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Motor Skill Performance and Sports Participation in Deaf Elementary School Children

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This study aimed to examine motor performance in deaf elementary school children and its association with sports participation. The population studied included 42 deaf children whose hearing loss ranged from 80 to 120 dB. Their motor skills were assessed with the Movement Assessment Battery for Children, and a questionnaire was used to determine their active involvement in organized sports. The deaf children had significantly more borderline and definite motor problems than the normative sample: 62% (manual dexterity), 52% (ball skills), and 45% (balance skills). Participation in organized sports was reported by 43% of the children; these children showed better performance on ball skills and dynamic balance. This study demonstrates the importance of improving deaf children's motor skill performance, which might contribute positively to their sports participation.

In the Netherlands, the prevalence of deafness among children aged 5 or older is 0.7 per 1,000 (Lamoré, Kapteyn, & Franck, 2000). Deaf children experience difficulties in their individual development, which may be reflected in their social, emotional, cognitive, language, and motor development (Bat-Chava, Martin, & Kosciw, 2005; Freeman, Carbin, & Boese, 1981; Obrzut, Maddock, & Lee, 1999; Vostanis, Hayes, Du Feu, & Warren, 1997). One of the reasons why motor development is important to a child's development is that adequate levels of motor skills may contribute to lifelong enjoyment of physical activity, participation in sports (Dummer, Haubenstricker, & Stewart, 1996; Krombholz, 2006), and healthy lifestyles (Stewart & Ellis, 1999). Indeed, deficiencies in motor skills could predispose people to inactive behavior (Frey & Chow, 2006; Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006) or less participation in sports (Okely, Booth, & Patterson, 2001); this may also be the case for deaf children.

In their review study assessing the psychomotor abilities of hearing impaired children and youth, Goodman and Hopper (1992) reported few studies on severe or profoundly deaf children (> 65 dB hearing loss). The results these presented on

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motor skills were generally inconclusive, though there was agreement regarding static balance, indicating lower static balance among deaf children compared with hearing children (Boyd, 1965; Brunt & Broadhead, 1982; Campbell, 1983; Lindsey & O'Neal, 1976; Pender & Patterson, 1982; Vance, 1968). The findings with regard to other motor skills (dynamic balance, manual dexterity, and ball skills) of deaf children were not as distinct as it was in the area of static balance. It has been suggested that some of the earlier research on the motor performance of deaf children had confounding factors that might have been responsible for the deficits in the deaf children's motor skills (Gheysen, Loots, & Van Waelvelde, 2008; Horn, Pisoni, & Miyamoto, 2006). In more recent studies, inferior motor performance was found in deaf children, possibly attributable to a longer reaction time (Savelsbergh, Netelenbos, & Whiting, 1991). Furthermore, deaf children had lower scores relative to hearing children in ball skills (Dummer et al., 1996; Savelsbergh et al., 1991). Some recent studies included profoundly deaf children using cochlear implants (CI; Cushing, Chia, James, Papsin, & Gordon, 2008; Horn, Pisoni, Sanders, & Miyamoto, 2005; Kutz, Wright, Krull, & Manolidis, 2003; Schlumberger, Narbona, & Manrique, 2004; Shin, Kim, Kim, Park, Kim, & Oh, 2007). This raises the question of whether deaf children with CI have motor problems. The findings are conflicting: Three of the studies found no differences in motor skills between deaf children with a CI and hearing children, and two studies found inferior motor skill performance in deaf children with a CI. Schlumberger et al. (2004) concluded that the auditory stimulation from a CI is insufficient to enable completely normal motor skill performance, because children with a CI showed delay relative to hearing children in development of complex motor sequences and balance.

