

How common are motor problems in children with a developmental disorder: rule or exception?

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Conflicts of Interest Statement

There are no conflicts of interest.

Short title

Motor problems in Developmental Disorders

Key words

- Developmental Coordination Disorder
- Learning disabilities
- Developmental disorders
- Co-morbidity
- Gender

Key messages

- Co-morbidity of motor problems with pervasive developmental disorder, a hyperkinetic disorder and/or a speech, language or learning disability varied between one fourth and one third of the children in this clinical sample.
- Co-morbidity rates of motor problems in developmental and behavioural disorders are lower than previously reported
- Co-morbidity of motor problems with pervasive developmental disorder, a hyperkinetic disorder and/or a speech, language or learning disability shows different patterns in boys and girls
- It is recommended to assess motor skills in children with developmental disorders

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Abstract

Background: Few co-morbidity studies have been conducted since the Leeds Consensus Statement on Developmental Coordination Disorder (DCD) in 2006. In this Statement, international cut-offs and inclusion criteria were agreed and consequently the status of DCD changed. Furthermore, most existing co-morbidity studies are small clinical studies, rather than epidemiological studies, resulting in a broad range of co-morbidity rates. DCD has a higher incidence for boys in comparison with girls, questions arise if this preponderance remains the same in combination with other developmental disorders. Therefore, in this study we aimed to determine co-morbidity and gender differences of motor problems in children with a pervasive developmental disorder, a hyperkinetic disorder and/or a speech, language or learning disability.

Methods: Profiles of 3608 children (mean age 9y 1mo) referred to rehabilitation centres for behavioural, developmental and sensorineural disorders were studied.

Results: Motor problems were reported in one fifth of the total sample. Co-morbidity of motor problems in specific disorders varied between almost one fourth to more than one third. The male/female ratio was significantly higher in children with motor problems and 2 or more other disorders compared to children with motor problems and less than 2 other disorders.

Conclusions: This study indicates that co-morbidity of motor problems with other clinical disorders is not exceptional and developmental deviance is seldom specific to one domain. However, current co-morbidity studies tend to overestimate the number of children with motor problems. In addition, there may be different patterns of symptoms between the genders. These findings stress the importance of assessing motor skills in children with various developmental disorders.

Introduction

Severe motor problems without a known medical condition that interfere with children's daily life are recognized as 'Developmental Coordination Disorder' (DCD) in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR) (American Psychiatric Association [APA] 2000). In the World Health Organization International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10) (World Health Organization 1992), the label 'Specific Developmental Disorder of Motor Function' is used to refer to this disability. DCD appears in 1.7% of the school-aged children and has a gender ratio of 1.8:1 males to females (Lingam *et al.* 2009). Moreover, motor problems exist as a co-morbid disability in children with other developmental disorders (Emck *et al.* 2009). Diagnosing motor problems is very important since recent findings show the pervasive impact of motor problems on children's performance in daily life or at school (Wang *et al.* 2009). Furthermore, developmental disorders are relatively persistent and whereas isolated problems are more likely to show a relatively good outcome, co-morbid disabilities increase the risk of long-term difficulties (Hellgren *et al.* 1993, Moffitt 1990, Rasmussen and Gillberg 2000). In this article, we will focus on motor problems in children with pervasive developmental disorders (PDD), hyperkinetic disorders, speech

and language disabilities and learning disabilities and we will evaluate its prevalence as a co-morbidity in boys and girls.

PDD is a group of disabilities characterized by qualitative impairments in social interaction and in communication and by stereotyped and repetitive motor mannerisms (American Psychiatric Association [APA] 2000). PDD has a prevalence of 0.6% (Fombonne 2005) with a male predominance of about 4 to 1 (Fombonne 2009). A recent study found that 79% of the children with PDD had definite movement impairments and 10% had borderline problems (Green *et al.* 2009). The range of co-morbid motor problems in PDD in small clinical sample studies is large, from 50% to 85% (Manjiviona and Prior 1995, Mayes and Calhoun 2003, Miyahara *et al.* 1997).

