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# Motor skills in children with ADHD: overlap with developmental coordination disorder

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## Abstract

Individuals with Attention-Deficit/Hyperactivity Disorder (ADHD) often have overlooked motor difficulties which can be at least partially attributed to co-occurring conditions such as Developmental Coordination Disorder (DCD). Understanding the influence of DCD and motor difficulties is important to detect in children for early support. Accordingly, the present study examined the prevalence of DCD diagnoses, cases of probable DCD, and related impairments among German-speaking parents of children with ADHD. A total of  $N=168$  parents completed an online study about their child's potential for co-occurring DCD via the Developmental Coordination Disorder Questionnaire (DCD-Q). Even after children with DCD diagnoses were removed from the sample ( $n=46$ ), a majority still remained below threshold for probable DCD (55.9%) according to parent-reports. Via exploratory analyses, we also found that a majority of parents in the sample had not heard of DCD before (64.9%) and that many parents did not deem DCD as relevant to their children, even when their DCD-Q scores were in the range of probable DCD. The results align with a high prevalence of DCD in children with ADHD despite a simultaneous lack of awareness of DCD. Furthermore, findings in our sample align with frequently estimated global co-occurrence rates of 50% between ADHD and DCD. Broadly, the results support that motor difficulties should be considered in ADHD assessment and intervention.

**Keywords** Attention deficit hyperactivity disorder, Motor ability, Comorbidity, Dyspraxia, Neurodevelopmental disorders

## Introduction

Attention-Deficit/Hyperactivity Disorder (ADHD) is known for inattentive and/or hyperactive symptoms, however, there is increasing evidence motor difficulties may be common to ADHD [1, 2]. While hyperactivity is related to a lack of motor inhibition, motor coordination is not a defining feature of ADHD in current diagnostic manuals (i.e., DSM-5 [3]; ICD-11 [4]). Simultaneously,

there is high overlap between ADHD and Developmental Coordination Disorder (DCD), a condition with motor learning, execution, and coordination deficits [5]. While it is known that ADHD and DCD are separate conditions [6], the profile of motor difficulties in ADHD is difficult to decipher. This is complicated by the co-occurrence rate of approximately 50% for ADHD and DCD [5].

Several studies have examined the prevalence of DCD in ADHD samples and have reported motor impairments related to DCD were present in at least half of participants [7–9]. While these studies have shown some consistencies in motor difficulties in ADHD, there are some inconsistencies the attribution of these difficulties. For example, some have suggested that motor difficulties may not be part of the ADHD phenotype alone, [8, 10], and

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instead, co-occurring conditions such as DCD may be the source [7, 9]. However, even when DCD is considered and excluded, more motor difficulties are often observed in ADHD compared to typically developing individuals [2, 7, 11]. As such, it is possible that motor difficulties in ADHD are present but less severe than motor difficulties observed in DCD [8]. However, this is yet to be conclusively determined because of sparse focus on motor difficulties in ADHD [1, 2], and a frequently ignored high overlap with DCD [12]. Therefore, overlooked co-occurring DCD might inflate the prevalence of motor difficulties in ADHD. As individuals with DCD can also have symptoms common to ADHD such as inattention and hyperactivity [13], there is potential for misidentification or misdiagnosis of DCD. This is complicated by the lack of understanding and awareness of DCD among clinicians [14, 15]. In order to determine the presence and extent of motor difficulties in ADHD, ADHD and DCD must be considered together in more studies with large samples and across more cultural groups [8].

A number of studies have shown various differences in motor functions among children with ADHD compared to typically developing children. Using the Movement Assessment Battery for Children, Piek et al. [16] found 8–11-year-old boys with ADHD scored in the range for probable DCD (total score < 16th percentile). Furthermore, several studies have indicated motor skills remain impaired in children with ADHD compared to typically developing peers even when participants with co-occurring DCD and probable DCD (i.e., MABC-2 scores < 16th percentile [17]) are excluded from the sample [11, 18]. These findings collectively demonstrate consistent reports of motor difficulties in ADHD compared to typically developing individuals across cultures and objective motor tests.

