Developmental coordination disorder in children with attention-deficit–hyperactivity disorder and physical therapy intervention

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Although physical therapy (PT) is effective in improving motor function in children with developmental coordination disorder (DCD), insufficient data are available on the impact of this intervention in children with combined attention-deficit–hyperactivity disorder (ADHD) and DCD. This prospective study aimed to establish the prevalence of DCD among a cohort of patients with ADHD, characterize the motor impairment, identify additional comorbidities, and determine the role of PT intervention on these patients. DCD was detected in 55.2% of 96 consecutive children with ADHD, mostly among patients with the inattentive type (64.3% compared with 11% of those with the hyperactive/impulsive type, $p<0.05$). Mean age was 8 years 4 months (SD 2y; 81 males, 15 females). Individuals with both ADHD and DCD more often had specific learning disabilities ($p=0.05$) and expressive language deficits ($p=0.03$) than children with ADHD only. Twenty-eight patients with ADHD and DCD randomly received either intensive group PT (group A, mean age 9y 3mo, SD 2y 3mo) or no intervention (group B, mean age 9y 3mo, SD 2y 2mo). PT significantly improved motor performance (assessed by the Movement Assessment Battery for Children; $p=0.001$). In conclusion, DCD is common in children with ADHD, particularly of the inattentive type. Patients with both ADHD and DCD are more likely to exhibit specific learning disabilities and phonological (pronunciation) deficits. Intensive PT intervention has a marked impact on the motor performance of these children.

See end of paper for list of abbreviations.

Attention-deficit–hyperactivity disorder (ADHD) and developmental coordination disorder (DCD) are among the most common neurodevelopmental problems in children. Patients with ADHD, particularly those with the inattentive type more often exhibit developmental coordination disorder than their healthy peers.[1]

DCD is defined by the American Psychiatric Association as a marked impairment in the development of motor coordination that significantly interferes with academic achievement or activities of daily living.[2] The diagnostic concept of DCD was introduced to include those patients with deficits in motor skills previously known as 'neurological soft signs' and 'clumsiness'. Throughout the years, it has become obvious that children born with DCD depict a high prevalence of attention deficits, and that individuals with ADHD demonstrate motor coordination disabilities consistent with a diagnosis of DCD.[3,4] Indeed, the rate of comorbidity between both conditions has been considered to be close to 50%.[5] In a major survey conducted by Martin et al., using mailed questionnaires completed by parents of 1285 twin pairs aged 5 to 16 years from the Australian Twin Registry, a strong shared additive genetic component was found between most ADHD and DCD subtypes. The DCD-fine motor and ADHD-inattentive subtypes were most strongly linked.[6]

This common association led to the introduction of the concept of deficits in attention, motor control, and perception (DAMP) which has been in use in Scandinavia since the 1970s. For a child to be given the diagnosis of DAMP, several criteria need to be fulfilled: ADHD and DCD according to the *Diagnostic and Statistical Manual of Mental Disorders*, 4th edition (DSM-IV), absence of cerebral palsy, and IQ above 70.[4] Although the existence of DAMP as a distinct entity has not been widely accepted, there is a considerable body of evidence for an overlap between ADHD and DCD.

Interestingly, this combination is detected irrespective of ADHD severity, as opposed to oppositional defiant disorder, whose prevalence among ADHD children increases as the severity of the attention deficit worsens. The prevalence of depression and antisocial behaviour among all patients with DAMP is also high, whereas autistic features and Asperger syndrome are quite common in patients with severe DAMP. Specific learning disabilities, including reading–writing disorder and difficulties with mathematics, and a broad range of speech and language impairments are also common among children fulfilling the diagnostic criteria of DAMP. Finally, personality disorder is frequently detected among these patients.[7] Whether DAMP can be considered a true diagnostic condition or not, there is enough evidence for the increased occurrence of psychiatric comorbidities and specific learning disabilities among children with combined ADHD and DCD.

Whereas ADHD affects 3 to 6% of all children in Scandinavia, USA, Australia, and other countries, clinically significant DAMP occurs in about 1.5% of school-age children.[8,9]

Apart from reports on pharmacological intervention for attention problems, little has been published on the management of children with combined ADHD/DCD.[9] Given the high incidence of social, personality, or psychiatric disorders that many of these children develop throughout the years, the need for a more comprehensive evaluation and treatment of these children is obvious, particularly for their motor skills. As for DCD alone, several intervention methods have

been used since the 1950s, including perceptual motor training (PMT), sensory integration therapy (SIT), and kinaesthetic training.[10] In a controlled study where physical therapists were blinded to the patient's performance on the Test of Motor Impairment and the ABC, Shoemaker et al.,[11] using a treatment based on sensory-motor training and the Bobath and Bobath technique, showed that the clumsy group's motor performance improved significantly over 3 months compared with the control group. However, many patients with DCD may not be recognized and will not receive appropriate intervention: a recent British audit among parents and caregivers of children with DCD showed that many children had difficulties accessing physical therapy intervention because of physicians' underdiagnosis of this condition.[12]

