

PEDIATRICS®

OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Motor Profile of Children With Developmental Speech and Language Disorders

Chris Visscher, Suzanne Houwen, Erik J.A. Scherder, Ben Moolenaar and Esther Hartman

Pediatrics published online Jun 18, 2007;

DOI: 10.1542/peds.2006-2462

The online version of this article, along with updated information and services, is located on the World Wide Web at:

<http://www.pediatrics.org/cgi/content/full/peds.2006-2462v1>

PEDIATRICS is the official journal of the American Academy of Pediatrics. A monthly publication, it has been published continuously since 1948. PEDIATRICS is owned, published, and trademarked by the American Academy of Pediatrics, 141 Northwest Point Boulevard, Elk Grove Village, Illinois, 60007. Copyright © 2007 by the American Academy of Pediatrics. All rights reserved. Print ISSN: 0031-4005. Online ISSN: 1098-4275.

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN™



Motor Profile of Children With Developmental Speech and Language Disorders

Chris Visscher, PhD^{a,b}, Suzanne Houwen, MSc^{a,b}, Erik J. A. Scherder, PhD^a, Ben Moolenaar, BEd^c, Esther Hartman, PhD^a

^aCenter for Human Movement Sciences and ^bUniversity Center for Sport, Movement, and Health, University Medical Center Groningen, University of Groningen, Groningen, Netherlands; ^cHanze Institute for Sports Studies, Hanze University Groningen, Groningen, Netherlands

The authors have indicated they have no financial relationships relevant to this article to disclose.

ABSTRACT

OBJECTIVES. The purpose of this study was to investigate the motor profile of 125 children with developmental speech and language disorders and to test for differences, if any, in motor profile among subgroups of children with developmental speech and language disorders.

METHODS. The participants were 125 children with developmental speech and language disorders aged 6 to 9 years from 2 special schools for children with communication problems in the northern Netherlands. They were tested with the Movement Assessment Battery for Children. The children were classified by the schools' speech and language therapists into 3 subgroups on the basis of language tests, oral motor tests, and clinical examinations: children with speech disorders ($n = 14$), language disorders ($n = 46$), or both ($n = 65$).

RESULTS. Compared with the norms of the Movement Assessment Battery for Children, children with developmental speech and language disorders performed significantly less well. Results showed that 51% of the children with developmental speech and language disorders had borderline or definite motor problems. Children with language disorders had significantly lower scores (ie, better performance) on the ball-skills subtest and the total test than children with speech disorders and children with both speech and language disorders. Furthermore, children with language disorders had significantly better performance on the balance subtest than children with both speech and language disorders.

CONCLUSIONS. The findings of this study support the idea that developmental speech and language disorders are frequently associated with motor problems and that the kind of developmental speech and language disorders affects motor performance differently. Speech and language disorders seem to have more impact on motor performance than only language disorders, and it seems that when speech production is affected, motor problems are more pronounced. The findings support the need to give early and more attention to the motor skills of children with developmental speech and language disorders in the educational and home setting, with special attention to children whose speech is affected.

www.pediatrics.org/cgi/doi/10.1542/peds.2006-2462

doi:10.1542/peds.2006-2462

Key Words

motor development, language development disorders, children

Abbreviations

DSLD—developmental speech and language disorder
ABC—Assessment Battery for Children
DCD—developmental coordination disorder

Accepted for publication Dec 12, 2006

Address correspondence to Chris Visscher, PhD, Center for Human Movement Sciences, University of Groningen, PO Box 196, 9700 AD, Groningen, Netherlands. E-mail: c.visscher@rug.nl

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275). Copyright © 2007 by the American Academy of Pediatrics

DEVELOPMENTAL SPEECH AND language disorders (DSLDS) are characterized by delays in speech and language development in the absence of mental or physical handicap, hearing loss, emotional disorder, or environmental deprivation.¹ The clinical picture is quite varied; many children have speech as well as language disorders, others may have pure speech disorders or pure language disorders.² The prevalence of DSLDS varies from 1.3% to 7.4%, depending on the definition used.²⁻⁴

Although most attention has been paid to the communication profile of children with DSLDS, it has been shown that motor problems are not uncommon in this population.⁵⁻⁹ The co-occurrence of motor problems and DSLDS may be explained by both factors within the child, such as a genetic risk or neurologic deficits,^{2,10-12} and environmental factors, such as communication difficulties negatively influencing social acceptance and participation in play and sports activities.^{13,14}