In addition to objective tests, motor difficulties in ADHD have been indicated with subjective measures, such as the parent-reported Developmental Coordination Disorder Questionnaire (DCD-Q; [19]). Fliers et al. [1] reported that one out of three children with ADHD in their sample had probable DCD based on their DCD-Q scores. Another study reported DCD-Q subscale and total scores were below the threshold for probable DCD in up to 80.9% of children with ADHD compared to only 15.6% in a typically developing control group [20]. Notably, Büniger et al. [20] also found that parent-report questionnaires used in their study, including the DCD-Q, better predicted a diagnosis of ADHD than behavioral performance measures (e.g., executive function and motor tasks). This indicated that using the DCD-Q as a parent-report tool can be useful for estimating motor impairments and probable DCD among children with ADHD.

In order to examine the symptom overlaps between ADHD and DCD, several studies have also compared groups with single-occurring ADHD or DCD and co-occurring ADHD + DCD. Pranjic and colleagues [6] summarized the biobehavioral findings of such studies in a recent systematic review, highlighting the presence of some common neural characteristics in each condition yet a unique presentation in co-occurring ADHD + DCD. This would suggest ADHD and DCD are similar but separate conditions [6].

### Current study

Therefore, in the present study, we examined the extent to which probable DCD could be detected with the DCD-Q in children with ADHD through parent-reports of motor symptoms. Further, as the presence of DCD is often underestimated in German-speaking clinicians [14], we sought to examine if a high prevalence of probable DCD within an ADHD group observed in British [7, 8] and Spanish individuals [9] can be replicated in a German-speaking sample through the parent-report DCD-Q.

We aimed to investigate if co-occurring DCD might explain the motor difficulties reported by parents in groups of children with ADHD. In line with common prevalence estimates of DCD, we expected to find that approximately half of participants with ADHD would be diagnosed with DCD or would have probable DCD based on DCD-Q scores in a German-speaking sample [5]. In line with Farran et al. [7], we further expected co-occurring DCD would account for a majority of parent-reported motor difficulties in ADHD. In order to clarify the links between symptoms and subtypes, we exploratorily examined associations between all questionnaires and subscales. Furthermore, given the lack of awareness of DCD among clinicians worldwide and in German-speaking countries [14, 15], our sample of German-speaking parents might not have been able to access a DCD diagnosis for their child. Therefore, it was important to ask if parents in the sample were aware of DCD themselves, and if they considered the diagnosis relevant to their children. To gather a more holistic view of our sample, we also explored the support options their children used and their links to motor symptoms as well as the diagnoses the parents had themselves.

Notably, the present study was conducted during the ongoing Covid-19 global pandemic among participants in mandated lockdown. Therefore, we used online measures only and streamlined the survey to the simplest possible design via parent-reports in consideration of time of families during the lockdown.

## Method

### Participants

Parents of children with ADHD were recruited via social media, support groups, and local clinics with an incentive of a €25 gift card given to a randomly selected participant. A total of  $N=191$  parents participated in the survey. Those whose children were not formally diagnosed with ADHD by clinical professionals were excluded from the sample ( $n=21$ ), as well as participants who were not fluent in German ( $n=2$ ). Therefore, the final sample included  $N=168$  parents of  $n=132$  boys (78.6%),  $n=36$  girls (21.4%), and whose children were an average age of 11.2 years old ( $SD=2.6$ ; Range: 8–17). The sample consisted of 60.7% children from Germany, 27.4% from Switzerland, and 11.9% from Austria. Many participants' children already had a diagnosis of DCD ( $n=46$ ); autism spectrum disorder ( $n=22$ ); and/or dyslexia ( $n=11$ ).