Hyperkinetic disorder is characterized by a pattern of inattention and/or hyperactivity and impulsivity (World Health Organization 1992). In a systematic review, the prevalence for ADHD/Hyperkinetic disorder was 5.29% (Polanczyk *et al.* 2007). The ratio of boys to girls is between 3:1 and 9:1 (Swanson *et al.* 1998). Hyperkinetic disorder is a heterogeneous condition, with frequent co-morbid disabilities such as motor problems (Fliers *et al.* 2008). Approximately 30% to 50% of children with hyperkinetic disorder show motor problems affecting equally boys and girls (Fliers *et al.* 2008, Gaub and Carlson 1997, Gillberg *et al.* 2004, Sergeant *et al.* 2006)

Children with speech and language disabilities fail to develop language at a normal rate without an explanation of a physical impairment or neurological disease (American Psychiatric Association [APA] 2000). They often have difficulties with tasks involving motor control in speaking. Speech and language disabilities occur in 6.3% of children with a male rate approximately double in comparison with females (Pinborough-Zimmerman *et al.* 2007). A recent study found that children with speech and language disabilities (27.3%) had a higher chance than children without this disability (11.4%) to have motor deficits (Cheng *et al.* 2009). There is a large range of reported co-morbid motor problems in speech and language disabilities going from 20% to 71% (Cheng *et al.* 2009).

There are two main learning disabilities, namely reading disabilities with an impairment in the development of reading and spelling skills and mathematical learning disabilities with an impairment in mathematical skills. Reading disabilities affect 1 to 33% of children, depending on the orthographic consistency of the language (Ziegler *et al.* 2010) with a male predominance between 1.74 and 2 (Liederman *et al.* 2005). To the best of our knowledge, there are no large co-morbidity studies on motor problems in children with reading disabilities. Studies investigating motor problems in a small clinical sample revealed co-morbidity rates ranging from 33.2 to 87.5% (Kaplan *et al.* 1998, Miyahara *et al.* 1997). Mathematical learning disabilities frequently occur in children with a prevalence rate between 5.9 and 13.8% (Barbaresi *et al.* 2005). Mathematical learning disabilities have an almost similar prevalence in boys and girls (Lewis *et al.* 1994). Sometimes boys are doing even slightly better (Gross-Tsur *et al.* 1996, von Aster 2000). We are not aware of a study that looked at co-morbidity of motor problems in children with mathematical learning disabilities (except the other way around).

In summary, the debate on the prevalence and co-morbidity remains unresolved. Most of the mentioned co-morbidity rates are derived from small clinical samples, rather than from epidemiological studies, resulting in a broad range of divergent co-morbidity rates. In this study we aim to determine the co-morbidity of motor problems in a large sample, in accordance with the ICD-10

(World Health Organization 1992) and the Leeds Consensus Statement (Sugden *et al.* 2006). In this Statement, international cut-offs and inclusion criteria were agreed for clinical and research purposes. Since then, the double diagnoses of PDD and DCD is encouraged when appropriate, which is in contrast with the DSM-IV-TR. Furthermore, a co-morbid diagnosis of mental disability and DCD is not longer advised, in the opposite of the ICD-10 and the DSM-IV-TR in which the motor problems must be in excess of those typically associated with a mental disability. The present study is one of the few studies on co-morbidity of motor problems with other disorders since the Leeds Consensus Statement on DCD in 2006. In addition, there is some controversy about co-morbidity patterns between the genders. Therefore, this study attempts to examine both gaps.

Methods

Participants

Records of the total yearly population of 31 rehabilitation centres, focusing mostly on ambulant rehabilitation of children and having a diagnostic and therapeutic task, were systematically collected and analyzed. Main target groups of these centres are PDD, hyperkinetic disorders, speech and language disabilities, learning disabilities, mental disabilities and conductive and sensorineural hearing loss. Centres are involved in the identification and the clarification of the nature, type and degree of the various developmental disorders. Outpatient therapy can be offered in various domains: language, speech and communication skills, (psycho) motor, (meta) cognitive, social-behavioural and emotional-affective abilities, 2 or 3 times a week. The team consists of different disciplines: physicians, social workers, psychologists, masters in educational sciences, speech therapists, audiologists, occupational therapists and physiotherapists. Rehabilitation involves at least three different team members with a different discipline providing face-to-face treatment.

