Children with behavioral problems and motor problems have a worse neurological condition than children with behavioral problems only

Peters, Lieke H. J.; Maathuis, Carel G. B.; Hadders-Algra, Mijna

Published in:
Early Human Development

DOI:
10.1016/j.earlhumdev.2014.09.001

Publication date:
2014

Early Human Development 90 (2014) 803–807

Contents lists available at ScienceDirect

Early Human Development

journal homepage: www.elsevier.com/locate/earlhumdev

Children with behavioral problems and motor problems have a worse neurological condition than children with behavioral problems only

Lieke H.J. Peters [a,*], Carel G.B. Maathuis [b], Mijna Hadders-Algra [a]

[a] University of Groningen, Department of Paediatrics — Developmental Neurology, Beatrix Children's Hospital, University Medical Center Groningen, Groningen, The Netherlands
[b] University of Groningen, Department of Rehabilitation Medicine, Center for Rehabilitation, University Medical Center Groningen, Groningen, The Netherlands

ARTICLE INFO

Article history:
Received 2 March 2014
Received in revised form 28 August 2014
Accepted 2 September 2014

Keywords:
Minor Neurological Dysfunction
Child Behavior Checklist
Teacher's Report Form
Movement Assessment Battery for Children
School age

ABSTRACT

Background: Some evidence suggests that children with specific behavioral problems are at risk for motor problems. It is unclear whether neurological condition plays a role in the propensity of children with behavioral problems to develop motor problems.
Aims: To examine the relation between behavioral problems, motor performance and neurological condition in school-aged children.
Study design: Cross-sectional study.
Subjects: 174 children (95 boys) receiving mainstream education and 106 children (82 boys) receiving special education aged 6 to 13 years (mean 9 y 7 m, SD 1 y 10 m).
Outcome measures: Behavior was assessed with questionnaires: the parental Child Behavior Checklist (CBCL) and Teacher's Report Form (TRF). Motor performance was assessed with the Movement Assessment Battery for Children (MABC). MABC-scores ≥5th percentile were considered as age-adequate and scores <5th percentile indicated definite motor problems. Neurological condition was assessed in terms of Minor Neurological Dysfunction (MND).
Results: The majority of specific behavioral problems were associated with definite motor problems, except somatic complaints and rule breaking behavior. Children with externalizing problems, according to the CBCL or TRF, and motor problems had more often MND than children with externalizing problems only. The same holds true for internalizing problems according to the CBCL.
Conclusions: The present study demonstrated that various forms of behavioral problems were associated with motor problems. Especially children with motor and behavioral problems showed MND.

1. Introduction

Developmental behavioral disorders and motor problems frequently co-occur during childhood. Especially the relationship between Attention Deficit and Hyperactivity Disorder (ADHD) and Developmental Coordination Disorder (DCD) has been frequently reported [1,2]. Rates of co-occurrence of ADHD and DCD have been stated to be as high as 50% or more [2–4]. Also, children with Autism Spectrum Disorders often show motor problems [5]. However, less is known about the relationship between internalizing and externalizing problems and poor motor performance. A few studies addressed behavioral problems in children with a poor motor performance. Cairney et al. [6] reported that children with a poor motor performance often show internalizing problems. In addition, the recent study of Lingam et al. [7] showed that children with probable DCD have an increased risk of self-reported and parent-reported depression.

It is suggested that neurobiological differences play a role in the pathophysiology of developmental behavioral disorders. To elucidate the role of structural differences in specific behavioral problems, brain imaging studies have been conducted. For example, the meta-analysis of neuroimaging studies by Valera et al. [8] showed that children with Attention Deficit and Hyperactivity Disorder (ADHD) have a smaller cerebellum, reduced total and right cerebral volume, corpus callosum, and right caudate, compared to controls. An advantage of imaging studies is that differences in brain regions can be precisely located. However, a disadvantage is that imaging is not yet clinically applicable to elucidate the neural mechanisms in each individual child with behavioral problems, even though imaging may rule out a structural lesion as the cause of behavioral problems in specific cases. A neurological examination might offer help, as it provides information on the child's specific neurological impairments, and may provide information on the child's vulnerability for the development of behavioral problems [9].