### Measures and procedures

To characterize symptoms of ADHD, the parent report questionnaire of the diagnostic system for mental disorders for ADHD in children (Diagnostik System für psychische Störungen – Fremdberichtbogen: DISYPS-II, FBB-ADHS; [21]) was included. The DISYPS-II includes 20 items with three subscales for attention (9 items), hyperactivity (7 items) and impulsivity (4 items). In our sample, the DISYPS-II FBB-ADHS had very good reliability ( $\alpha=0.92$ ), as did its subscales (attention:  $\alpha=0.85$ ; hyperactivity:  $\alpha=0.89$ ; impulsivity:  $\alpha=0.85$ ). Higher sum scores on the DISYPS-II indicate elevated ADHD features and increased severity of ADHD symptoms. The raw average DISYPS-II score in the sample was 38.2 ( $SD=11.2$ ; Range: 12–60).

To screen for DCD, the German translation of the revised DCD-Q was included [19], known as the DCDQ-G [22]. The DCDQ-G contains 15 items with overlapping subscales for control during movement (9 items), fine motor functions and handwriting (11 items), and general coordination (10 items). Reliability for the DCDQ-G in our sample was very good overall ( $\alpha=0.92$ ), and fair to very good in all subscales (control during movement:  $\alpha=0.92$ ; fine motor and handwriting:  $\alpha=0.86$ ; general coordination:  $\alpha=0.69$ ). Lower sum scores on the DCD-Q indicate more motor difficulties, and thereby, low scores are relevant to probable DCD. The average DCD-Q score in the sample was 44.1 ( $SD=12.8$ ; Range: 15–70).

In addition to standardized measures to indicate parent-reported potential for DCD and ADHD, we also asked about confirmed diagnosis of DCD and ADHD among parents and their children. Furthermore, we asked parents about all treatment experiences their children had previously or were currently undergoing at the time of completing the questionnaire, such as use of medication, participation in psychotherapy, and occupational

therapy. With respect to DCD, we also asked parents about (1) their own awareness of DCD, including all known and historically used terms i.e., Dyspraxia, clumsy child syndrome, and specific developmental disorder of motor function (abbreviated as “UEMF” in German), and (2) if a description of the DCD diagnosis according to the DSM-5 was relevant to the profile of their child.

The study was conducted online through SoSciSurvey [23] from January to March 2021 and approved by the University of Mannheim ethics committee.

### Statistical analysis

DCD-Q scores were calculated based on two age group thresholds for probable DCD (ages 8–10: scores 15–55; ages 10–17: scores 15–57). Lower DCD-Q scores indicate higher risk for potential DCD. In contrast, DISYPS-II sum scores indicate greater risk for potential ADHD. To broadly describe the sample, including aspects based on the above/below threshold scores, we calculated many descriptive statistics (i.e., proportions) to describe the sample. Associations between subscale and overall DCD-Q and DISYPS-II sum scores were examined with Pearson correlations. For exploratory analysis to compare DCD-Q and DISYPS-II scores between parents who reported their children were taking medication or were not, we used independent samples t-tests with significance at the 5% level.

Analyses were conducted with IBM SPSS version 26. The minimum sample size was determined with an a-priori power analysis (G\*Power 3.1; [24]), which yielded a required sample of at least  $N=111$  participants for correlation analysis and  $N=176$  for group comparisons of two independent samples for power of 0.95 and error of 0.05.

## Results

### DCD: Confirmed and probable cases

27.3% of participants in the sample reported their children had a previously confirmed diagnosis of DCD. Parent-reported DCD-Q scores were significantly lower for children with co-occurring DCD and ADHD ( $M=38.67$ ;  $SD=11.29$ ), indicating more motor difficulties, compared to parents with children only diagnosed with ADHD ( $M=46.11$ ;  $SD=12.83$ ;  $t(166)=3.46$ ,  $p=0.001$ ). DISYPS-II scores relevant to ADHD symptoms did not significantly differ between parent-reports of children with ADHD-only compared to co-occurring ADHD and DCD ( $p>.05$ ).