The majority of studies concerning motor problems in children with DSLDS mainly focused on fine motor tasks.¹⁵ Studies indicate that these children are significantly slower than regular children on tasks that mainly challenge eye-hand coordination (ie, pegboard, threading beads, fastening buttons, and tapping).^{2,16,17} Of note is that motor problems seem to not be restricted to tasks involving time constraints.^{18,19} For gross motor skills, it has been observed that skills like stepping, running, stair climbing, muscle tone, standing on 1 leg, hopping on 1 leg, toe gait, heel gait, and skills that involve object control or locomotor activity of children with language problems were poor relative to regular children.^{6,19} Moreover, balancing on 1 leg proved to be 1 of the most discriminating measures between children with specific language impairment and regular children.¹⁸ In contrast, results of an early study found no difference between children with specific language impairment and regular children in duration of balance.²⁰

Quite clearly there is strong evidence of clinically significant overlap between DSLDS and motor problems; however, 2 things are of note. First, hardly any attention has been paid to ball skills of children with DSLDS, although these skills explicitly may challenge eye-hand coordination, depend on balance control, and importantly contribute to the child's social interaction with peers.^{21,22} Because children with DSLDS may already have problems with social acceptance,¹⁴ because of their communication difficulties,¹³ inadequate ball skills may further restrict the child's capacity to interact socially and physically with peers. Within this scope, it is noteworthy that recent epidemiologic studies emphasize the value of a social and physical active lifestyle, particularly when started early in life.^{23,24} One of the major effects of such a lifestyle is reducing the risk for cognitive impairment later in life.²⁴

Second, research examining the motor performance of subgroups of children with DSLDS is limited. Hill¹⁵

suggested that subgroups of children with DSLDS differ in their performance on fine motor tasks. Bishop² addressed the issue of subtype-specific differences in relation to motor performance and found some interesting results. In 2 twin studies where 1 or both twins had speech/language impairment along with a control group of unaffected children, she found that children with combined speech and language impairments obtained poorer scores on a pegboard and tapping task than unaffected children. Furthermore, she concluded that the link between speech/language impairments and motor problems was stronger for speech than for language impairments. It is important to gain insight in the performance profile of subgroups of children with DSLDS, because this information may provide clues for effective intervention.

Specifically, this study had 2 aims. The first aim was to investigate the motor profile of children with DSLDS with respect to manual dexterity, ball skills, and balance. The second aim was to test for differences, if any, in motor profile among 3 subgroups of children with DSLDS: children with speech disorders, children with language disorders, and children with both speech and language disorders.

METHODS

Participants

A total of 125 children with DSLDS aged 6 to 9 years (93 boys and 32 girls; mean age: 7.4 years; SD: 1.1 years) were recruited from 2 special schools for children with communication problems in the northern Netherlands. Children with other impairments, like hearing impairments or physical impairments, were excluded from the study. No child had an intelligence quotient <80.

Subtests of the Dutch Language Test for Children (Taaltest voor Kinderen)²⁵ have been used by the schools' speech and language therapists to establish the diagnosis of the children. This test battery is composed of subtests that provide information about the child's receptive and expressive language skills in the areas of morphology, syntax, and semantics. The word forms production test (woordvormen produktie test), the syntax production test (zinsbouw produktie test), and the vocabulary production test (woordenschat produktie test) were used to provide information about a child's expressive language skills. The concealed meaning test (verzwegen betekenis test), the syntax choice test (zinsbouw keuze test), syntax evaluation test (zinsbouw beoordeling test), and the vocabulary choice test (woordenschat keuze test) were used to provide information about a child's receptive language skills. Speech skills (oral motor function) were assessed with both oral motor tests and clinical examinations.

The children were considered to have language and/or speech problems when the speech and language

therapists had noted a deviation of ≥ 1 SD compared with age standards. The schools' speech and language therapists independently reviewed the available data to classify the children into 3 subgroups of DSLDs. The few discrepancies in classification were discussed until consensus was reached.