A standardized and age-specific neurological assessment is 'The neurological examination of the child with Minor Neurological Dysfunction'

* Corresponding author at: University Medical Center Groningen, Beatrix Children's Hospital, Developmental Neurology, Hanzeplein 1, 9713 GZ Groningen, The Netherlands. Tel.: +31 50 3614247; fax: +31 50 3636905.
E-mail address: l.h.j.peters@developmentalneurology.com (L.H.J. Peters).

http://dx.doi.org/10.1016/j.earlhumdev.2014.09.001
0378-3782/

[9,10]. The examination pays special attention to the presence of Minor Neurological Dysfunction (MND). MND indicates a coherent cluster of neurological signs in the absence of a serious neurological condition, such as cerebral palsy. Hence, the assessment allows for the detection of subtle neurological deficits, e.g., mild diffuse hypotonia or coordination problems, that can be of significance in children with developmental disorders. The examination provides a profile of the neurological make-up of the child. Therefore it gives insight into the child's neurological strengths and limitations.

Accordingly, the present study had two aims: first, we evaluated what different types of behavioral problems are related to poor motor performance. Second, we examined whether neurological condition, in terms of MND, differs between children with both behavioral and motor problems from that of children with behavioral problems only. To achieve our goals, we studied children who attended either a primary school for regular education or a primary school for special education. We deliberately chose this mixed population as we aimed for a wide range of behavioral problems and motor performance.

2. Methods

All children aged six years and older who attended a primary school for mainstream education and a primary school for special education in Appingedam, a small town in the Netherlands, were asked to participate in the study. Indications for referral to the school for special education were specific learning disorders with or without accompanying behavioral problems. The level of education at this type of school is similar to that in mainstream education, implying that the contents of the information taught do not differ between the two educational systems. The systems differ in the way they deliver the educational contents to the pupils. At the special school children receive more educational support e.g., more individual support by means of small groups. None of the children had a major neurological impairment, such as cerebral palsy. Parents of 209 children receiving mainstream education and parents of 147 children receiving special education were asked whether their child was allowed to participate in the study. In total, 176 (84%) children receiving mainstream education and 122 (83%) children receiving special education participated. Eighteen children (7 boys) had entered puberty and were excluded from the study, as puberty is known to affect the expression of MND substantially [11], leaving 280 children eligible for the study. The onset of puberty was defined by the presence of secondary sexual characteristics according to Tanner [11], assessed during the clinical part of the assessment. A group of five research assistants, i.e., medical students with special training in the assessment of MND and supervised by the senior author (MH-A), see Peters et al. [12], assessed the children at school in a separate, quiet room without knowledge of the children's behavioral scores. All parents gave informed consent and children aged 9 years and older provided assent to participate. The study was approved by the ethics committee of the University Medical Center Groningen.

The Dutch version of the Child Behavior Checklist (CBCL), a parental questionnaire, and the Teacher's Report Form (TRF) for children in the age of 6 to 18 years were used to assess behavioral problems. [13,14] The CBCL and TRF largely contain the same items, but a few questions are different. For instance, only the CBCL has a question on nightmares, whereas only the TRF addresses the question "sleeps in class". The CBCL and TRF have good reliability and validity [14]. The questionnaires include 113 items that measure behavioral problems. The items are rated as 'not at all true' (0) 'sometimes true' (1) or 'mostly true' (2). On the basis of the 113 items eight syndrome scales can be distinguished: (1) anxious/depressed, (2) withdrawn/depressed, (3) somatic complaints, (4) social problems, (5) thought problems, (6) attention problems, (7) rule breaking behavior, and (8) aggressive behavior. The sum of the first three subscales together forms the score of internalizing behavior; the sum of the last two subscales results in the score of externalizing behavior. Total scores are calculated by adding all items. In the analyses, we used T-scores converted to scores within the normal range, borderline range and clinical range. Scores within the borderline and clinical ranges were classified as "behavioral problem" [15]. Questionnaires were excluded when more than eight items were missing (CBCL n = 8; TRF n = 7). When eight or less items were missing, '0' was filled out when no explanation of the item was given or when the item was mistakenly interpreted and '1' was filled out when the given explanation fitted the question (CBCL n = 32; TRF n = 39). The parents stated in the questionnaires whether their child had a medical diagnosis. Maternal and paternal profession was recorded on the CBCL.