Based on the literature, we posed the first research question: Do deaf children have lower motor skills compared with children without disabilities? The second research question was this: Do deaf children who participate in sports have higher motor skills compared with deaf children who do not? Sports participation is important for deaf children, as participants experience physical, psychological, and social benefits (Stewart, 1991). Furthermore, a deaf child who experiences success in physical activity or sport might be more likely to adopt a physically active lifestyle (Lieberman, Volding, & Winnick, 2004). The second research question is based upon the so-called activity-deficit hypothesis, which proposes that it is difficult for children with motor problems to participate in physical activity, especially when their peers begin to perform in more competitive and demanding settings (Wall, 2004)—as is the case, for example, in organized sports. It is difficult for children with motor problems to acquire the expertise they require in more demanding, spatially and temporally constrained environments. Wall (2004) illustrated the physical-activity-deficit hypothesis with results from several studies: Children with movement difficulties frequently avoided participation in physical activity (Bouffard, Watkinson, Thompson, Caugrove Dunn, & Romanow, 1996), they spent considerably more time in nonmotoric behaviors than their more skilled peers during physical education lessons (Thompson, Bouffard, Watkinson, & Caugrove Dunn, 1994), or they opted for easier tasks if these were available (Bouffard et al., 1996).

With regard to the second research question, Wrotniak et al. (2006) showed in their study of children without disabilities aged 8–10 that those who had better motor abilities were more physically active and less likely to be sedentary than those with poorer motor skills. In addition, Graf and colleagues (2004) found in children without disabilities aged 6–9 that better gross motor performance was related to more participation in organized sports. To our knowledge, this relationship has not been investigated in deaf children to date. Therefore, this study aimed to examine motor performance in deaf elementary school children and its association with sports participation.

Method

Participants

Fifty-one deaf children aged 6–12 were eligible to participate in this study. They were recruited from a special institute for deaf children in the northern Netherlands where two languages are used: Dutch sign language (the institute's official language) and spoken Dutch. From the children's individual files, it appeared that 6 children had other physical problems (forms of cerebral palsy) and 3 children had cochlear implants; these 9 children were excluded from the study population. The final study population included 42 native Dutch children (24 girls and 18 boys) and their mean age was 9.8 years (*SD* = 1.7; range 7–12). From the children's individual files, it appeared that 33.3% of the children had a below-average IQ: borderline (70 < IQ < 80) or mild intellectual disability (49 < IQ < 71; Diagnostic and Statistical Manual of Mental Disorder IV, 1994). Fifty percent of the children had an average IQ, and 16.7% of the children had an above-average IQ. The children were profoundly deaf and the onset of deafness had been before the age of 2. Table 1 shows the degree of hearing loss and the diagnosis of the children in the study. The mean body height of the children was 142.2 cm (*SD* = 11.4) and their mean body weight was 34.7 kg (*SD* = 7.4). Compared with reference values for the Body Mass Index of children, 2.4% of the deaf children were underweight, 88.1% were of normal weight, 7.1% were overweight and 2.4% were obese (Cole, Bellizzi, Flegal, & Dietz, 2000). The children participated in two 45-min general physical education classes at the institute where the activities included athletics, gymnastics, swimming, sport skills, and self-defense.

Informed consent to participate was obtained from the children's parents. The procedures were in accordance with the ethical standards of the Faculty of Medical Sciences of the University of Groningen.

Materials

Movement Assessment Battery for Children. The Movement Assessment Battery for Children (MABC) was used as test battery (Henderson & Sugden, 1992). This is a widely used, standardized assessment of motor performance in children with or without movement difficulties (Smits-Engelsman, Fiers, Henderson, & Henderson, 2008; Smits-Engelsman, Henderson, & Michels, 1998). The Dutch version was used, which Smits-Engelsman (1998) has translated into Dutch and validated for Dutch children. There are four age bands (4–6, 7–8, 9–10, and 11–12 years), each consisting of eight items in 3 subtests: manual dexterity (3 items), ball skills (2 items), and static and dynamic balance (3 items). Each item is scored on a scale from 0 to 5. Summing the item scores of the three subtests produces a profile of the child's performance. The manual dexterity subtest score

Table 1 Degree of Hearing Loss and Diagnosis of the Children in the Study (n = 42)