It was found that 46 children had language problems (34 boys and 12 girls; mean age: 7.7 years; SD: 1.1 years), of which 26 had expressive problems and 20 had mixed expressive-receptive problems. Sixty-five children had both speech and language problems (50 boys and 15 girls; mean age: 7.2 years; SD: 1.1 years), of which 43 had expressive language problems combined with oral motor problems and 22 had expressive-receptive language problems combined with oral motor problems. Fourteen children had oral motor problems (9 boys and 5 girls; mean age: 7.3 years; SD: 1.3 years). The 3 groups did not differ significantly on age (analysis of variance: $F_{2,122} = 2.88$; $P > .05$).

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.

Movement Assessment Battery for Children

The Movement Assessment Battery for Children (ABC) is a test battery designed for diagnosis of delays or deficits in motor development.²² The Movement ABC consists of 4 age-related item sets (4–6, 7–8, 9–10, and 11–12 years). Each set is built up of 8 tasks, which are assessed under the following 3 subtests: manual dexterity, ball skills, and static and dynamic balance. Only the first 3 age-related item sets were used, because the study was performed with children from 6 to 9 years old.

Each item is scored on a scale from 0 to 5. Summing the item scores of the 3 subtests produces a profile of the child's performance. The manual-dexterity subtest score varies from 0 to 15, the ball-skills subtest score from 0 to 10, and the static and dynamic balance subtest from 0 to 15. The 3 subtest scores can be summed to produce a total test score ranging between 0 and 40. High scores indicate poor motor performance. The 3 subtest scores and the total test score can be transformed into percentile scores that show the child's level of performance in comparison with his or her peers. 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."

The test has acceptable validity and reliability. Interrater reliability ranges from .70 to .89, and the test-retest reliability is .75.²² In an earlier pilot study with 59 children, it seemed that the test-retest reliability of the Movement ABC was .83 for children with communication problems. Van Waelvelde et al²⁶ recently confirmed the concurrent validity of the total test score and the

ball-catching item of the second age band of the Movement ABC.

Procedure

The Movement ABC was administered individually in a quiet room at the school of each participant. Depending on the age and performance level of the individual child, test duration ranged from 25 to 35 minutes. The same examiner conducted all of the testing. The examiner was blind to the subgroup diagnosis of the children with DSLDs. Movement ABC testing was conducted according to the manual of this test.

Data Analysis

The statistics were performed by using SPSS 11.0 (SPSS Inc, Chicago, IL). The difference between the group of children with DSLDs and the normative population with respect to the proportion of children with motor problems was assessed with the χ^2 test. The nonparametric Kruskal-Wallis test was used to determine whether there were differences among median scores on the Movement ABC for the 3 subgroups of children with DSLDs with an α level set at .05. If a significant difference was found between the 3 groups, 2-group Mann-Whitney U comparisons were made. Because type 1 error can be inflated by performing multiple statistical tests, the α level was corrected using the Bonferroni correction and set at .017 for each posthoc comparison (.05 divided by the 3 posthoc comparisons).

To assist in determining the meaningfulness of group effects, correlational effect size statistics for nonparametric data were calculated for each dependent variable. Effect size was calculated by dividing the z score by the square root of the number of children contributing to the analyses. An effect size of $r = 0.10$ was defined as small, $r = 0.30$ as medium, and $r = 0.50$ as large.²⁷

RESULTS

Motor Profile of Children With DSLDs

On the basis of the test, the children were categorized as having definite motor problems, borderline motor problems, or no motor problems (see Table 1). Among the children with definite motor problems, the total test score of the Movement ABC ranged from 13.5 to 36.0.

TABLE 1 Number and Percentage of Children With DSLDs Scoring in the Categories "Definite Motor Problems," "Borderline Motor Problems," and "No Motor Problems" on the Movement ABC

Test	Definite, n (%)	Borderline, n (%)	No Problems, n (%)	χ^2	P
Manual dexterity	25 (20)	16 (13)	84 (67)	61.89	.000
Ball skills	38 (31)	44 (35)	43 (34)	278.32	.000
Balance	23 (19)	19 (15)	83 (66)	53.36	.000
Total test	38 (30)	26 (21)	61 (49)	195.14	.000

The χ^2 test revealed that the proportions of children with DSLDs with borderline motor problems (21%) and definite motor problems (30%) differed significantly ($P < .001$) from the proportions that would have been expected in a normal population (10% and 5%, respectively). Furthermore, it can be seen that a similar picture was obtained for the 3 subtests (see Table 1). The χ^2 tests revealed that more children with DSLDs scored in the category "definite motor problems" and in the category "borderline motor problems" than a normal population for the manual-dexterity, ball-skill, and balance subtests ($P < .001$). This effect was most pronounced for ball skills.