Motor performance was assessed with the first edition of the Movement Assessment Battery for Children (MABC), which has four age bands (4–6, 7–8, 9–10 and 11–12 years) [16]. Each age band consists of eight items measuring manual dexterity (three items), ball skills (two items) and static and dynamic balance (three items). High scores indicate poor performance. Raw scores were converted to percentile scores. MABC scores at or above the 5th percentile were considered as age-adequate and scores below the 5th percentile (p5) as definite motor problems. We used MABC total scores in the analysis as total scores are mostly used in DCD-diagnostics [17]. The MABC has satisfactory reliability and validity [16].

The neurological assessment was carried out according to 'The neurological examination of the child with Minor Neurological Dysfunction' [9,10]. The examination is age-specific and consists of 97 items that are organized in eight functional domains: posture and muscle tone, reflexes, involuntary movements, coordination, fine manipulation,

Table 1
Background characteristics, behavioral outcome, motor performance and neurological condition in children receiving mainstream education and special education.

	Mainstream education N = 174	Special education N = 106	Test statistic, P-value
Age median, (range)	9 y7 m (6 y–12 y9 m)	10 y4 m (6 y–13 y)	U = 7559[b], P = 0.02
Boys *n*, (%)	95(55)	82(77)	χ^2 = 14.7[a], **P < 0.001**
Maternal profession			
Low *n*, (%)	55(32)	88(83)	χ^2 = 77.6[a], **P < 0.001**
Medium and high *n*, (%)	114(65)	12(11)	
Missing *n*, (%)	5(3)	6(6)	
Paternal profession			
Low *n*, (%)	48(28)	77(73)	χ^2 = 76.2[a], **P < 0.001**
Medium and high *n*, (%)	120(69)	13(12)	
Missing *n*, (%)	6(3)	16(15)	
CBCL *n* (%) with behavioral problems	N = 157	N = 78	
Total score	10(6)	37(47)	χ^2 = 54.9[a], **P < 0.001**
Internalizing behavior	22(14)	36(46)	χ^2 = 29.0[a], **P < 0.001**
Externalizing behavior	15(10)	39(50)	χ^2 = 48.2[a], **P < 0.001**
TRF *n* (%) with behavioral problems	N = 155	N = 100	
Total score	4(3)	28(28)	χ^2 = 37.8[a], **P < 0.001**
Internalizing behavior	17(11)	26(26)	χ^2 = 9.8[a], **P = 0.002**
Externalizing behavior	6(4)	30(30)	χ^2 = 34.2[a], **P < 0.001**
MABC	N = 174	N = 106	
≥5th percentile *n*, (%)	168(97)	37(35)	
<5th percentile *n*, (%)	6(4)	69(65)	χ^2 = 127.6[a], **P < 0.001**
Neurological classification	N = 174	N = 106	
Neurologically normal *n*, (%)	132(76)	10(10)	
Simple MND *n*, (%)	33(19)	48(45)	
Complex MND *n*, (%)	9(5)	48(45)	χ^2 = 125.1[a], **P < 0.001**

Maternal/paternal profession: medium and high = requiring junior vocational college, vocational college or university education required; low = no profession obtained or profession requiring only primary education. Bold values indicate statistically significant differences, i.e. P < 0.01.

Abbreviations: CBCL: Child Behavior Checklist; m: months; MABC: Movement Assessment Battery for Children; MND: Minor Neurological Dysfunction; TRF: Teacher's Report Form; y: years.