Mean Hearing Loss in dB (min, max)	101 (80–120)
Origin of deafness (n)	
Congenital	78.6% (33)
Acquired	21.4% (9)
Cause of deafness (n)	
Genetic	31.0% (13)
Meningitis	11.9% (5)
Waardenburg syndrome	2.4% (1)
Unknown	54.8% (23)

varies from 0 to 15, the ball skill subtest score from 0 to 10, and the static and dynamic balance subtest from 0 to 15. The three subtest scores can be summed to produce a total test score, ranging between 0 and 40. High scores indicate poor motor performance. The three subtest scores and the total test score can be transformed into percentile scores that show the child's level of performance in comparison with its peers on the basis of results of a normative sample (see Henderson & Sugden, 1992). The range between the 100th and 16th percentile was regarded as "no motor problems," 15th to 6th percentile as "borderline motor problems," and the 5th percentile and below as "definite motor problems." Other studies have shown that the test has acceptable validity and reliability. In the normative sample, interrater reliability ranged from 0.70 to 0.89 and a test-retest reliability was 0.75 (Henderson & Sugden, 1992). The MABC has been used in a wide range of study populations, such as deaf children (Gheysen et al., 2008), children with learning disabilities (Van Waelvelde et al., 2004), children born prematurely (Jongmans, Mercuri, De Vries, Dubowitz, & Henderson, 1997), children with Down Syndrome (Spano et al., 1999), and children with visual impairments (Houwen, Visscher, Lemmink, & Hartman, 2008). Studies on the validity of the MABC, and especially evidence based on relations to other variables (American Psychological Association, 1999), revealed Spearman correlation coefficients varying from 0.6–0.8 between the score on the MABC and other tests in a study of children from mainstream schools and special education schools (Van Waelvelde, De Weerdt, De Cock, & Smits-Engelsman, 2004).

For our study, an expert in sign language from the institute for deaf children trained the test administrators how to explain the items of the MABC using sign language. The children were tested individually at school during physical education. Before test administration, a pilot-study was conducted with five deaf children who were not involved in the current study. During administration of each test item, the skill being assessed was demonstrated and instructions were provided using sign language, spoken language, and pictures of the test item. During the demonstration, the test leaders emphasized the most important features in sign language, as suggested by Henderson and Sugden (1992). After the demonstration, the children were asked to indicate if the explanation was entirely clear. If not, the test was demonstrated again. During the test administration, one teacher was present to provide assistance in case of communication problems.

Sports Participation

The children were asked to complete a short questionnaire about their active involvement in organized sports. Organized sports were defined as being performed under the supervision of a trainer on a regular weekly basis, within a sports club setting (Okely et al., 2001) and involving regular training or competition for a minimum of 1 hr per week. The children were asked to fill in a printed version of the questionnaire individually. The questionnaire was administered in the morning in the classroom by a teacher, who was permitted to give explanations in sign language of words that were not understood. The teacher was familiar to the children, and he could assist if there were any communication problems. The questionnaire included questions on membership of a sports club, its name, number of hours of sports participation at the club per week, and the type of sport. The children were asked about the name of their sports club to check whether they had understood the questions correctly. The reliability and validity of the questionnaire had been tested in a pilot study in a population of children with intellectual disabilities. The test-retest reliability of the questionnaire for the questions “membership of a sports club” and “participation in organized sports with a minimum of 1 hr per week” was “very good” (Cohen’s Kappa > 0.9). The validity of the questionnaire, and especially evidence based on relations to other variables (American Psychological Association, 1999), revealed a correlation of 0.64 between “number of hours organized sports per week” and their physical activity pattern (number of counts measured by accelerometry), which can be interpreted as a “large effect” (Field, 2005).

Data Analysis

The data were analyzed using SPSS for Windows 11.0. The children’s motor performance was classified as “no motor problems,” “borderline motor problems” (below the 15th percentile), or “definite motor problems” (below the 5th percentile) in comparison with the percentages expected in the normative sample (which were 85%, 10%, and 5%, respectively). The classification was tested using a Chi-square test. The percentage of children with borderline and definite motor problems was compared with the percentage of children with no motor problems. In addition, the classification was made per test item (according to Henderson & Sugden, 1992), and Chi-square tests were used to test the differences between the items. Chi-square tests were also conducted to test differences between children with average or above-average IQ and children with average or above-average IQ. No analysis was conducted with children who were not overweight and overweight children, because the number of children in the overweight group was too small ($n = 4$).