Motor Profile of Subgroups of Children With DSLDs

Table 2 displays the means, medians, SDs, and ranges of performance for each subgroup of children with DSLDs for manual dexterity, ball skills, balance, and total test. Significant differences were found for the ball-skills ($H_2 = 21.42$; $P < .001$) and balance ($H_2 = 7.39$; $P < .05$) subtests and for the total test ($H_2 = 13.85$; $P \leq .001$).

Mann-Whitney U tests with Bonferroni correction showed that children with language disorders scored significantly lower (ie, better performance) on the ball-skills subtest than children with speech disorders ($z = -3.21$; $P \leq .001$; $r = 0.42$) and children with both speech and language disorders ($z = -4.29$; $P < .001$; $r = 0.41$). For the balance subtest, it was found that children with language disorders scored significantly lower than children with both speech and language disorders ($z = -2.69$; $P < .01$; $r = 0.25$). For the total test, the results showed that children with language disorders scores

significantly lower than children with speech disorders ($z = -2.52$; $P < .01$; $r = 0.33$) and children with both speech and language disorders ($z = -3.49$; $P \leq .001$; $r = 0.33$). These effect size statistics represent moderate-to-large effects, except for the balance subtest, where the effect was small-to-moderate. The other posthoc comparisons were nonsignificant with small effect-size statistics.

DISCUSSION

Our study showed that the overall motor performance of children with DSLDs was quantitatively impaired. The children with DSLDs demonstrated deficits in manual dexterity, ball skills, and static and dynamic balance as measured by the Movement ABC. The results revealed that 51% of the children with DSLDs had borderline or definite motor problems. Other studies that used the Movement ABC, or its predecessor the Test of Motor Impairment, in children with speech and language disorders found similar percentages, ranging from 40% to 90%.^{5,7,9,28-30} However, in these studies, no distinction was made between problems in the different subtests or skills. Furthermore, in many other studies often 1 aspect of motor performance, primarily fine motor skills, has been investigated. Striking was that in the present study motor problems in children with DSLDs seemed most pronounced for ball skills as measured by catching a moving object and throwing at a target. Wiznitzer et al³¹ had mentioned that problems could be expected in throwing and catching for children with developmental language disorder.

Why are motor problems in children with DSLDs so considerable? According to the atypical brain development framework, developmental variation in brain structures and functions leads to variation in abilities underscoring the interrelatedness of developmental disorders.¹² Unfortunately, the atypical brain development framework does not address how specific areas of the brain explain particular abilities. In this case, it is interesting to discuss possible mechanisms underlying the present findings. Important brain structures involved in each of the 3 types of motor activity examined in our study are the basal ganglia. In catching a ball, the basal ganglia coordinate the duration of the reach and approach of the ball.³² Furthermore, the basal ganglia play a role in balance control³³ and in some types of manual dexterity such as handwriting.³⁴ Interestingly, a disturbance in language production and speech initiation could be viewed as a consequence of a disturbed function of the left basal ganglia.³⁵ It is also interesting to discuss possible mechanisms underlying the present findings at the level of neural circuits. One of the structures of the basal ganglia is the caudate nucleus, which has a strong functional relationship with the prefrontal cortex.¹⁰ Damage to 1 of these regions may express itself in a decline in the control and execution of movements

TABLE 2 Movement ABC Scores for Children With Speech Disorders, Language Disorders, and Both Speech and Language Disorders