[b] Mann–Whitney *U* test.

[a] Chi-square test.

Table 2
Relationship between types of behavioral problems and definite motor problems.

CBCL N = 235			TRF N = 255		
	MABC < p5	Test statistic, P-value		MABC < p5	Test statistic, P-value
Anxious/depressed			Anxious/depressed		
Yes (N = 24)	8 (33)		Yes (N = 19)	11 (58)	
No (N = 211)	49 (23)	χ^2 = 1.2, P = 0.315	No (N = 236)	59 (25)	χ^2 = 9.6, **P = 0.004**
Withdrawn/depressed			Withdrawn/depressed		
Yes (N = 35)	20 (57)		Yes (N = 12)	7 (58)	
No (N = 200)	37 (19)	χ^2 = 24.2, **P < 0.001**	No (N = 243)	63 (26)	χ^2 = 6.0, P = 0.021
Somatic complaints			Somatic complaints		
Yes (N = 21)	10 (48)		Yes (N = 12)	7 (58)	
No (N = 214)	47 (22)	χ^2 = 6.9, P = 0.015	No (N = 243)	63 (26)	χ^2 = 6.0, P = 0.021
Social problems			Social problems		
Yes (N = 36)	23 (64)		Yes (N = 29)	16 (55)	
No (N = 199)	34 (17)	χ^2 = 36.4, **P < 0.001**	No (N = 226)	54 (24)	χ^2 = 12.6, **P = 0.001**
Thought problems			Thought problems		
Yes (N = 25)	11 (44)		Yes (N = 18)	12 (67)	
No (N = 210)	46 (22)	χ^2 = 5.9, P = 0.024	No (N = 237)	58 (25)	χ^2 = 15.0, **P < 0.001**
Attention problems			Attention problems		
Yes (N = 35)	20 (57)		Yes (N = 11)	9 (82)	
No (N = 200)	37 (19)	χ^2 = 24.2, **P < 0.001**	No (N = 244)	61 (25)	χ^2 = 17.1, **P < 0.001**
Rule breaking behavior			Rule breaking behavior		
Yes (N = 15)	7 (47)		Yes (N = 10)	5 (50)	
No (N = 220)	50 (23)	χ^2 = 4.4, P = 0.057	No (N = 245)	65 (27)	χ^2 = 2.7, P = 0.143
Aggressive behavior			Aggressive behavior		
Yes (N = 33)	15 (46)		Yes (N = 20)	11 (55)	
No (N = 202)	42 (21)	χ^2 = 9.4, **P = 0.004**	No (N = 235)	59 (25)	χ^2 = 8.3, **P = 0.006**
Internalizing behavior			Internalizing behavior		
Yes (N = 58)	23 (40)		Yes (N = 43)	21 (49)	
No (N = 177)	34 (19)	χ^2 = 9.9, **P = 0.003**	No (N = 212)	49 (23)	χ^2 = 11.9, **P = 0.001**
Externalizing behavior			Externalizing behavior		
Yes (N = 54)	23 (43)		Yes (N = 36)	19 (53)	
No (N = 181)	34 (19)	χ^2 = 12.8, **P = 0.001**	No (N = 219)	51 (23)	χ^2 = 13.5, **P < 0.001**
Total score			Total score		
Yes (N = 47)	23 (49)		Yes (N = 32)	20 (63)	
No (N = 188)	34 (18)	χ^2 = 19.5, **P < 0.001**	No (N = 223)	50 (22)	χ^2 = 22.6, **P < 0.001**

Values represent the number and percentage of children classified with behavioral problems and a MABC score <5th percentile (<p5) and children without behavioral problems and a MABC score <p5.
Chi-square test. Bold values indicate statistically significant differences, i.e. P < 0.01.
Abbreviations: CBCL: Child Behavior Checklist; MABC: Movement Assessment Battery for Children; TRF: Teacher's Report Form.