The sample comprised 3608 children, including all patients on a yearly basis whatever their main diagnosis. Children were between 1 and 21 years with a mean age of 9 years 1 month (SD 2y 6mo). Children between 5 and 12 years were the most common age group (87%). The male/female ratio in the total sample was 2/1. From these children, 81.4% attended regular education, 15.3% attended special education and 3.3% was not going to school.

Design and procedure

During 1 year and starting on January 1st, 2006, all Dutch-speaking rehabilitation centres in Belgium registered client information including gender, the main disability and (eventually) co-morbid disabilities based on the ICD-10 classification. Whereas the index disability was defined as the main disability or the most impairing disability in daily life, a co-morbid disability was defined as another important disability. Every child underwent a quite similar battery of standardized tests. Tests that were commonly used in the diagnostic protocol for DCD were the Movement Assessment Battery for Children (Henderson and Sugden 1992) and the Bruininks-Oseretsky Test of Motor Proficiency (Bruininks 1978). In order to register a main or a co-morbid disability, a score below percentile 10 on a standardized test and the presence of the defined clinical

features by ICD-10 (the category ‘Specific Developmental Disorder of Motor Function’), were required for a clinical diagnosis. Criteria described by the ICD-10 are quite similar to those in the DSM-IV for DCD (Henderson and Barnett 1998). The centres received six-months training, a manual of the registration system and extra support if needed. ICD-10 classification codes were compared and discussed to develop a uniform application. Informed consents were obtained to use data for scientific purposes. When parents did not give permission, data were excluded. All processing of data was done anonymously. The study was in accordance with the privacy law (included in the agreement of the clients appealing to rehabilitation centres). All data were cleaned for data validation purposes. Data were reviewed and a post hoc random sample verification was performed (including 1% of the data) to look for clerical errors. Researchers telephonically checked if the obtained data in the registration form were in correspondence with the clinical diagnosis in the centre. All telephonically received information was consistent with the ICD-codes (F80, F81, F84, F90 etc.) in the database.

Analysis of data

The participants were grouped with respect to presence of co-morbid motor problems. The number of children with motor problems and the gender ratio are presented in Table 1. Frequencies were calculated and Pearson's chi-square tests were conducted. Descriptive statistics compared the proportion of co-morbid motor problems with the general population (1.7%) (Lingam *et al.* 2009) using the test based on binomial distribution.

Results

The proportion of children with motor problems (registered with ICD-10 code F82) was 20.4% (n=735 out of the 3608 children). In most of these cases (79.8%), it was registered as a co-morbid disability, in 5.3% it was the only diagnosis. All 735 children were at least of average intelligence (IQ>70). The male/female ratio was 2.6/1 and the age range was between 3 and 17 years (mean 9y 1mo, SD 2y 3mo). From the children with motor problems, a minority had no other behavioural or developmental disorder. The majority had one (40.3%), two (43.7%), or three or more (10.7%) behavioural and/or developmental disorders (see Table 1). In addition, the proportion of boys versus girls was significantly higher in children with motor problems and 2 or more other disorders compared to children with motor problems and less than 2 other disorders ($\chi^2=6,14$; $df=1$; $p<.01$).

Insert Table 1 about here

In Table 2, an overview is outlined of the motor problems in the different behavioural and developmental disorders with disregard of a registration as a main or a co-morbid disability. For each diagnostic category (e.g. PDD), all children with this diagnosis either as a main or a co-morbid disability were taken into account. This means that one child can be counted more than once.

Binomial analysis revealed that there were significantly more co-morbid motor problems in speech and language disabilities or F80 (33.7%) as opposed to 1.7% (Lingam *et al.* 2009) in the general population ($p<.0001$). Significantly more

motor problems have also been established in learning disabilities or F81 (24.8%) as opposed in the general population ($p<.0001$). In addition, 25% of the children with PDD (or F84) and 23.9% of the children with a hyperkinetic disorder (or F90) had motor problems, which is significantly more in comparison with the general prevalence of motor problems (both $p<.0001$).