For evaluating the differences in motor performance per subtest and per item between children who participated in organized sports and children who did not, an analysis of covariance (ANCOVA) was conducted, controlling for age band, BMI (in categories), and IQ (in categories). For all analyses, a statistical significance level of 0.05 was used.

Results

Motor Performance of Deaf Children

Table 2 gives the results of the children for the MABC. The percentage of children with borderline and definite motor problems was 61.9% for manual dexterity, 52.4% for ball skills, and 45.3% for balance skills. On all subtests, significantly more deaf children were classified as having borderline and definite motor problems than would be expected in the normative sample (manual dexterity: $\chi^2 = 72.47$, $p = 0.000$; ball skills: $\chi^2 = 46.03$, $p = 0.000$; balance skills: $\chi^2 = 30.12$, $p = 0.000$). Deaf children with below-average IQ did not differ significantly from the children with average or above-average IQ on the three subtests (manual dexterity: $\chi^2 = 2.47$, $p = 0.116$; ball skills: $\chi^2 = 0.05$, $p = 0.827$; balance skills: $\chi^2 = 0.192$, $p = 0.661$).

From the classifications per test item, it appeared that on all test items except dynamic balance while moving fast, deaf children ($n = 42$) scored significantly differently from the normative sample: more deaf children were classified as having borderline and definite motor problems. The highest percentages of children with borderline and definite motor problems were obtained for static balance (76%) and eye-hand coordination (76%). Table 3 gives the results of the differences between the items. For manual dexterity skills, the best performance was obtained for bimanual coordination (item 2; 26.2% of the children had borderline and definite motor problems), followed by speed and accuracy of each hand separately (item 1; 50% of the children had borderline and definite motor problems) and eye-hand coordination (item 3; 76.2% of the children had borderline and definite motor problems). For ball skills, the performance on catching a moving object (item 1; 28.6% of the children had borderline and definite motor problems) was significantly better than performance on aiming at goal (item 2; 50% of the children had borderline and definite motor problems). For balance skills, the performance on dynamic balance while moving fast or slowly (items 2 and 3; 26.2% of the children had borderline and definite motor problems) was significantly better than performance on static balance (item 1).

Association Between Deaf Children's Motor Skills and Their Sports Participation

Participation in organized sports for a minimum of 1 hr per week was reported by 42.9% ($n = 18$) of the children. This compares with the figure of 67% for the participation in organized sports by children without disabilities aged 6–12 in the northern Netherlands reported by Hartman, Visscher, and Houwen (2007). All children participated in organized sports with hearing children. The following sports were reported by the deaf children: soccer (38.8%), basketball (16.7%), judo (11.1%), hockey (11.1%), gymnastics (5.6%), horse riding (5.6%), cycle racing (5.6%), and water polo (5.6%). None of the deaf children participated in more than one organized sport. On average, their participation in their chosen organized sport was 1.94 hr per week ($SD = 0.87$). Most of the children (76.2%) participated in organized sports for more than two hours per week. The children were training 1–3 times per week on average, and they participated in competition. The frequency

Table 2 MABC Scores for the Children in the Study (n = 42) Compared With the Normative Sample[a] per Subtest and per Test Item

