

Motor skills in children with visual impairment

(overview essay)

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Abstract: *The overview essay presents a narrative literary review of the facts about the motor skills in association with visual impairments in children from current studies. This contribution presents various knowledge and selected research surveys in issue. Motor skills and motor development in children with visual impairment is expected to be different from that in typically developing children in many ways. The aim of the contribution is to summarize appropriate and essential studies that show experiences with problem of motor skills, in a broader context, in child individuals with sensory loss.*

Keywords: *vision, impairment, movement, gross motor skills, motor function, motor development*

1 Introduction

Investigation of motor skills in children with visual impairment is limited because of an absence of instruments for assessing motor function in these children (Bakke, Cavalcante, de Oliveira et al., 2019). Children with low vision have poorer motor skills than did the children who were sighted. Furthermore, the children with low vision have weaker gross motor skills, especially balance, than fine motor skills (Bouchard & Tétreault, 2000). Severe congenital visual disability delays and alters development in all areas; the impact on motor development is complex with much secondary to delays in other areas (Sonksen, Levitt, & Kitsinger, 1984). Ocular accommodation provides a well-focused image, feedback for accurate eye movement control, and cues for depth perception. To accurately perform visually guided motor tasks, integration of ocular motor systems is essential. Children with motor coordination impairment are established to be at higher risk of accommodation anomalies (Rafique & Northway, 2015).

Children with visual impairments often reveal higher levels of sedentary time and lower levels of fundamental motor skills, health-related fitness, and physical activity than peers without visual impairments (Brian, Pennell, Haibach-Beach et al., 2019). Fundamental motor skills are an underlying mechanism driving physical activity behavior and promoting positive developmental trajectories for health. However, little is known about fundamental motor skills of preschool-aged children with visual impairments (Brian, Miedema, Johnson et. al., 2021). The changes in such human motor performance processes as stability maintenance, production of a response to the environment may be observed if loss of vision or any vision impairment appears. Insufficient visual information hampers motor performance and maybe the development of the compensatory motor reactions of the legally blind. Intensified tactile or vestibular function cannot absolutely replace the presence of normal vision in motor control (Juodzbalienė & Muckus, 2006). Visually impaired children show difficulties in recognizing their own bodies, objects around them and the spatial parameters that are essential for independent movement (Navarro, Fukujima, Fontes et al., 2004). Although imagery is traditionally thought to be inherently linked to visual perception, growing evidence shows that mental images can arise also from nonvisual modalities. Paradigmatic in this respect is the case of individuals born blind or that became blind soon after birth. It was reviewed evidence pertaining to different aspects of cognition showing that blind individuals can generate analogical mental images based on haptic or auditory input. These representations allow blind individuals to perform efficiently in a variety of domains which require the use of imagery (such as memory, spatial and navigation abilities, numerical cognition), though exhibiting in some cases specific limitations or differences, which likely depend on the modality in which information is usually acquired in these individuals (e.g., via haptics and hearing) and the strategies employed (Renzi, Cattaneo, Vecchi et al., 2013).

2 Overview of research findings to the solved topic

Assessment of motor skills in children with visual impairment is problematic. To minimize systematic errors and improve the quality of the investigations, increasing the number of studies regarding the tools, functionality of their activities, and testing the adaptations is necessary (Bakke, Cavalcante, de Oliveira et al., 2019).

The study of the Wagner, Haibach, & Lieberman (2013) provided an empirical basis for teaching gross motor skills in children with visual impairments. For this purpose, gross motor skill performance of 23 6–12-year-old, boys and girls who are blind, and 28 sighted controls with comparable age and gender characteristics was compared on six locomotor and six object control tasks using the TGMD-2. Results indicate that children who are blind perform significantly ($p < .05$) worse in all assessed locomotor and object control skills, whereby running, leaping, kicking, and

catching are the most affected skills, and corresponding differences are related to most running, leaping, kicking, and catching component.

The study of Brambring (2001) used actometers to measure leg and arm activity in 20 children who were blind, 15 who were partially sighted, and 35 sighted controls from the same pre-school groups matched for age and gender. The results showed strong and highly significant restrictions in leg movements in the blind compared with sighted peers (63% of the leg activity of sighted controls). Differences in arm movements did not attain statistical significance (83% of the arm activity of sighted controls). The partially sighted group revealed stronger restrictions in leg movements (77% of the leg activity of sighted controls) than in arm movements (90% of the arm activity of sighted controls). However, none of the differences between the partially sighted and sighted were significant. Nonetheless, the degree of visual impairment or the birth status (full-term vs. pre-term) related significantly with activity levels in the group of visually impaired. Entering these variables as covariates revealed statistically non-significant differences between the blind and partially sighted and between the pre- and full-term visually impaired groups. This method could be used to evaluate the effects of different interventions on motor activities and to observe developmental progress in children with visual impairment at various ages.