associated movements, sensory function and cranial nerve function [9,12]. The majority of items is scored as typical or age-adequate versus mildly or definitely abnormal. Essential in the diagnostics of MND is the presence of coherent clusters of signs. Single signs do not have clinical significance; they only have significance when they co-occur with other signs within a functional domain. The examination results in a clinical classification: neurologically normal, simple MND, complex MND or neurologically abnormal. Prior to the onset of puberty, the following rules for classification are valid [9,18]. A child is neurologically normal when no domain is classified as dysfunctional or in the case of the isolated presence of dysfunctional reflexes. A child is classified as simple MND when one or two dysfunctional domains are present and as complex MND when three or more dysfunctional domains are present. A child is neurologically abnormal when a clear neurological disorder, such as cerebral palsy, is present. Complex MND is considered to be the clinically relevant form of MND [18].

Data were analyzed using SPSS for Windows version 15. All data were skewed; therefore non-parametric tests (Mann Whitney U, chi-square) were used to identify differences between groups. Two different analyses were performed: first, we analyzed whether children with behavioral problems more often showed definite motor problems (MABC < p5) than children without behavioral problems. Second, we evaluated whether the neurological condition of children with behavioral and definite motor problems differed from those with behavioral problems only. Logistic regression analysis was performed to assess the contribution of motor performance to behavioral problems (according to the CBCL and TRF total scores), while taking into account sex, paternal profession and type of school as confounders. Because of the explorative nature of the study and multiple testing, a P-value < 0.01 (two-tailed) was considered statistically significant [19].

3. Results

For the 280 children included in the study, 235 parents (84%) filled out the CBCL and 255 teachers (91%) filled out the TRF. Forty seven children (20%) had behavioral problems according to the CBCL total scores and 32 (13%) children had behavioral problems according to the TRF total scores. Motor performance and neurological condition were available for all 280 children. In total, 205 children (73%) showed a normal motor performance and 75 (27%) children showed definite motor problems. One hundred and forty two children (51%) had a neurologically normal condition, 81 children (29%) had simple MND and 57 children (20%) had complex MND. Parents of 32 children reported that their child had one or more clinical psychiatric diagnoses (ADHD, Pervasive Developmental Disorder—Not Otherwise Specified, Gilles de la Tourette, dyslexia): 18 children (56%) had definite motor problems. Children receiving mainstream education had less often behavioral problems, definite motor problems and MND than children receiving special education (Table 1).

Internalizing and externalizing problems and problematic total scores reported by parents and teachers were significantly associated with definite motor problems (Table 2). The majority of specific behavioral problems were significantly associated with definite motor problems, either reported by parents or teachers. Exceptions to this general rule were somatic complaints and rule breaking behavior; children with these behavioral problems did not have more often definite

Table 3
Relationship between the number of behavioral problems based on the CBCL and TRF subscales and motor performance.

Number of subscales with behavioral problems	MABC ≥ p5	MABC < p5	Test statistic, P-value
CBCL			
0 (N = 155)	134 (86)	21 (14)	
1 (N = 34)	23 (68)	11 (32)	
2 (N = 10)	4 (40)	6 (60)	
3 (N = 10)	5 (50)	5 (50)	
≥4 (N = 26)	12 (46)	14 (64)	$\chi^2 = 33.8$, **P** < **0.001**
TRF			
0 (N = 193)	154 (80)	39 (20)	
1 (N = 31)	18 (58)	13 (42)	
2 (N = 14)	6 (43)	8 (57)	
3 (N = 6)	5 (83)	1 (7)	
≥4 (N = 11)	2 (18)	9 (82)	$\chi^2 = 31.2$, **P** < **0.001**

The values represent the motor performance (number and percentage) of children classified with: (0) no behavioral problems based on the eight subscales, (1) behavioral problems in one subscale, (2) two subscales, (3) three subscales and (≥4) four or more subscales. Motor performance is dichotomized into MABC scores at or above the 5th percentile (p5) and below the 5th percentile.
Chi-square test for trend. Bold values indicate statistically significant differences, i.e. P < 0.01.
Abbreviations: CBCL: Child Behavior Checklist; MABC: Movement Assessment Battery for Children; TRF: Teacher's Report Form.

motor problems than children without these behavioral problems (Table 2). Parents reported more often behavioral problems than teachers (Table 2). The presence of a higher number of behavioral problems was significantly associated with definite motor problems (Table 3).