Overall,  $n=137$  (81.5%) parent-reported DCD-Q scores were in the range of probable DCD. Among these cases,  $n=15$  already had a child with a confirmed diagnosis of DCD. The remaining  $n=122$  parents reported that their child was not diagnosed with DCD, however,  $n=94$  (55.9%) of this group scored in the range of probable DCD via below threshold parent-reported DCD-Q

**Table 1** Distribution of diagnosed DCD and DCD-Q score ranges

	Scored in probable range for DCD from parent report DCD-Q (n)	Scored in range of typical development from parent DCD-Q (n)	Total (n)
Confirmed diagnosis of DCD	15	31	46
No confirmed diagnosis of DCD	94	28	122
Total overall			168

Note The  $n=28$  cases who scored in the typical range for motor skills without DCD had significantly higher parent-reported DCD-Q sum scores ( $M=61.68$ ,  $SD=5.41$ ;  $t(89.2) = -13.54$ ,  $p < .001$ ), indicating less motor difficulties, and significantly lower parent-reported DISYPS-II scores [ $t(120)=4.00$ ,  $p < .001$ ], indicated less attention difficulties and lower hyperactivity than those who scored in the range of probable DCD and no with DCD diagnosis ( $n=94$ )

**Table 2** Means, standard deviations, and correlations between DCD-Q and DISYPS-II Scores

Measure	Mean	SD	1	2	3	4	5	6	7	8
1. Control During Movement	23.68	7.24	--							
2. Fine Motor Skills	33.80	9.87	0.880*	--						
3. General Coordination	30.67	9.45	0.894*	0.921*	--					
4. Total score on DCD-Q	44.07	12.83	0.949*	0.972*	0.974*	--				
5. Inattention	19.14	4.92	-0.477*	-0.383*	-0.422*	-0.437*	--			
6. Hyperactivity	11.49	5.25	-0.302*	-0.290*	-0.320*	-0.315*	0.532*	--		
7. Impulsivity	7.64	3.18	-0.305*	-0.342*	-0.315*	-0.333*	0.437*	0.671*	--	
8. Total score on DISYPS-II	38.21	11.17	-0.431*	-0.395*	-0.418*	-0.427*	0.807*	0.890*	0.795*	--

\* $p < .001$

Note Measures 1–3 are subscales on the DCD-Q-German and are scores from 1 (does not at all apply) to 5 (completely applies) [19]. Measures 5–7 are subscales in the DISYPS-II parent-report and values were scored from 1 (not at all applies) to 4 (especially applies) [21]. Lower DCD-Q scores indicate probable DCD, whereas higher DISYPS-II scores indicate probable ADHD

scores ( $M = 41.47$ ;  $SD = 10.53$ ). An overview is provided in Table 1.

Furthermore, DCD-Q scores correlated significantly with DISYPS-II scores in the entire sample ( $r = -.427$ ,  $p < .001$ ; Table 2). In addition, the DCD-Q and DISYPS-II subscales had significant and positive intercorrelations, and were all significantly related to the sum scores of the DCD-Q and DISYPS-II (Table 2).

### Awareness of DCD

Parent participants indicated their own awareness of DCD such that 64.9% had not heard of any term for DCD before while only 35.1% reported knowledge of DCD or an equivalent term. Coincidentally, 35.1% of participants also indicated a description of DCD according to the DSM-5 criteria was relevant to their child while 64.9% indicated DCD was not relevant to their child. Notably, when excluding cases of already diagnosed DCD, the 35.1% of parents who reported relevance of the DCD description reduced to 25.4%.

### Support options among children and diagnosis of parents

Regarding current or past treatment,  $n = 106$  (63%) parents reported their children took medication,  $n = 82$  (48.8%) attended psychotherapy, and  $n = 44$  (26%) had worked with an occupational therapist. We also explored the influence of medication on parent-reported DCD and ADHD symptoms. There were no significant differences via independent samples t-tests on DCD-Q subscale and total scores as well as DISYPS-II scores between

parents who reported their children taking medication or not ( $p > .05$ ). Among parents themselves,  $n = 44$  (26.1%) reported having ADHD, but only  $n = 2$  had a diagnosis of DCD.