Insert Table 2 about here

When children with a ‘Specific developmental disorder of scholastic skills’ (F81) were studied more in detail, most children (63.1%) had a ‘Mixed disorder of scholastic skills’ (this is a disability in reading or spelling together with a disability in mathematics). The other children had an isolated reading disability (18.0%), an isolated mathematical learning disability (13.3%) or an isolated spelling disability (5.6%). The male/female ratio in the children with a reading disability or a spelling disability was 2.6/1 and 1.1/1 in the mathematical learning disability group. When co-morbid motor problems were taken into account in the latter group (25.5%), the male predominance increased significantly to 1.8 ($\chi^2=3.68$; $df=1$; $p<.05$). For the children with a combined reading disability and mathematical learning disability, a gender difference of 1.5/1 was found with a significant ($\chi^2=4.23$; $df=1$; $p<.05$) increase to 2.0/1 when co-morbid motor problems were taken into account (24.6%). Next to a mathematical learning disability and a combined reading disability and mathematical learning disability, there was also a significant difference in male/female ratio whether or not motor problems were reported for hyperkinetic disorders ($\chi^2=6.85$; $df=1$; $p<.01$), with an increase from 2.9/1 to 4.2/1. This was not found for the other developmental disorders, namely PDD and speech and language disabilities.

Discussion

The present study aimed to gather co-morbidity and gender data on motor problems in children with PDD, hyperkinetic disorders, speech and language disabilities and learning disabilities after the Leeds Consensus Statement (Sugden *et al.* 2006). To our knowledge, no data about the relationship between DCD and other developmental disorders is currently available since this Statement.

Co-morbidity

Our results illustrate that co-morbidity of motor problems in other disabilities is not exceptional since developmental deviance is seldom specific to one domain. The co-morbidity of motor disabilities with other developmental and behavioural disorders ranges from 23.9% to 33.7% with the highest co-morbidity in speech and language disabilities. Our results suggest that motor problems in these disabilities exist more frequently than can be expected by chance. It is questionable whether these motor problems should be considered as a co-morbid disability or as another phenomenon with a different aetiology, as proposed by different models of co-morbidity (Pennington 2006, Rhee *et al.* 2005, Willcutt *et al.* 2005). Although the term co-morbidity is used in this paper because of its common use in literature and in clinical practice, we agree with Kaplan and colleagues (Kaplan *et al.* 2006) that the term ‘co-occurrence’ is more appropriate to describe associations among developmental disorders. Co-morbidity might assume that the underlying pathophysiological origins of these disorders are

independent and not causally related while co-occurrence can be used in cases with assumptions of a shared or completely unrelated aetiology (Kaplan *et al.* 2006). In this study, the overlap of motor problems with other developmental disorders could be the result of a shared aetiology.

Findings in our study could assume that co-morbidity studies in small clinical samples tend to overestimate the number of children with motor problems. A possible explanation could be the used definition of motor problems. Another possible explanation could be that the population in our study is indeed less (PDD, hyperkinetic disorder, learning disability) or more (speech and language disability) severely affected than in other co-morbidity studies, because our study population has not been recruited in the context of an experimental study. Indeed, in contrast with the 79% of motor problems in PDD (Green *et al.* 2009), only 25% of the children with PDD in our dataset had motor problems. The same was the case for hyperkinetic disorder. In our dataset only 23.9% of the children with hyperkinetic disorder had motor problems, whereas this was the case of 30 to 50% according to the literature (Fliers *et al.* 2008, Gillberg *et al.* 2004). In addition, findings in this study support 24.8% of motor problems in children with learning disabilities, which is much less than the co-morbidity range from 33.2% to 87.5% (Kaplan *et al.* 1998, Miyahara *et al.* 1997). However, in our dataset we found a slightly higher co-morbidity of motor problems in speech and language disabilities (33.7%) compared to the 27.3% from Cheng and colleagues (2009). These findings suggest at first the need for more epidemiological research on prevalence and co-morbidity rates. How to explain these differences in prevalence and co-morbidity rates? The Leeds Consensus Statement suggests to exclude children with IQ below 70, but in most previous studies this exclusion criterion was already adapted. A possible explanation is a more stringent adaptation of the criterion requiring a significant interference with the activities of daily living at home and/or at school. The recent study of Lingam and colleagues (2009) is in line with this finding by reporting a lower prevalence of DCD (1.7%) in comparison with the prevalence of 6% described by the American Psychiatric Association (1994). This last study was also based on the 'stringent' application of the 4 DCD criteria.