	No Motor Problems % (n)	Border-line Motor Problems % (n)	Definite Motor Problems % (n)	χ^2	p
Total MABC score	35.7 (15)	16.7 (7)	47.6 (20)	166.45	0.000
Manual dexterity	38.1 (16)	19.0 (8)	42.9 (18)	134.70	0.000
1. Speed and accuracy of each hand separately	50.0 (21)	31.0 (13)	19.0 (8)	41.07	0.000
2. Bimanual coordination	73.8 (31)	9.5 (4)	16.7 (7)	12.06	0.002
3. Eye-hand coordination	23.8 (10)	26.2 (11)	50.0 (21)	199.61	0.000
Ball skills	47.6 (20)	23.8 (10)	28.6 (12)	61.59	0.000
1. Catching a moving object	71.4 (30)	16.7 (7)	11.9 (5)	6.78	0.034
2. Aiming at goal	50.0 (21)	26.2 (11)	23.8 (10)	46.78	0.000
Balance	54.8 (23)	16.7 (7)	28.6 (12)	53.06	0.000
1. Static balance	23.8 (10)	28.6 (12)	47.6 (20)	185.56	0.000
2. Dynamic balance while moving fast	73.8 (31)	19.0 (8)	7.1 (3)	4.44	0.108
3. Dynamic balance while moving slowly	73.8 (31)	7.1 (3)	19.0 (8)	17.54	0.000

[a] Percentages of the normative sample: definite motor problems: 5%, borderline motor problems: 10%, and no motor problems: 85%

Table 3 Comparison of the Items From the MABC: Testing the Percentage of Children (n = 42) With Borderline and Definite Motor Problems

	Borderline and Definite Motor Problems % (n)	Item 1 Versus Item 2 χ^2 (p)	Item 2 Versus Item 3 χ^2 (p)	Item 1 Versus Item 3 χ^2 (p)
Manual dexterity				
1. Speed and accuracy of each hand separately	50.0 (21)	9.52	54.28	11.52
2. Bimanual coordination	26.2 (11)	(0.002)	(0.000)	(0.001)
3. Eye-hand coordination	76.2 (32)			
Ball skills				
1. Catching a moving object	28.6 (12)	9.42	—	—
2. Aiming at goal	50.0 (21)	(0.002)		
Balance				
1. Static balance	76.2 (32)	57.92	0.00	57.92
2. Dynamic balance while moving fast	26.2 (11)	(0.000)	(0.999)	(0.000)
3. Dynamic balance while moving slowly	26.2 (11)			

of competition was dependent on their level of competition, and varied from once per week to several times per year. Table 4 presents the results of the MABC, according to whether the children participated in sports. In general, the children who participated in sports showed no significantly different motor performance than the children who did not. For manual dexterity and balance skills, children who participated in sports did not have significantly different scores from those who did not. For ball skills, however, there was a significant difference between the groups: the children who participated in sports had lower (i.e., better) scores than those who did not.

Analysis per item revealed significant associations, favoring children who participated in sports, for "catching a moving object" (F = 5.520, $p = 0.024$), "aiming at goal" (F = 4.163, $p = 0.049$), and "dynamic balance while moving fast" (F = 4.547, $p = 0.040$). No associations were found for the other test items ($p > 0.1$).

Table 4 MABC Scores: Comparison Between Children Who Participated in Sports (*n* = 18) and Children Who Did Not (*n* = 24), per Subtest and per Test Item

	Sports Participation M (*SD*)	No Sports Participation M (*SD*)	F	*p*
Total MABC score	12.28 (5.14)	15.98 (9.17)	0.673	0.417
Manual dexterity	6.08 (2.02)	6.27 (4.45)	0.087	0.770
1. Speed and accuracy of each hand separately	1.86 (1.77)	1.72 (1.65)	0.001	0.981
2. Bimanual coordination	0.61 (1.38)	1.57 (2.00)	0.735	0.397
3. Eye-hand coordination	3.61 (1.58)	2.87 (2.03)	2.201	0.147
Ball skills	1.83 (1.70)	4.44 (3.13)	6.031	0.019
1. Catching a moving object	0.44 (0.94)	1.89 (1.86)	5.520	0.024
2. Aiming at goal	1.39 (1.24)	2.52 (1.90)	4.163	0.049
Balance	4.08 (3.25)	5.65 (4.13)	0.461	0.501
1. Static balance	2.92 (1.92)	3.33 (1.72)	0.001	0.981
2. Dynamic balance while moving fast	0.44 (1.34)	1.65 (2.17)	4.547	0.040
3. Dynamic balance while moving slowly	0.72 (1.23)	0.83 (1.50)	0.132	0.718

Note. The better the performance, the lower the score; ANCOVA, controlling for age band, BMI, and IQ.