The rationale for physical therapy intervention in children with DCD is based on the assumption that muscle strengthening, improving trunk control, and repeated training with increasing degrees of difficulty improve motor control and performance, and the ability to cope with different motor tasks.[13–15] McNevin et al.,[16] based on multiple studies, concluded that three factors affect the efficiency of physical therapy and enhance the learning of motor skills: the performer's attentional focus, self-control, and practice in small groups.

The principal aim of this study was to determine whether intensive group physical therapy based on these factors would influence the motor performance of children with combined ADHD/DCD.

We also studied the frequency of DCD among the different ADHD subgroups, and the prevalence of comorbidities such as oppositional defiant disorder or specific learning disabilities in this cohort of patients with ADHD/DCD diagnosed in a hospital-based paediatric neurology clinic by a paediatric neurologist, according to DSM-IV criteria.

Method

PARTICIPANTS

This study was performed at the Paediatric Neurology Clinic at Wolfson Medical Center, Holon. Phase 1 (T1) of the study involved identifying elementary-school children with ADHD among the clinic population and diagnosing their comorbid disorders (specific learning disabilities, oppositional-defiant disorder, conduct disorder, mood disorder, anxiety, developmental language delay, and tic disorder) according to DSM-IV criteria by a paediatric neurologist after interviews with patient and parent interviews, neurologic examination, review of teacher and parent questionnaires, and (when available) educational and psychological evaluation. Chronic neurological conditions unrelated to ADHD and major neurological findings on examination constituted exclusion criteria.

MEASURES

All children with ADHD underwent a motor performance assessment by the same physical therapist (NW) using the Movement Assessment Battery for Children (MABC).[17] MABC evaluates three domains: manual dexterity, ball-handling skills, and static–dynamic balance. The three domains were assessed in all the patients.

Patients were diagnosed with DCD if the MABC score was no more than 5%; a score between 5% and 15% suggested that the child was at risk for DCD; whereas any score above 15% was considered normal. Based on this evaluation, patients were classified into a pure ADHD group and an ADHD/DCD group.

To determine the relative frequency of DCD among different ADHD types, all patients with ADHD were subclassified into those with predominantly inattentive ADHD (ADHD-PI), those with mostly hyperactive–impulsive symptoms (ADHD-HI), and children with combined inattentiveness and hyperactivity (ADHD-C) according to DSM-IV classification.

Furthermore, the prevalence of comorbid disorders in each ADHD subgroup and in patients with combined ADHD/DCD was also assessed.

PROCEDURE

The second phase of the study aimed to analyze the impact of intensive physical therapy using perceptual motor training, sensory integration therapy, kinaesthetic training, and neurodevelopmental treatment on the motor performance of children affected with both ADHD and DCD. The flowchart of the study is depicted in Figure 1.

All the children with ADHD and DCD were offered participation in phase 2 of the study during the summer holidays. Twenty-eight of the patients with combined ADHD/DCD symptoms consented and were randomly divided into two groups matched for age, sex, and initial MABC scores (the period between phase 1 and phase 2 did not vary between the control and intervention group).

Group A received a 4-week course of physical therapy according to a twice-weekly, 1-hour session programme. Therapy was conducted by the same physical therapist in age-related groups of four or five patients each, based on an individualized approach according to each patient's needs. Parents and children were also instructed on home therapy according to the therapist's specifications: daily, half-hour