Gender

Our results regarding male/female ratios in the different developmental and behavioural disorders are in line with those reported in the literature (Fombonne 2009, Gross-Tsur *et al.* 1996, Lewis *et al.* 1994, Liederman *et al.* 2005, Pinborough-Zimmerman *et al.* 2007, Swanson *et al.* 1998).

In addition, we found a significant gender difference in children with motor problems regarding the number of reported co-morbid disabilities: the male/female ratio was higher in the sample of children with motor problems and two or more co-morbid disabilities, with a significant higher preponderance in boys, in comparison to the male/female ratio in the sample of children with motor problems and less than two co-morbid disabilities. To the best of our knowledge, this was not mentioned in literature before.

Finally, a significant difference was found in the male/female ratio whether or not motor problems were reported for mathematical learning disabilities, combined reading disabilities and mathematical learning disabilities and hyperkinetic disorders but not for the other developmental disorders, namely PDD and speech and language disabilities. These results might be explained by a different pattern of symptoms between genders. Boys with a mathematical

learning disability , a combined reading disability and mathematical learning disability or a hyperkinetic disorder seem to have motor problems more often than girls. This suggest a greater vulnerability of boys to motor problems. However, this might also be an artefact based on selection and referral criteria. For example, girls are thought to be less disruptive and are therefore underidentified and undertreated for hyperkinetic disorder in comparison with boys. Additional studies seem indicated.

Clinical implications

Our results indicate that co-morbidity is not exceptional, stressing the importance of assessing motor skills in children with PDD, hyperkinetic disorders, speech and language disabilities and learning disabilities. The lack of correct and complete diagnoses may negatively influence the choice of appropriate care. Early assessment of motor problems might have a positive influence on the psychological development in individuals with PDD, hyperkinetic disorders, speech and language disabilities and/or learning disabilities. If the motor weaknesses are taken into account, different interventions and treatments may be considered to address the problems.

Strengths and limitations

This study adds data since the Leeds Consensus Statement on co-morbidity and gender data on motor problems in a large sample of children with PDD, hyperkinetic disorders, speech and language disabilities and learning disabilities. Records of 3608 children in ambulatory rehabilitation centres, specialized in behavioural and developmental disorders were retrospectively investigated. The results should therefore be interpreted with care since the data are based on individuals who have documented disabilities in a rehabilitation centre based on an ICD-10 registration. Because of the multidisciplinary character of these centres, rather higher co-morbidity rates might be expected and it cannot be an explanation for the finding that current co-morbidity studies tend to overestimate the number of children with motor problems. Recruiting in these centres gave us a more broaden view on co-morbidity by making it possible to compare between various developmental disorders.

Future research

The overlap of motor problems with other developmental disorders could be the result of an aberrant brain development. Future research is necessary to find the pathophysiological mechanisms underlying motor problems and other developmental disorders. A better understanding would have implications for diagnosis and treatment. Further research could also differentiate between various aspects of motor functioning, like fine motor skills, gross motor skills and balance.

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Tables

Table 1: Children registered with ICD-10 code F82 (motor problems), either as a main or a co-morbid diagnosis: number of additional disabilities and gender

Motor problems	Prevalence		Male/female ratio
	Boys	Girls	
+ no other disabilities	26	13	2/1
+ 1 other disability	202	94	2.1/1
+ 2 other disabilities	244	77	3.2/1
+ 3 or more other disabilities	61	18	3.4/1
Total	533	202	2.7/1

Table 2: Motor problems in the different behavioural and developmental disorders (one child could be counted more than once)

Disability	Prevalence of the disability		Prevalence of the disability		Male/female ratio	Prevalence of motor problems in this disability		Prevalence of motor problems in this disability		Male/female ratio when motor problems
	n	%	Boys	Girls		n	%	Boys	Girls	
Specific developmental disorders of speech and language (code F80)	1278	35.4	859	419	2.1/1	431	33.7	297	134	2.2/1
Specific developmental disorders of scholastic skills (code F81)	1319	36.6	823	496	1.7/1	320	24.8	216	104	2.1/1
Pervasive developmental disorders (code F84)	660	18.3	546	114	4.8/1	165	25.0	143	22	6.5/1
Hyperkinetic disorders (code F90)	949	26.3	705	244	2.9/1	225	23.9	182	43	4.2/1

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