Variable	Speech (n = 14)	Language (n = 46)	Both (n = 65)	Total (N = 125)
Manual dexterity				
Mean	4.35	3.25	4.06	3.79
Median	3.00	2.50	4.00	3.00
SD	4.13	3.03	3.12	3.20
Range	0-12.5	0-12	0-13.5	0-13.5
Ball skills				
Mean	4.58	2.19	4.37	3.59
Median	4.00	2.00	4.00	3.00
SD	2.39	2.28	2.84	2.80
Range	0-9	0-9	0-10	0-10
Balance				
Mean	3.62	2.61	4.52	3.72
Median	3.00	2.00	4.00	3.00
SD	3.42	2.69	3.77	3.46
Range	0-9.5	0-12	0-15	0-15
Total test				
Mean	12.54	8.07	12.77	11.01
Median	10.00	7.00	12.25	10.00
SD	6.09	5.81	7.54	7.12
Range	6.5-24	0-30	0-36	0-36

combined with cognitive deficits, among which are specific language disturbances.¹⁰ A similar clinical outcome emerges from damage to a neural circuit in which the prefrontal cortex closely cooperates with the cerebellum. A disturbance in this latter neural circuit might be responsible for impairments in timing precision found in children with specific language disorders or dyslexia.¹⁰

Environmental factors, however, probably also play a role in the link between DSLDs and motor problems. Children with DSLDs experience communication difficulties,¹³ which may negatively influence social acceptance.¹⁴ Children who have lower levels of social acceptance are supposed to participate less in play with peers. As a consequence, a lack of practice of motor skills may occur, which may result in low levels of motor skills. When one considers that ball skills are a part of many play and sport activities, it seems obvious that less participation in play and sport activities may affect the adequate learning of these skills.

Regarding the effects of subgroup division on motor performance, we found that subgroups differed in motor performance: children with language disorders had better performance than children with speech disorders and children with both speech and language disorders on the ball-skills subtest and total test, and children with language disorders had better performance on the balance subtest than children with both speech and language disorders. Although the differences between children with language disorders and children with speech disorders were only significant for ball skills and the total test, it is worth mentioning that there was a tendency for the children with speech disorders to perform worse than children with language disorders and that their scores were going more in the direction of those obtained by the children with both speech and language disorders. In our study, only 14 children with speech disorders participated, so this is likely to account for the lack of significance. Thus, it seems that when speech production is affected, motor problems are more pronounced. The results are partly in line with the findings of Bishop.² She found that children with both speech and language disorders aged 7 to 13 years showed the greatest motor problems as measured by a peg-moving and tapping task.

What could be the reason that children with speech disorders and children with both speech and language disorders had a worse performance on ball skills and the total test than children with only language disorders? Diversity in outcomes may be the result of the different neural circuits in which brain structures participate.¹⁰ Because of the marked segregation and specificity of inputs and outputs of brain structures, dysfunctions of slightly different parts of a specific brain structure may express themselves in different ways in subgroups of children with DSLDs. Furthermore, for children with both speech and language disorders, it is not inconceiv-

able that having both disorders has a greater impact on social functioning and social behavior than only language disorders because of the more complicated communication.

Our study showed that motor problems were evident in a large proportion of children aged ≥ 6 years. Recently, it has been shown that co-occurrence of motor problems and language delays already exists at the age of 4 years.³⁶ Because the role of verbal communication is less important in play and sports activities of very young children³⁷ but becomes more and more important when children grow older, one might expect the motor problems to become even bigger. Because motor problems may have important consequences for both a child's academic performance and a child's ability to participate in play and sports activities, intervention at an early age is warranted. There is some evidence that interventions may lead to improvements in motor performance of children with speech and language problems.⁷ Information provided by the Movement ABC may be helpful in deciding to provide interventions or not. For children with a score below the 5th percentile, an intervention is imperative, but the mode and type may vary. For children with scores between the 5th and 15th percentile, the decision to intervene has to depend on the impact of the child's motor problems on both daily life motor functioning, as well as other developmental areas, such as social functioning.²² Although a score below the 15th percentile on the Movement ABC is indicative of developmental coordination disorder (DCD), a child has to meet other criteria to be diagnosed as having DCD.³⁸ This means that for the children in our study who scored below the 15th percentile on the Movement ABC, further investigation is warranted. Establishing a diagnosis of DCD was, however, not an aim of this study; therefore, we cannot assert with certainty that these children also have DCD.

A delimitation of this study was the small sample size of the children with only speech disorders and the missing information about the etiology of the disorders. This study, however, is the first onset to give a more comprehensive view of the motor profile of children with DSLDs and differences between subgroups. In future studies, more attention should be given to the motor profiles of children with speech, language, or both speech and language disorders.