Children with definite motor problems and internalizing problems reported by parents or externalizing problems reported by parents or teachers, showed more often MND than children with these behavioral problems with age-adequate motor performance (Table 4). Children with definite motor problems and behavioral problems according to the CBCL or TRF total scores did not show more often MND than children with these behavioral problems and an age-adequate motor performance (CBCL chi-square for trend $\chi^2 = 5.4$, P = 0.022; TRF chi-square for trend $\chi^2 = 3.1$, P = 0.112).

Logistic regression analysis revealed that motor performance predicted behavioral problems according to the CBCL and TRF total scores when adjusting for sex and parental profession, however not when type of school was taken into account (Table 5).

4. Discussion

The present study demonstrated that children with behavioral problems are at risk for motor problems. Both internalizing problems and externalizing problems reported by parents or teachers were associated with poor motor performance. Parents reported more often behavioral problems than teachers. Children with externalizing or internalizing problems at home and motor problems more often showed MND than their peers with similar behavioral problems not in combination with motor problems.

In addition to the current literature, our study showed that virtually all types of behavioral problems were associated with motor problems. Previous studies showed that especially internalizing problems [6,7] and attention problems or ADHD [2–4] are related to motor problems. Our study extends these results and showed that also externalizing problems were associated with motor problems.

Most studies investigated the relationship between motor problems and parent-rated behavioral problems [3,4,7]. In the present study, parents more often reported behavioral problems than teachers did, a finding which is consistent with literature [20]. These differences between teacher and parent ratings may be explained by (a) cross-situational differences in behavior of the child, (b) a difference in perspective and impartiality, c) situational differences in how the assessed behavior manifests itself; and (d) measurement error [21]. Despite these situational differences, our data showed that behavioral problems in the home situation and at school were equally strong related to poor motor performance.

The relationship between behavioral problems and motor problems can be explained in various ways. First, inattention may lead to a poor motor performance since the child can pay less attention to a task [6]. Second, reversely, motor problems may also cause behavioral problems. For example, motor problems may lead to lower self-esteem and internalizing problems. [6] Third, behavioral problems and motor problems may be the result of (part of) the same neural networks [22]. This is supported by the fact that the majority of children with behavioral problems and poor motor performance had MND. MND reflects the functioning and vulnerability of the child's brain. Consequently, a neurological assessment in terms of MND might be helpful to identify those children at risk for comorbidity.

The results of our study must be interpreted in light of the strengths and limitations of the study. The strengths of this study are the relatively large sample size, high response rates and the use of well validated instruments. The main limitation of the study is that we investigated the relation between motor performance, neurological condition and behavioral problems in a sample of children receiving mainstream

Table 4
Relationship between neurological classification, internalizing and externalizing problems and motor performance.

a. CBCL internalizing problems	MABC ≥ p5	MABC < p5
	N = 35	N = 23
Neurologically normal	16 (46)	1 (4)
Simple MND	14 (40)	12 (52)
Complex MND	5 (14)	10(43)*
*Chi-square test for trend $\chi^2 = 12.3$, **P = 0.001**		
b. TRF internalizing problems	MABC ≥ p5	MABC < p5
	N = 22	N = 21
Neurologically normal	12 (54)	6 (29)
Simple MND	7 (32)	8 (38)
Complex MND	3 (14)	7 (33)
c. CBCL externalizing problems	MABC ≥ p5	MABC < p5
	N = 31	N = 23
Neurologically normal	11 (35)	–
Simple MND	13 (42)	13 (56)
Complex MND	7 (23)	10(44)*
*Chi-square test for trend $\chi^2 = 8.1$, **P = 0.006**		
d. TRF externalizing problems	MABC ≥ p5	MABC < p5
	N = 17	N = 19
Neurologically normal	6 (35)	–
Simple MND	7 (41)	7(37)
Complex MND	4 (24)	12(63)*
*Chi-square test for trend $\chi^2 = 9.2$, **P = 0.003**		