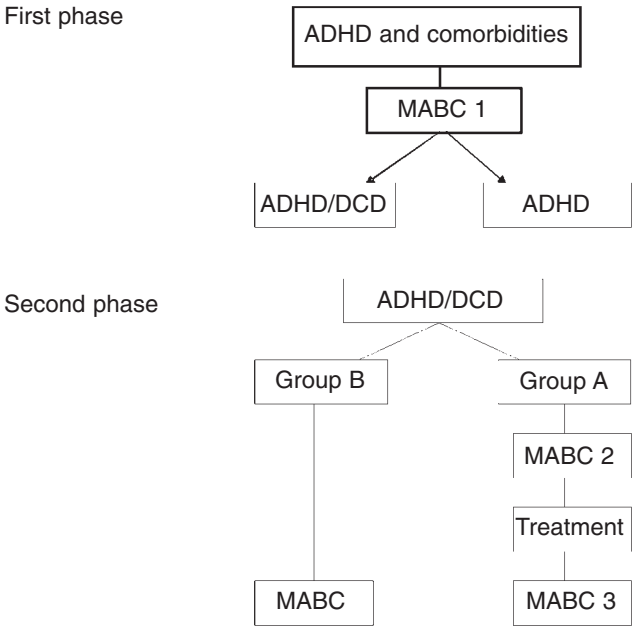

Figure 1: *Randomization of 28 patients with combined attention-deficit–hyperactivity disorder (ADHD)/developmental coordination disorder (DCD) to either receive intensive physical therapy or remain untreated for 4wk period. MABC, Movement Assessment Battery for Children.*

training of muscle strengthening, stretching, and balance exercises as learned at the therapy sessions. All physical therapy intervention was performed during the summer vacation, when patients did not receive any other form of therapy such as occupational or speech therapy, and were not enrolled in any after-school intervention programme.

The intervention programme included a cognitive, task-specific approach;[15] attention to performance of skills and self-control in the ability to perform the activities was stressed.[16] In addition, knowledge of motor learning and motor control[14] was integrated into the treatment protocol. An important aspect of the intervention was to ensure that each child kept a diary where an individualized, home programme (according to his/her specific needs) was recorded, which had to be performed daily. At the beginning of every session each child was asked to demonstrate his/her specific home programme, for example a balance exercise incorporated into a functional activity. This element of the intervention was essential and stimulated motivation and competition among the children and spurred them on to succeed.

Group B consisted of children with ADHD/DCD without any intervention, who served as the control group.

Patients receiving pharmacological therapy were instructed to continue taking it, whereas in no case was the medication stopped or begun during the four-week physical therapy course.

All 28 patients (groups A and B) were evaluated by MABC score upon recruitment and at the end of the eight-session treatment (T3). Group A also received MABC testing at the beginning of the physical therapy course (T2), because often weeks to months had elapsed until the summer vacation arrived and the physical therapy sessions began. The investigator was not blinded to the intervention offered.

The study design and patient recruitment were approved by the Institutional Medical Ethical Committee (Wolfson Medical Center). Informed consent for participation in the study was obtained from all parents according to the Institutional Review Board at the Wolfson Medical Center.

STATISTICAL ANALYSIS

A power analysis was conducted to determine the total number of 96 subjects for the research design. A χ^2 test was applied to determine the relation between the different ADHD subtypes and DCD. The same test was also used to seek for differences in the relative prevalence of comorbidities between the ADHD-alone group and the ADHD/DCD group. To test the efficacy of intensive physical therapy according to MABC results, paired *t*-testing was applied within group comparisons between T2 and T3. Finally, an independent *T*-test evaluated the mean differences between the first and third MABC assessments of both group A (treated) and group B (control) patients.

Results

In phase 1, 96 consecutive children aged 6 to 12 years (mean 8y 4mo, SD 2y; 81 males, 15 females) with ADHD were initially identified. Evaluation of these patients using the MABC score revealed that 53 (55.2%) of these children also had DCD. (A confidence interval of 95% was obtained for the major estimate of prevalence of DCD in ADHD and showed between 46 and 65.8%.)

DCD was significantly more prevalent among patients with a predominantly inattentive component: 64.3% of children with ADHD-PI ($n=18$) and 58.9% of those with the ADHD-C ($n=33$) were diagnosed with DCD, compared with only 11% of patients with the predominantly hyperactive–impulsive subtype ($n=1$; $p<0.05$).

Table I compares the prevalence of comorbidities between children with ADHD and DCD and those with ADHD only. Specific learning disabilities ($p=0.05$) and phonological (pronunciation) disorder ($p=0.03$) were more prevalent among patients with both ADHD and DCD. Conversely, conduct disorder ($p=0.043$) and mood disorder ($p=0.048$) were more common among patients with ADHD alone. No statistical difference was found for tics, Tourette syndrome, oppositional-defiant disorder, anxiety, and expressive language impairment.

Twenty-eight children entered phase 2. Both group A (intensive physical therapy) and B (control) included 14 patients each. Mean age was similar for both groups (9y 3mo; SDs 2y 3mo and 2y 2mo respectively). There were 12 males and two females in each group. The average pre-treatment MABC score was 1.93% (SD 1.14) for group A and 1.29% (SD 0.83) for group B, both scores well within the range of DCD diagnosis.