CONCLUSIONS

Our results support the idea that DSLDs are frequently associated with motor problems and that the kind of DSLDs affects motor performance differently. Speech and language disorders seem to have more impact on motor performance than only language disorders, and it seems that when speech production is affected, motor problems are more pronounced. The results support the need to give early and more attention to motor devel-

opment of children with DSLDs in the educational and home setting in addition to other developmental skills. Special attention should be given to children with both speech and language disorders.

ACKNOWLEDGMENTS

We thank M. C. B. van der Nagel for her assistance in this research project and all of the teachers, other staff, and children of the schools for their cooperation.

REFERENCES

1. Bishop DVM. The underlying nature of specific language impairment. *J Child Psychol Psychiatry*. 1992;33:3–66
2. Bishop DVM. Motor immaturity and specific speech and language impairment: evidence for a common genetic basis. *Am J Med Genet B Neuropsychiatr Genet*. 2002;114:56–63
3. Keating D, Turrell G, Ozanne A. Childhood speech disorders: reported prevalence, comorbidity and socio-economic profile. *J Paediatr Child Health*. 2001;37:431–436
4. Shriberg LD, Tomblin JB, McSweeney JL. Prevalence of speech delay in 6-year-old children and comorbidity with language impairment. *J Speech Lang Hear Res*. 1999;42:1461–1481
5. Hill EL. A dyspraxic deficit in specific language impairment and developmental coordination disorder? Evidence from hand and arm movements. *Dev Med Child Neurol*. 1998;40:388–395
6. Rintala P, Linjala J. Scores on test of gross motor development of children with dysphasia: a pilot study. *Percept Mot Skills*. 2003;97:755–762
7. Rintala P, Pienimäki K, Ahonen T, Cantell M, Kooistra L. The effects of a psychomotor training programme on motor skill development in children with developmental language disorders. *Hum Mov Sci*. 1998;17:721–737
8. Webster RI, Majnemer A, Platt RW, Shevell MI. Motor function at school age in children with a preschool diagnosis of developmental language impairment. *J Pediatr*. 2005;146:80–85
9. Webster RI, Erdos C, Evans K, et al. The clinical spectrum of developmental language impairment in school-aged children: language, cognitive, and motor finding. *Pediatrics*. 2006;118(5). Available at: www.pediatrics.org/cgi/content/full/118/5/e1541
10. Diamond A. Close interrelation of motor development and cognitive development and of the cerebellum and prefrontal cortex. *Child Dev*. 2000;71:44–56
11. Gilger JW, Kaplan BJ. Atypical brain development: a conceptual framework for understanding developmental learning disabilities. *Dev Neuropsychol*. 2001;20:465–481
12. Kaplan B, Crawford S, Cantell M, Kooistra L, Dewey D. Comorbidity, co-occurrence, continuum: what's in a name? *Child Care Health Dev*. 2006;32:723–731
13. Camarata S, Conture E. Disorders of speech and language development. In: Wolraich M, ed. *Disorders of Development and Learning*. Hamilton, Ontario, Canada: B.C. Decker, Inc; 2003: 175–194
14. Gertner BL, Rice ML. Influence of communicative competence on peer preferences in a preschool classroom. *J Speech Lang Hear Res*. 1994;37:913–923
15. Hill EL. Non-specific nature of specific language impairment: a review of the literature with regard to concomitant motor impairments. *Int J Lang Commun Disord*. 2001;36:149–171
16. Owen SE, McKinlay IA. Motor difficulties in children with developmental disorders of speech and language. *Child Care Health Dev*. 1997;23:315–325
17. Preis S, Schittler P, Lenard HG. Motor performance and handedness in children with developmental language disorder. *Neuropediatrics*. 1997;28:324–327
18. Powell RP, Bishop DVM. Clumsiness and perceptual problems in children with specific language impairment. *Dev Med Child Neurol*. 1992;34:755–765
19. Noterdaeme M, Mildenerger K, Minow F, Amorosa H. Evaluation of neuromotor deficits in children with autism and children with a specific speech and language disorder. *Eur Child Adolesc Psychiatry*. 2002;11:219–225