Results of the TGMD-2 by Brian, Taunton, Lieberman et al. (2018) consistently show acceptable validity and reliability for children/adolescents who are sighted and those who have visual impairments. Results of the Test of Gross Motor Development-3 (TGMD-3) are often valid and reliable for children who are sighted, but its psychometric properties are unknown for children with visual impairments.

When controlling for vision, age, and BMI z-score, in study of Brian, Pennell, Haibach-Beach et al. (2019), home-based self-report physical activity moderately correlated with camp-based accelerometer data ($p < .001$); home-based and camp-based physical activity associated with object control and locomotor subscales ($p < .001$); object control and locomotor skills were the most influential factors above and beyond vision associating with both physical activity measures. Cardiorespiratory fitness and grip strength were significantly associated with both object control and locomotor skills ($p < .001$).

In the study realized by Brian, Miedema, Johnson et al. (2021) was examined the fundamental motor skills of preschool-aged children ($N = 25$) with ($n = 10$) and without ($n = 15$) visual impairment as measured using the TGMD-3. Children without visual impairments performed significantly higher than their peers for locomotor ($p = .014$), and ball skills ($p < .001$). Regardless of the presence of a visual impairment, many participants struggled with developing fundamental motor skills, with the greatest disparity resting within ball skills. These findings help to clarify the fundamental motor skill levels of preschool-aged children with visual impairment. Thus, there is a need for both further inquiry and intervention for all children.

In study of Caputo, Tinelli, Bancale et al. (2007) investigated perceptual-motor and motor coordination abilities of 19 children with essential congenital esotropia who underwent a late surgery (after 4 years), compared to 23 age-matched controls. Strabismus is one of the most common visual disorders in infancy. While there is a great attention on the effects of the timing of surgery as to the development of binocular vision, little is known about the possible influence of congenital strabismus on perceptual-motor and more generally, on neuromotor development. Children were tested using the Movement Assessment Battery for Children (MABC) that were performed both 1-week before surgery (T1) and about 3 months (72 weeks) after surgery (T2). At T1, abnormal or borderline results were found in more than half of the children with strabismus, as opposed to only about 17% of the controls. At T2 none of the children showed abnormal MABC total scores and there was no difference in global scores between the study and the control group. The two groups also did not show any significant difference in individual items of the MABC apart from those assessing ball skills. Our results suggest that surgical correction of strabismus, even when performed after the 4th year of life, appears to be effective in improving perceptual-motor and motor function.

Elisa, Josée, Oreste et al. (2002) assessed early neuromotor development in 20 congenitally blind or severely visually impaired children, nine without (B) and 11 with associated handicaps (B 1 H), to develop a strategy for early intervention in these subjects. The mean age at first observation was 11.4 months (range: 4–30 months). The mean follow-up duration was 16.9 months (range: 3–36 months). Assessment included developmental history, neurological examination, videorecording of spontaneous activity and administration of the Reynell–Zinkin Scales and neuroradiological and neurophysiological investigations. All B children walked independently (mean age 19.8 months) and 55.5% crawled (mean age 15 months); the B 1 H subjects displayed absence of almost all neuromotor functions, except one who walked at 20 months. All the B and just one (9%) of the B 1 H children developed satisfactory fine motor abilities. ‘Reach on sound’ at distance was achieved by all the B children by the age of 14.2 months while in the B 1 H group it was achieved by only two subjects at a median age of 19.5 months. It is conclusion that, it is possible to describe the profile of neuromotor development in B and B 1 H children; strategies to help postural motor development and ‘reach on sound’ appear to be fundamental in early intervention in these subjects.

Haibach, Wagner, & Lieberman (2014) in study examined the influence of age, sex, and severity of visual impairment upon locomotor and object control skills in 100 children with visual impairments from across the United States by means of TGMD-2. The full range of visual impairments according to United States Association for Blind Athletes (USABA; B3 = 20/200–20/599, legally blind; B2 = 20/600 and up, travel vision; B1 = totally blind) were assessed. The B1 group performed significantly

worse than the B2, or B3 groups. However, there were no significant differences between B2 and B3 except for the run, catch, and throw. Age and sex did not play an important role in most of the skills, apart from boys outperforming girls striking, dribbling, and throwing, and older children outperforming younger children in dribbling. The significant impact of the severity of visual impairment is likely due to decreased experiences and opportunities for children with more severe visual impairments. In addition, it is likely that these reduced experiences explain the lack of age-related differences in children with visual impairments.