Discussion

The aim of the current study was to examine motor performance in deaf elementary school children and its association with sports participation. The study revealed that on the three subtests, manual dexterity, ball skills, and balance, more deaf children were classified as having borderline and definite motor problems than the normative sample. The highest percentage of children with borderline and definite motor problems was obtained for the items “eye-hand coordination” and “static balance.” In general, children who participated in sports did not show significantly different motor performance compared with children who did not, but they had lower (i.e., better) scores on specific motor items: “catching a moving object,” “aiming at goal,” and “dynamic balance while moving fast.”Motor Skill Performance of Deaf Children

The skills causing most problems for the deaf children were eye-hand coordination (which measures accuracy during drawing) and static balance. This raises the question of whether the deficit in motor skills is due to deafness or due to low IQ scores (one third of the deaf children had below-average IQ scores)—or both. The results revealed that both subgroups of deaf children showed deficits in motor skills and that the two groups were not statistically significantly different from each other. From this we conclude that the deficit in motor skills is not due to low intelligence of the children. Although it seems that the deficit in motor skills is due to deafness, it should be acknowledged that other factors that were not taken into account may also have played a role.

The problems with accuracy in eye-hand coordination were not expected, because the children in our study population used sign language as their main language. This refutes the contention that deaf children develop superior eye-hand coordination to compensate for their hearing loss (Brunt & Broadhead, 1982). They found that severe and profoundly deaf children (aged 7–14) were superior on items of eye-hand coordination (drawing a line and copying a circle) compared with hearing children. An unexpected finding was that the children demonstrated greater deficiencies in eye-hand coordination (76% had borderline and definite motor problems) than in catching a moving object (29% had borderline and definite motor problems). One could argue that the latter skill requires a high level of the former skill. There seem to be several explanations for the differences in performance between the items eye-hand coordination and catching a moving object. First, in the MABC, skills seem to be task-specific. Haga, Pedersen, and Sigmundsson (2008) found low correlations between eye-hand coordination and ball skills in their study of young children. They stated that eye-hand coordination, as measured by the MABC, is a specific motor skill. It requires eye-hand coordination in the control of a pen or pencil. Haga et al. (2008) argued that the fine motor coordination for handwriting is only one of the many skills categorized under fine motor control. Second, the differences may be explained by the association between the motor and language development of the children. Many deaf children experience communication and language disorders (Sherrill, 1998), which may have consequences for the development of specific motor skills. This can be illustrated by citing two studies. Horn et al. (2006) concluded that the impact of hearing impairment and its associated language problems, on the development of fine motor skills, could be different from that on the development of gross motor skills. They suggested a disassociation between fine and gross motor development in deaf children. In their study, gross motor skills (skills relating to general balance, postural control, and walking, for example "rolling a ball while sitting") as well as fine motor skills (skills relating to manual behaviors, for example "cutting paper along a line with scissors") were measured. It appeared that fine motor skills, in contrast to gross motor skills, tend to lag behind as the deaf children grow older. Estil, Whiting, Sigmundsson, and Ingvaldsen (2003) concluded that where motor and language impairments co-occur, the motor deficiencies may be restricted to a small number of fine motor skills. Their study of children with language problems showed that these children had problems with the manual dexterity items of the MABC (bimanual coordination and eye-hand coordination) but not with regard to ball skills.

Our finding of highly impaired performance on static balance (in comparison with the dynamic balance items) replicates findings from other studies (Boyd, 1965; Brunt & Broadhead, 1982; Campbell, 1983; Lindsey & O'Neal, 1976; Pender & Patterson, 1982; Vance, 1968). This supports the suggestion of Siegel, Marchetti, and Tecklin (1991) that most deaf children are not able to compensate for their balance deficits by using other sensory systems, such as vision or kinesthesis. The deaf children's problems with static balance may be partly attributable to vestibular problems. Deaf children are at risk for vestibular dysfunction because damage to the inner ear may extend to the vestibular system as well (Suarez et al., 2007). In our study, vestibular functioning was not measured, so it was not possible to determine to what extent impaired performance on static balance might be attributable to vestibular deficits.