20. Stark RE, Tallal P. Perceptual and motor deficits in language impaired children. In: Keith RW, ed. *Central Auditory and Language Disorders in Children*. San Diego, CA: College-Hill Press; 1981:121–144
21. Gallahue DL, Ozmun JC, eds. *Understanding Motor Development: Infants, Children, Adolescents, Adults*. 5th ed. New York, NY: McGraw-Hill; 2002
22. Henderson SE, Sudgen DA, eds. *Movement Assessment Battery for Children: Manual*. London, England: Psychological Corporation; 1992
23. Fratiglioni L, Paillard-Borg S, Winblad B. An active and socially integrated lifestyle in late life might protect against dementia. *Lancet Neurol*. 2004;3:343–353
24. Fritsch T, Smyth KA. Associations between dementia/mild cognitive impairment and cognitive performance and activity levels in youth. *J Am Geriatr Soc*. 2005;53:191–196
25. Van Bon WHJ, ed. *Taaltest Voor Kinderen*. Lisse, Netherlands: Swets & Zeitlinger; 1982
26. Van Waelvelde H, De Weerd W, De Cock P, Smits-Engelsman BCM. Aspects of the validity of the Movement Assessment Battery for Children. *Hum Mov Sci*. 2004;23:49–60
27. Field A, ed. *Discovering Statistics Using SPSS*. 2nd ed. London, England: SAGE Publications; 2005
28. Cermak SA, Ward EA, Ward LM. The relationship between articulation disorders and motor coordination in children. *Am J Occup Ther*. 1986;40:546–551
29. Fernell E, Norrelgen F, Bozkurt I, Hellberg G, Löwing K. Developmental profiles and auditory perception in 25 children attending special preschools for language-impaired children. *Acta Paediatr*. 2002;91:1108–1115
30. Robinson RJ. Causes and associations of severe and persistent specific speech and language disorders in children. *Dev Med Child Neurol*. 1991;33:943–962
31. Wiznitzer M, Rapin I, Allen D. Motor function in school-age children with developmental language disorders. *Ann Neurol*. 1986;20:413–414
32. Bullock D. Adaptive neural models of queuing and timing in fluent action. *Trends Cogn Sci*. 2004;8:426–433
33. Visser JE, Bloem BR. Role of the basal ganglia in balance control. *Neural Plast*. 2005;12:161–174; discussion 263–272
34. Siebner HR, Limmer C, Peinemann A, Bartenstein P, Drzezga A, Conrad B. Brain correlates of fast and slow handwriting in humans: a PET-performance correlation analysis. *Eur J Neurosci*. 2001;14:726–736
35. Fabbro F, Clarici A, Bava A. Effects of left basal ganglia lesions on language production. *Percept Mot Skills*. 1996;82:1291–1298
36. Valtonen R, Ahonen T, Lyytinen P, Lyytinen H. Co-occurrence of developmental delays in a screening study of 4-year-old Finnish children. *Dev Med Child Neurol*. 2004;46:436–443
37. Visscher C. *Deafness and Sports*. [In Dutch, English summary]. Groningen, Netherlands: Grafisch Centrum Rijksuniversiteit Groningen; 2000
38. Geuze RH, Jongmans MJ, Schoemaker MM, Smits-Engelsman BCM. Clinical and research diagnostic criteria for developmental coordination disorder: a review and discussion. *Hum Mov Sci*. 2001;20:7–47

Motor Profile of Children With Developmental Speech and Language Disorders

Chris Visscher, Suzanne Houwen, Erik J.A. Scherder, Ben Moolenaar and Esther Hartman

Pediatrics published online Jun 18, 2007;

DOI: 10.1542/peds.2006-2462

Updated Information & Services

including high-resolution figures, can be found at:
<http://www.pediatrics.org/cgi/content/full/peds.2006-2462v1>

References

This article cites 30 articles, 1 of which you can access for free at:
<http://www.pediatrics.org/cgi/content/full/peds.2006-2462v1#BIBL>

Citations

This article has been cited by 1 HighWire-hosted articles:
<http://www.pediatrics.org/cgi/content/full/peds.2006-2462v1#otherarticles>

Subspecialty Collections

This article, along with others on similar topics, appears in the following collection(s):
Developmental/Behavior
<http://www.pediatrics.org/cgi/collection/developmental:behavior>

Permissions & Licensing

Information about reproducing this article in parts (figures, tables) or in its entirety can be found online at:
<http://www.pediatrics.org/misc/Permissions.shtml>

Reprints

Information about ordering reprints can be found online:
<http://www.pediatrics.org/misc/reprints.shtml>

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN™

