perception	Bayley Developmental Scale	Comparative
Sellers et al. (2001)	21 participants; 10–21 years of age	Severe low vision or total blindness	Motor and Process Skills Scale	Validation
Wagner et al. (2013)	14 males, 9 females; aged 6–12 years	No light perception	Test of Gross Motor Development-2	Comparative

[a] United States Association of Blind Athletes Classification System

[b] World Health Organization Classification System

the 11 included studies, none were considered to be intervention studies.

Visual Impairment Levels

When describing visual impairment levels, five studies utilized established visual impairment classification systems, including four that used the World Health Organization's classification system (2013) and one that used the United States Association of Blind Athletes classification system (2013). The other six studies featured visual impairment levels without a specific classification system (e.g., partial vision loss, no light perception). Of the studies in this review, four (36 %) concentrated on one visual impairment level (e.g., only individuals with no light perception), while the other seven (64 %) included individuals with two or more visual impairment levels.

Topical Focus

Ten of the 11 (91 %) studies included in this review pertained to locomotor skills only, and four (36 %) included evaluations of both locomotor and object control skills. Of the studies which pertained to locomotor skills only (n=10), six (60 %) compared participants with visual impairments to peers without visual impairments. Three of four studies pertaining to object control skills and locomotor skills compared participants with and without visual impairments.

Dependent Variable

Of the 11 studies that met the inclusion criteria, 10 (91 %) utilized observational scales to evaluate objective control and/ or locomotor skills. Of those 10, five (45 %) utilized the Test of Gross Motor Development-2 (TGMD-2; Ulrich 2000), two the Bruininks-Oserestsky Test of Motor Proficiency (BOT-2; Bruininks and Bruininks 2005), one the Bielefeld Observation Scale (Brambring 2006), one the Motor and Process Skills Scale (Sellers et al. 2001), and one the Bayley Developmental Scale (Levtzion-Korach et al. 2000). In addition to those that featured observational scales, Celeste (2002) used a parent report to obtain information about the motor development of children with visual impairments.

Major Findings

Compared with their sighted peers, school-aged individuals with visual impairment demonstrated significantly lower scores in object control skills (Houwen et al. 2007; Wagner et al. 2013). Object control skills that tended to have the highest delays were dribbling and catching (as evaluated by the TGMD-2). Conflicting evidence has been found in regard to locomotor skill comparisons between those with and without visual impairments, where two studies found significant differences between those with visual impairments and those without (Houwen et al. 2010a; Wagner et al. 2013) and one study did not (Houwen et al. 2007). Further, individuals with visual impairments tend to demonstrate delays in the acquisition of locomotor skills, such as walking independently, cruising around furniture, and walking up and down stairs (Brambring 2006; Celeste 2002; Levtzion-Korach et al. 2000).

Of those with visual impairments, those with more severe impairments (e.g., B1) tend to perform significantly lower than others with visual impairments (e.g., B2 or B3) in FMS (Haibach et al. 2014). Those with prior sport experiences also

Table 2 Major findings across studies

Study	Major findings
Bouchard and Tetreault (2000)	Children with low vision had inferior motor skills when compared to those without visual impairments
Brambring (2006)	Participants with visual impairments had significant delays in comparison to those without visual impairments in areas of (a) dynamic balance, (b) acquisition of locomotion, and (c) refinement of locomotion
Celeste (2002)	Children with visual impairments had developmental delays in all gross motor areas surveyed. Largest delays in walking independently, cruising around furniture, and walking up and down stairs
Fotiadou et al. (2014)	Participants with total and partial vision loss scored lower on motor development and self-esteem than peers who were sighted. Results indicate an interaction between motor development and self-esteem
Haibach et al. (2014)	Significant differences between B1 group and B2 and B3 groups. Boys significantly outperformed girls in striking, dribbling, and throwing. Older children significantly outperformed younger children in dribbling
Houwen et al. (2007)	Significant differences in object control skills between participants with and without visual impairments. Significantly higher object control scores for participants with visual impairments who participated in sports than those who do not. No significant difference found in locomotor skills found between participants with and without visual impairments
Houwen et al. (2010a)	Significant differences in object control skills between sighted participants with and without visual impairments. Significant differences in locomotor skills found between participants with and without visual impairments
Houwen et al. (2010b)	Results support validation of Test for Gross Motor Development-2 (TGMD-2) for use with students with visual impairments
Levtzion-Korach et al. (2000)	Significant delays in all motor skills tested including rolling, crawling, standing without support, sitting from a supine position, and walking with help or alone
Sellers et al. (2001)	Results support validation of the Assessment of Motor and Process Skills (AMPS) for use with severe low vision or total blindness
Wagner et al. (2013)	Children who are blind performed significantly worse than peers without visual impairments in all assessed locomotor and object control areas

tended to score higher on object control skills (Houwen et al. 2007). Gender and age tend not to influence FMS competence among individuals with visual impairments, with exception to males outperforming females in striking, dribbling, and throwing and older participants outperforming younger participants in dribbling (Haibach et al. 2014). FMS competence for individuals with visual impairments has also been found to have a positive relationship with their self-esteem when performing these tasks, meaning while one of these variables increases, the other has also been found to increase (Fotiadou et al. 2014).

Discussion

The purpose of this paper was to review the published research literature on FMS for school-aged individuals with visual impairment by describing study characteristics and major findings of the extant literature. As a result, a number of outcomes have emerged. First, the review reveals some new information to enhance our understanding of FMS for school-aged individuals with visual impairments. Second, the lack of empirical research in this area, particularly intervention research, is a concern and suggestions are offered when conducing future studies.