Significant differences between deaf children and children without disabilities, favoring the latter group, were found for all motor items, except "dynamic balance while moving fast." Several mechanisms might account for this finding. Profoundly deaf children do not have auditive feedback during learning and regulation of motor skills, they do not have auditive feedback from their own movements, they do not rehearse movements as a result of intriguing or pleasant sound effects, and they cannot use auditive information visual orientation behavior (Savelsbergh et al., 1991; Visscher, 2000; Wiegersma & Van der Velde, 1983). Furthermore, they may have deficient "internalized" language while learning motor skills (Kohen-Raz & Masalha, 1988). In future studies, it would be interesting to investigate which mechanisms could account for deaf children's deficits in motor performance.

Motor Skills and Sports Participation

Deaf children who participated in organized sports performed significantly better on ball skills (catching a moving object and aiming at goal) than those who did not. Apparently, there is no evidence for a global association between motor skill performance and sports participation. However, a more specific association can be suggested. The results are in line with a study of children with other sensory impairments (visual impairments), which showed an association between object control skills and sports participation but not between locomotor skills and sports participation (Houwen, Visscher, Hartman, & Lemmink, 2007). A plausible explanation for the finding of a specific association between ball skills and sports participation is that the most frequently mentioned sports were ball sports (72% of the children who participated in sports). The results showed that deaf children can perform ball skills relatively successfully compared with other items (for example eye-hand coordination and static balance). Successful performance on ball skills might stimulate sports participation. However, it should be noted that children at this age participate in sports not solely because of their superior motor skills, but also because of aspects such as parental and peer influence (Starkes & Ericsson, 2003). In turn, increased levels of participation in ball games might result in increased levels of skills such as kicking, throwing, catching, and rolling. The results for ball skills are in contrast with the results reported by Smyth and Anderson (2001), who found no relationship between ball skills and participation in soccer in children with a developmental coordination disorder (DCD). A possible explanation for the different findings in our study is that we included not only soccer, but also other ball sports that may have a stronger relationship with certain ball skill items (such as catching and rolling) than soccer.

Deaf children who participated in organized sports performed significantly better on "dynamic balance while moving fast." This item is an important factor in sports participation. For example, Butterfield (1991) found that the performance on dynamic balance was related to the performance on running, which is one of the fundamental motor skills important for sport and recreation. The results are in line with Smyth and Anderson (2001), who in their study found a relationship between balance skills and participation in soccer, with the biggest contribution to "dynamic balance while moving fast."

In the current study, it was remarkable that children who participated in organized sports did not perform significantly better on static balance. A possible explanation for this is lack of variety in the study population, as about half of the deaf children had definite motor problems for this item.

Study Limitations

An association was found between specific motor items and sports participation. Because of the cross-sectional nature of the study, the results give no insight into the causality of the association: Does better motor performance lead to increased sports participation, or vice versa? Furthermore, the small study sample and the general information on the sports participation did not allow us to investigate the association between motor skill performance and types of sports or degree of sports participation (in number of hours per week).

Recommendations for Future Research

Future longitudinal studies in larger study samples and more variety in motor skill performance are needed to identify more specific associations between motor skill performance and sports participation in deaf children.

Conclusion

In conclusion, this study showed that deaf elementary school children have inferior motor performance, the most problems being experienced in performance on eye-hand coordination and static balance. The MABC can be used as instrument to measure improvement of deaf children's motor skill performance. Deaf children who participated in organized sports showed better performance on ball skills and dynamic balance than children who did not. It is assumed that increased levels of specific motor skills (ball skills and "dynamic balance while moving fast") might contribute positively to deaf children's sports participation.

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