Cells represent: (a) the number and percentage of children with behavioral problems based on the CBCL internalizing scores with MABC score at or above the 5th percentile (p5) (left column) and children with behavioral problems based on the CBCL internalizing scores with a MABC score <p5 (right column). The same approach was applied for (b) TRF internalizing scores, (c) CBCL externalizing scores and (d) TRF externalizing scores. Bold values indicate statistically significant differences, i.e. P < 0.01.
Abbreviations: CBCL: Child Behavior Checklist; dys: dysfunctional; MABC: Movement Assessment Battery for Children; MND: Minor Neurological Dysfunction; TRF: Teacher's Report Form.

Table 5
Poor motor performance and total behavioral problem scores: unadjusted and adjusted odds ratios.

	Unadjusted OR (95% CI)	Adjusted[a] OR (95% CI)	Adjusted[b] OR (95% CI)
CBCL total problem score	4.3 (2.2–8.6)	3.1 (1.4–6.8)	0.8 (0.3–2.1)
TRF total problem score	5.8 (2.6–12.6)	3.3 (1.3–8.3)	1.1 (0.4–3.1)

Cells represent odds ratios (OR) with 95% confidence interval (95% CI): unadjusted OR.
Reference categories are MABC > 5th percentile (p5), sex (girl), medium/high paternal profession and regular school.
[a] OR adjusted for sex and paternal profession.
[b] OR adjusted for sex, paternal profession and type of school.

and special education. Consequently, our results cannot be generalized to the general population, nor to the population of children with DCD. By including children attending a school for special education, children with behavioral problems, MND and motor problems were over-represented; this may be considered an advantage for a study on relationships between behavioral problems, neurological condition and motor performance, but may also have confounded the relationships. This suggestion is supported by the results of the logistic regression analysis, which indicated that the behavioral problems no longer were associated with motor problems when the type of school was taken into account. However, as other studies firmly established the association between behavioral and motor problems [4,6,7], we feel confident that the associations reported in the present study make sense, even though – as noted before – they cannot be generalized.

In conclusion, the present study demonstrated that children with various forms of behavioral problems were at risk for motor problems. On the basis of the current findings, we suggest that clinicians in charge of care for children with behavioral problems pay attention to the possibility of co-existing motor problems. The assessment of MND may be useful as it offers insight into the child's neurological capacities and limitations. What we still need to know is whether the co-morbid motor problems interfere with the effect of intervention or the prognosis in children with behavioral problems. Future studies are needed to answer these questions.

Conflict of interest

MHA is the author of the revised edition of the manual 'The neurological examination of the child with Minor Neurological Dysfunction'. The authors LHJP and CGB declared no conflict of interest.

Acknowledgments

We gratefully acknowledge the assistance of Marjolein Hamming, MD, Eva Kouw, MD, Jessika van Hoorn, MD, and Akke-Nynke van der Meer, MD in testing the children and all children, parents and teachers for their participation. The study was financially supported by the Junior Scientific Masterclass and the Graduate School Behavioral and Cognitive Neurosciences, University of Groningen.