Seven of the 14 patients in group A reached MABC scores above 15% (normal) after the physical therapy course. In a further five patients, MABC scores improved from less than 5% to the borderline DCD group (5–15%). Interestingly, the two patients who showed no improvement were siblings

Table I: Comparison of comorbidities detected in patients with ADHD and in children with both ADHD and DCD

	Number of cases	*Percentage of patients with ADHD*	*Percentage of patients with ADHD/DCD*	*Percentage of all cases*	*p value*[a]
Specific learning disabilities	42	33.3	52.8	44.2	0.050
Phonological (pronounciation) disorder	9	2.4	15.1	9.5	0.036
Conduct disorder	11	19.0	5.7	11.6	0.043
Mood disorder	3	7.1	0.0	3.2	0.048
Tics	11	7.1	15.1	11.6	0.229
Tourette syndrome	2	4.8	0.0	2.1	0.108
Oppositional-defiant disorder	43	47.6	43.4	45.3	0.681
Anxiety disorder	11	9.5	13.2	11.6	0.577
Expressive language disorder	22	23.8	22.6	23.2	0.893

[a]$p \leq 0.05$ significant. ADHD, attention-deficit–hyperactivity disorder; DCD, developmental coordination disorder.

(Fig. 2). These improvements were statistically significant ($p=0.001$). None of the patients in group B reached normal scores on the MABC administered after 4 weeks of the summer vacation, following the physical therapy period of group A. Nine of the 14 children in group B showed no change at all; four reached scores up to 3%, and in one case the score on the second MABC increased from 4% to 5% The differences between groups were statistically significant ($p=0.001$; Fig. 3).

Discussion

In our patients, children with ADHD of the primary inattentive and combined subtypes were more likely to suffer from DCD. This finding concurs with that of Pitcher et al.[18] who, using the MABC score, found that although males with ADHD have significantly poorer movement ability than control children, those with primary inattentive and combined ADHD subtypes depict worse fine and gross motor abilities. Moreover, the poor fine motor ability associated with ADHD indeed represents a primary motor deficit, not attributed to inattentiveness or hyperactivity/impulsiveness.

We detected a significantly higher occurrence of specific learning disabilities and phonological deficits among patients with combined ADHD/DCD. Learning difficulties, particularly reading disability[19,20] with or without writing and spelling difficulties,[3] often accompany both ADHD and DCD. Specific language impairment (SLI) also occurs frequently in patients with DCD, probably on the basis of a dyspraxic deficit.[3,21] In line with these findings, pronunciation difficulties among our patients were significantly more common in children with ADHD/DCD than in those with ADHD alone.

In this study, a brief course of intensive physical therapy proved very efficacious in improving the motor performance of children with both DCD and ADHD, as measured by the MABC score. In all, 50% of treated children obtained normal scores (greater than 15%) and 35% showed improvement without reaching normal scores after four weeks of intensive physical therapy. Conversely, none of the untreated patients (group B) showed any clinical improvement. Of note, the MABC test was not repeated later for either group. Thus, whether the response to intensive physical therapy in children with ADHD/DCD is sustained could not be determined.

Physical therapy has received relatively little attention in the published literature as a means of enhancing motor performance in children with DCD. The most comprehensive study on this subject, published by Schoemaker et al.[11], involved 18 children. Using a similar approach to that of our study, the authors showed that a 3-month course of physical therapy twice a week significantly improved their motor performance compared with untreated patients with DCD (only). Moreover, the beneficial effect of physical therapy was still

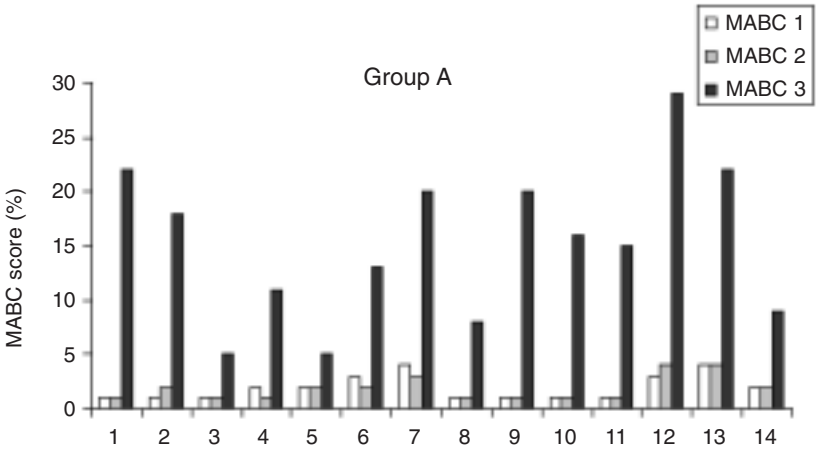

Figure 2: *Group A: effect of intensive physical therapy on Movement Assessment Battery Scores (MABC) of treated children with attention-deficit–hyperactivity disorder /developmental coordination disorder . A score above 15% is considered normal.*