Studies in the current review have affirmed and expanded our understanding of FMS for individuals with visual impairments. The Skaggs and Hopper (1996) review suggested that individuals with visual impairments tend to develop delays in FMS in comparison to peers without visual impairments. Although one study found conflicting evidence (Houwen et al. 2007), most follow-up studies included in this review found results that are consistent with Skaggs and Hopper, which continue to demonstrate delays between those with and without visual impairments (e.g., Wagner et al. 2013). Further, recent research in this review has expanded our knowledge by exploring variables that may influence FMS development for individuals with visual impairments (e.g., Haibach et al. 2014). Specifically, Haibach et al. (2014) found those with more severe visual impairments to perform worse than peers with less severe visual impairments. Moreover, those with previous sport experiences outperformed peers

without those experiences (Houwen et al. 2007). Variables that were found not to influence FMS competence were gender and age. The model used by Haibach et al. that examined each particular object control and locomotor skill evaluated should continue to be utilized in research in this arena to find the most specific information about FMS.

Another important finding of this review is that there is a current lack of research in this area. This review found few studies ($N=11$) in the over 30-year period since the Depauw (1981) review. While other reasons may apply, one such reason why there may be a lack of intervention research in this area is difficulty with obtaining an appropriate number of participants with visual impairments (Haegele and Porretta 2015). Based on the results of this review, a number of considerations should be taken into account when conducting future research. These considerations include conducting intervention research, exploring the relationship between FMS and physical activity empirically, making further comparisons between visual acuities, utilizing normative evaluations for individuals with visual impairments, and utilizing theoretical or conceptual models in research.

While it is known that individuals with visual impairments demonstrate delays in FMS, this review found no intervention studies in the extant literature. Intervention research pertaining to object control and locomotor skills has been given much attention recently when considering individuals with (e.g., Kirk and Rhodes 2011) and without disabilities (Logan et al. 2011). These interventions can and should be modified to be implemented and evaluated for individuals with visual impairments as well. When conducting intervention research, those conducting studies should consider school-based interventions that can be implemented by practitioners to improve FMS skills in an ecologically valid way. These school-based interventions may be the most likely research to translate to practice and impact children with visual impairments.

In addition to conducting intervention research, scholars should continue to explore variables that may have relationships to FMS competence and development. Two such variables are physical activity and perceived motor competence. Scholars have postulated that a relationship exists between physical activity, perceived motor competence, and FMS development for children (without disabilities; Stodden et al. 2008). As a result, researchers have begun to examine this potential relationship. Current research suggests that individuals with visual impairments tend to have low physical activity participation (Haegele and Porretta 2015) as well as delays in motor development (e.g., Houwen et al. 2010a). While research is growing in both areas (physical activity and FMS), these variables are yet to be compared in this population. Future research should also continue to compare participants across visual impairment classifications. Of the studies included in this review, seven included more than one visual impairment level. However, not all included a standardized visual impairment classification system (e.g., USABA). By including individuals in multiple, operationally defined groups, researchers can make inferences about differences between individuals with different visual impairment levels and determine which groups are in most need of future interventions. One example, the study by Haibach et al. (2014) demonstrated significant differences in performance of FMS between visual impairment classification levels (e.g., B1 being less successful than B2 and B3). These results provide evidence that those with less vision may benefit further than others from future, FMS-related interventions.

Future research may also consider the use of normative evaluations specifically designed for those with visual impairments. Several issues may exist with measurement techniques used to evaluate participants with visual impairments. For example, while this review includes evidence supporting the validation of two assessment instruments, evidence is only applicable to a narrow population of individuals with visual impairments (e.g., similar to those included in the validation study). Further, these validation studies did not include step-by-step instructions as to how to implement the assessment instruments for individuals with visual impairments. Skaggs and Hopper (1996) suggest that rather than using psychomotor assessments developed for typically developing students, researchers should develop assessments designed specifically for individuals with visual impairments. If researchers create a normative assessment for individuals with visual impairments, it would be important to consider using standardized visual acuity classifications within the assessment. Norms would be needed to each classification (e.g., USABA classification system; B1 norms, B2 norms, B3 norms) in order for the assessment tool to be most useful for future research. Equally, a standardized script of instructions and demonstrations would be critical to the success of such an instrument.

Lastly, when conceptualizing future research in this arena, researchers should consider utilizing theoretical or conceptual models to underpin their studies. Scholars in adapted physical activity research have stressed the importance of utilizing theoretical or conceptual models to drive research (Reid and Stanish 2003). When utilizing these models, hypotheses are developed based on them and those models can either be confirmed or revised as appropriate based on those results (Haegele and Porretta 2015). Irrespective of the importance of theoretical or conceptual frameworks, no studies were found that took them into consideration in this review. Some common FMS-related theoretical models include Dynamical Systems Theory (Thelen and Ulrich 1991), Newell's Constraints Theory (1984, 1986), and Seefeldt's Progression of Motor Skill Proficiency Model (1980). Future studies incorporating theoretical or conceptual frameworks in this arena may contribute to the broader knowledge base expanding outside of the studies pertaining only to those with visual impairments.

Conclusion

School-aged individuals with visual impairments are less physically active than their peers without visual impairments (Haegele and Porretta 2015). FMS are basic movement patterns which may contribute to the overall ability of those with visual impairments to become physically active (Stodden et al. 2008). This review found evidence to support delays in FMS competence areas including object control and balance skills. Mixed results were found while comparing students with visual impairments to typically developing peers in regards to locomotor movements. As researchers continue to discuss FMS competence for individuals with visual impairments, focus should transition from describing differences between individuals with visual impairments and typically developing peers, to determining appropriate interventions for increasing FMS competence and exploring the relationship between FMS competence and physical activity.

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