Hallemans, Ortibus, Truijten et al. (2011) compared locomotion of children and adults with a visual impairment (ages 1–44, $n = 28$) to that of age-related individuals with normal vision ($n = 60$). Participants walked barefoot at preferred speed while their gait was recorded by a Vicon1 system. Walking speed, heading angle, step frequency, stride length, step width, stance phase duration and double support time were determined. Differences between groups, relationships with age and possible interaction effects were investigated. With increasing age overall improvements in gait parameters are observed. Differences between groups were a slower walking speed, a shorter stride length, a prolonged duration of stance and of double support in the individuals with a visual impairment. These may be considered either as adaptations to balance problems or as strategies to allow to foot to probe the ground.

Gross motor skill performance of children with visual impairments and its association with the degree of visual impairment and sports participation was examined in study of Houwen, Visscher, Hartman et al. (2007). Twenty children with visual impairments (mean age 9.2 years) and 100 sighted children (mean age 9.1 years) from mainstream schools participated. The results showed that children with visual impairments had significantly lower object control but not locomotor skill scores than the sighted children. No significant differences were found between children with a moderate and severe visual impairment. Children with visual impairments who participated in sports had significantly higher object control skill scores than those who did not. No significant associations between motor skills and sports participation were found in the sighted children.

Houwen, Visscher, Lemmink et al. (2008) examined performance of children with visual impairments aged 7 to 10 years on different types of motor skills. Furthermore, the association between the degree of the visual impairment and motor performance was examined. The motor performance of 48 children with visual impairment (32 males, 16 females; mean age 8 years 10 months) was assessed using the MABC. Their performance was compared with 48 children without visual impairment (33 males, 15 females; mean age 8 years 9 months). Children with visual impairment showed the poorest performance compared with peers without visual impairment on unimanual speed, eye-hand coordination, catching, static balance, and dynamic balance while moving slowly. There was no significant difference between

children with moderate and severe visual impairment, except for bimanual coordination in 7- to 8-year-olds and eye-hand coordination in both the 7- to 8-year-olds and 9- to 10-year-olds, favouring the children with moderate visual impairment. The poor performance compared with children without visual impairment is related to vision, but the degree of the visual impairment does not appear to relate to motor performance, except when associated with bimanual and eye-hand coordination. For children with visual impairment, it seems very important to adjust the environmental context and task to enhance motor performance.

Motor skill performance of children and adolescents with visual impairments studied Houwen, Visscher, Lemmink et al. (2009). Three major groups of variables are considered (child, environmental, and task). Thirty-nine studies are included in this review, 26 of which examined the effects of child, environmental, and/or task variable(s) on motor skill performance and 13 of which reported suggestions by experts about variables related to performance. Weak evidence was found for three relationships: (a) between the degree of visual impairment and dynamic balance and manual dexterity, (b) between amblyopia/strabismus and fine motor skills, and (c) between movement interventions and motor skill performance. In addition, weak evidence was found to refute a relationship between gender and static balance.

Houwen, Hartman, & Visscher (2009) stated that the physical activity levels of children with, and without visual impairments is different. Total activity was significantly higher in children without visual impairment. Time spent in sedentary and light behaviors averaged 81.4% and 15.9% in the children with visual impairment and 78.1% and 18.6% in the children without visual impairment, with significant between-group differences. Participation in moderate-to-vigorous physical activity was significantly higher in children without visual impairment versus children with visual impairment. Time spent in sedentary activity was inversely correlated with locomotor and object control scores in children with visual impairment. Light activity was positively associated with locomotor scores; total activity and moderate-to-vigorous physical activity were positively associated with object control scores. For children without visual impairment, total activity and time spent in moderate-to-vigorous physical activity were positively associated with locomotor scores, and time spent in sedentary activity inversely associated with object control scores. The present results emphasize the importance of promoting an active lifestyle in children.

Ibrahimi, Mendiola-Santibañez, & Gkaros (2021) investigate the potential impact of strabismus and amblyopia on visual-perceptual skills and visual-motor skills of patients according to the type of strabismus, visual acuity, state of binocularity, and sex. This was observational, transverse, prospective study which analyzed a sample of 146 children with strabismus (88 male and 58 female) aged 5–15 years. To determine the strabismus type, we considered the deviation direction, frequency, binocularity state, and associated and dissociated elements. Visual-perceptual skills and

visual-motor skills were evaluated using the Test of Visual Perceptual Skills 3rd ed. (TVPS-3) and Visual-Motor Integration Test of Beery 6th ed. (VMI-6). Sex was the main variable associated with the performance of the analyzed patients on TVPS-3 and VMI-6 ($p < .05$); boys obtained better scores than girls in all evaluated aspects.