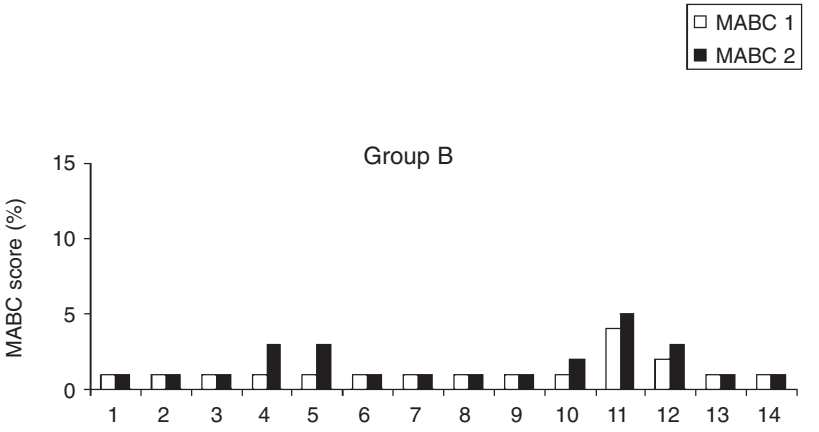

Figure 3: *Movement Assesssment Battery for Children (MABC) scores in untreated children (group B) before and after physical therapy period of group A. A score of no more than 5% is considered diagnostic of developmental coordination disorder (DCD). Note that the score of all patients in the untreated group remained within the DCD range.*

obvious 3 months after cessation of therapy. We also noted significant improvement in motor skills of treated patients. However, our study differs from Schoemaker's in that it involved children with both DCD and ADHD, suggesting that attention deficit may not constitute an impediment for physical therapy to be efficacious in children with DCD. Furthermore, our study shows that a shorter physical therapy course is also effective in these patients. This fact could have important economic implications for the families of these children.

Interestingly, a study addressing verbal actions of physical therapists to enhance motor learning in children with DCD showed that therapists who were blinded to the initial MABC score explained the difficulty of a task more frequently to children with lower scores.[22] Although the findings were not significant, they point to the fact that physical therapists, being well-trained providers, are likely to be quite perceptive of the difficulties faced by children with DCD and may adopt a more active and intensive therapeutic attitude when needed. Indeed, individualizing therapy according to the child's needs and progress seems to be of utmost importance to ensure efficacy of physical therapy for these patients.[23,24] Furthermore, increasing the involvement of family members in the treatment course, while promoting a more active attitude towards the child's performance, appears to further enhance the chances for improving the patient's motor skills and self-esteem.[23,25] In our study, based on these principles, we attempted to cover both aspects to provide children with ADHD/DCD in group A with better tools to achieve higher MABC scores.

The paucity of studies addressing the role of physical therapy in DCD is reflected by the fact that recent guidance issued by the American Academy of Pediatrics for prescribing therapy services for children with motor disabilities failed to include DCD among the disabilities to be treated.[26] In comparison, the literature on other methods such as perceptual motor training, sensory integration therapy, kinesthetic training, cognitive affective training, and task-specific intervention is much broader.[10]

Several mechanisms have been proposed to explain the improvement in motor performance of children with DCD treated with the different techniques: strengthening of the shoulder girdle,[23,25] use of repetitive exercises of increasing frequency,[27] enhancing motivation to perform the exercises through improvement in self-esteem, use of cognitive techniques to sharpen the child's ability to incorporate new tasks,[28] and administration of physical therapy such as group therapy, especially in small groups.[16,23]

Conclusion

Our study evaluated the impact of a brief physical therapy course on the motor performance of children with both DCD and ADHD. Fifty per cent of treated patients reached normal M-ABC scores (>15%) by the end of the therapy course, while clinical improvement without attaining normal scores was seen in a further 35%. In comparison, none of the untreated patients showed normal MABC scores by the end of the 4-week therapy period.

These findings suggest that physical therapy should be more extensively investigated as a potential means of improving motor performance in children with DCD. Of note, a concomitant diagnosis of ADHD in these children had no influence on the effect of physical therapy.

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List of abbreviations

ADHD	Attention-deficit–hyperactivity disorder
DAMP	Deficits in attention, motor control, and perception
DCD	Developmental coordination disorder
MABC	Movement Assessment Battery for Children