References

[1] Lichtenstein P, Carlstrom E, Rastam M, Gillberg C, Anckarsater H. The genetics of autism spectrum disorders and related neuropsychiatric disorders in childhood. Am J Psychiatry 2010;167:1357–63.
[2] Kadesjö B, Gillberg C. Developmental coordination disorder in Swedish 7-year-old children. J Am Acad Child Adolesc Psychiatry 1999;38:820–8.
[3] Lingam R, Golding J, Jongmans MJ, Hunt LP, Ellis M, Emond A. The association between developmental coordination disorder and other developmental traits. Pediatrics 2010;126:e1109–18.
[4] Brossard-Racine M, Shevell M, Snider L, Belanger SA, Majnemer A. Motor skills of children newly diagnosed with Attention Deficit Hyperactivity Disorder prior to and following treatment with stimulant medication. Res Dev Disabil 2012;33:2080–7.
[5] Green D, Charman T, Pickles A, et al. Impairment in movement skills of children with autistic spectrum disorders. Dev Med Child Neurol 2009;51:311–6.
[6] Cairney J, Veldhuizen S, Szatmari P. Motor coordination and emotional–behavioral problems in children. Curr Opin Psychiatry 2010;23:324–9.
[7] Lingam R, Jongmans MJ, Ellis M, Hunt LP, Golding J, Emond A. Mental health difficulties in children with developmental coordination disorder. Pediatrics 2012;129:e882–91.
[8] Valera EM, Faraone SV, Murray KE, Seidman LJ. Meta-analysis of structural imaging findings in attention-deficit/hyperactivity disorder. Biol Psychiatry 2007;61:1361–9.
[9] Hadders-Algra M. The neurological examination of the child with minor neurological dysfunction. 3rd ed. London, United Kingdom: Mac Keith Press; 2010.
[10] Touwen B. Examination of the child with minor neurological dysfunction. 2nd ed. London; Philadelphia: William Heinemann for Spastics International Medical Publ.; Lippincott; 1979.
[11] Lunsing RJ, Hadders-Algra M, Huisjes HJ, Touwen BC. Minor neurological dysfunction from birth to 12 years. II: puberty is related to decreased dysfunction. Dev Med Child Neurol 1992;34:404–9.
[12] Peters LH, Maathuis KG, Kouw E, Hamming M, Hadders-Algra M. Test–retest, inter-assessor and intra-assessor reliability of the modified Touwen examination. Eur J Paediatr Neurol 2008;12:328–33.
[13] Verhulst FC, van der Ende J, Koot HM. Handleiding voor de CBCL/4–18. Rotterdam: Department of Child Psychiatry, Sophia Children's Hospital; 1996.
[14] Achenbach TM, Rescorla LA. Manual for the ASEBA school-age forms & profiles. Burlington: VT: University of Vermont, Research Center for Children, Youth & Families; 2001.
[15] Oddy WH, Kendall GE, Li J, et al. The long-term effects of breastfeeding on child and adolescent mental health: a pregnancy cohort study followed for 14 years. J Pediatr 2010;156:568–74.
[16] Henderson SE, Sugden DA. The movement assessment battery for children. London: Psychological Cooperation; 1992.
[17] Blank R, Smits-Engelsman B, Polatajko H, Wilson P. European Academy for Childhood Disability. European Academy for Childhood Disability (EACD): recommendations on the definition, diagnosis and intervention of developmental coordination disorder (long version). Dev Med Child Neurol 2012;54:54–93.
[18] Hadders-Algra M. Two distinct forms of minor neurological dysfunction: perspectives emerging from a review of data of the Groningen Perinatal Project. Dev Med Child Neurol 2002;44:561–71.
[19] Shaffer JP. Multiple hypothesis testing. Annu Rev Psychol 1995;46:561–84.
[20] Verhulst FC, Akkerhuis GW. Agreement between parents' and teachers' ratings of behavioral/emotional problems of children aged 4–12. J Child Psychol Psychiatry 1989;30:123–36.
[21] Rettew DC, van Oort FV, Verhulst FC, et al. When parent and teacher ratings don't agree: the Tracking Adolescents' Individual Lives Survey (TRAILS). J Child Adolesc Psychopharmacol 2011;21:389–97.
[22] Caspi A, Houts RM, Belsky DW, et al. The p factor one general psychopathology factor in the structure of psychiatric disorders? Clin Psychol Sci 2014;2:119–37.