Levtzion-Korach, Tennenbaum, Schnitzer et al. (2000) assess the characteristic motor developmental pattern in blind children in Israel. The study compared the developmental data concerning 10 motor skills (rolling, crawling, standing alone with support, sitting from a supine position, walking with help, walking alone, climbing up the stairs with help, standing on one foot, jumping with two feet, climbing up the stairs alone) of 40 blind children to a control group of sighted children and to the motor developmental milestones of the Bayley Developmental Scale and the Revised Denver Developmental Screening Test. The motor development of blind children was delayed, the delay being significant in all 10 motor skills that were examined. This delay emphasizes the major importance of vision as a sensory input modality for the process of sensory–motor development. An adequate stimulating environment and proper parental handling could potentially shorten the motor developmental delay but probably not eliminate it entirely.

The study of the Rafique & Northway (2015) examined the relationship between ocular accommodation and motor tasks, which are often overlooked, to better understand the problems experienced by children with motor coordination impairment. Visual function, gross and fine motor skills were assessed in children with developmental coordination disorder and typically developing control children. Children with developmental coordination disorder had significantly poorer accommodation facility and amplitude dynamics compared to controls. Results indicate a relationship between impaired accommodation and motor skills. Specifically, accommodation anomalies correlated with visual motor, upper limb, and fine dexterity task performance. Consequently, we argue accommodation anomalies influence the ineffective coordination of action and perception in developmental coordination disorder. Furthermore, reading disabilities were related to poorer motor performance. It was postulated the role of the fastigial nucleus as a common pathway for accommodation and motor deficits.

Schott, Haibach-Beach, Knöpfle et al. (2021) present that while the development of motor imagery has been extensively studied in sighted children, it is not clear how children with different severities of visual impairment represent motor actions by using the motor representations constructed through the remaining intact senses, especially touch. Mental chronometry and generation/manipulation of mental imagery were examined in children with and without visual impairment. Participants included 64 youth with and without visual impairment (33 without visual impairments, 14 moderate-to-severe, and 17 blind). Mental chronometry was assessed with the imagined Timed-Up-and-Go-Test (iTUG), and generation/manipulation of mental

imagery with the Controllability-of-Motor-Imagery-Test (CMI). In addition, the effect of working memory performance (Letter-Number-Sequencing) and physical activity upon mental imagery were evaluated. Mental duration for the iTUG was significantly shorter than the active durations. Results also provided evidence of better haptic representation than motor representation in all participants; however, only for the CMI-regeneration condition controls outperformed children with visual impairments and blindness. Exercise and working memory performance showed a significant contribution only on a few tests of motor imagery. Results suggest a possible relationship between motor performance, body representation deficits and visual impairment which needs to be addressed in the evaluation and treatment of children with visual impairment and blindness.

3 Conclusion

Some studies identified constraints on motor development and discussed together with ideas for remediation and developmental prevention. Assessment of motor skills in children with visual impairment is problematic. Increasing the number of research regarding the tools, functionality of their activities, and testing the adaptations is necessary. These findings help to clarify the fundamental motor skills levels of children with visual impairment. There is a need for inquiry and intervention for all children. Testing results of the sighted, visually impaired, and totally blind subjects are not equal. It can be assumed that intensified tactile or vestibular function cannot absolutely replace the presence of normal vision in motor control. It was found that, the visually impaired children performed worse in tests evaluating balance and appendage coordination compared to normal sighted children, and this suggests that visual deficiency impairs children's neuro-psychomotor development. Gender and physical activity play a role in skill score. Children with visual impairments who participated in sports had significantly higher object control skill scores than those who did not. Sex seems to be the main variable associated with the results, and boys obtained better scores than girls in some evaluated aspect. Gait differences between groups were found: a slower walking speed, a shorter stride length, a prolonged duration of stance and of double support in the individuals with a visual impairment. These may be considered either as adaptations to balance problems or as strategies to allow foot to probe the ground, probably. Some results indicate a relationship between impaired accommodation and motor skills. Is postulated the role of the fastigial nucleus as a common pathway for accommodation and motor deficits. Some results suggest a possible relationship between motor performance, body representation deficits and visual impairment which needs to be addressed in the evaluation and treatment of children with visual impairments and blindness. The design of new re-

habilitation interventions that focus on strengthening adequate body perception and representation, in the context of the motor imagery, should be proposed and tested to promote motor development in children with visual impairments and blindness. It is stated that an adequate stimulating environment and proper parental handling could potentially shorten the motor developmental delay but probably not eliminate it entirely. Based on selected studies, we conclude that it is possible to describe the profile of neuromotor development in visually impaired children and appropriate strategies to help postural motor development appear to be fundamental in early intervention in these subjects.

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