### Discussion

The motor difficulties involved in ADHD have been historically underestimated and complicated by co-occurring DCD [2, 5]. In the present study, we found a high rate of parent-reported DCD symptoms in an ADHD sample consistent with co-occurrence estimates around 50% [5]. The majority of DCD-Q scores fell below threshold for DCD (81.5%), indicating a strong potential for motor difficulties and probable DCD as reported by parents in this sample. Notably, even when parents with children already diagnosed DCD were considered, a majority (55.9%) of cases with parent-reported DCD-Q scores still were below the threshold for DCD, or high prevalence of motor difficulties. These results are consistent with studies conducted with ADHD samples in different regions. For example, in UK-based samples, motor difficulties were noted in 47% and 58% of children with ADHD [7, 8], while in a Spanish sample, 75% of participants with ADHD had probable DCD based on the DCD-Q [9].

While we could not confirm the diagnosis of DCD with objective motor tests due to the Covid-19 related lockdowns at the time of testing and the online nature of the study, this evidence provides important insights about DCD and ADHD and patterns observed from the parent-perspective. Furthermore, there is foundational evidence

that the use of parent-report measures can better predict a diagnosis of ADHD in children than behavioral performance measures, particularly for the parent-report DCD-Q [20]. Overall, the results add to the growing research suggesting that motor difficulties are highly relevant to ADHD and should be considered in the diagnostic and treatment processes [10].

#### **Awareness and relevance of DCD**

Despite only 25% of parents reporting that their children did not have DCD and it was not relevant, just over half of these parent-reports indicated their children were in the range of probable DCD. Even in the chance that the reported motor difficulties are inflated in our sample due to ADHD alone, the rate of diagnosed DCD in the sample is still below the known co-occurrence rate of 50% for DCD and ADHD [5]. This suggests that the motor difficulties, and potentially the relevance of DCD, are likely underestimated by the parents in our sample. Furthermore, a minority (25%) of parents reported knowing about DCD in general. Therefore, underestimation of DCD in the sample is not surprising. This is consistent with other findings that showed DCD is less understood and under-recognized compared to ADHD, as many clinicians in German-speaking populations do not consider screening for DCD or related motor difficulties [14] and similar patterns have been reported internationally [15, 25].

#### **Relationships between DCD and ADHD symptoms**

Interestingly, the significant correlations between the DCD scores (DCD-Q) and ADHD (DISYPS-II) highlighted moderate associations between the subscale and total scores which might reflect the inherent overlap between motor and cognitive processes. However, it is curious that our results are not necessarily consistent with other studies in this regard. For example, one study which found the DCD-Q motor ability subscale did not relate to ADHD symptom via the Conners 3 parent-report scale [8]. This same study concluded that the ADHD phenotype did not include motor symptoms [8], however, given our conflicting results, it must be considered whether the type of ADHD symptom scale used could influence the relationship between level of probable DCD and ADHD. More research should examine how motor-related difficulties and symptoms of ADHD can vary between questionnaires before conclusions can be made about the presence or absence of phenotypic motor symptoms in ADHD. Relatedly, it is possible that due to the similarities of cognitive and motor symptoms as well as the overlap of ADHD and DCD, there is potential for the separate questionnaires to not only be associated, but that some items may predict symptoms in opposing areas (e.g., inattention and control during movement). This

could be more definitively assessed in a sample which includes both DCD-only and ADHD-only groups.

It is also possible that a cultural difference influenced our findings. More specifically, because DCD is under-recognized among German-speaking clinicians compared to ADHD, it is likely that children with ADHD are lacking a DCD diagnosis in our sample [14]. Therefore, future research must continue to examine the rate of motor difficulties in ADHD when co-occurring DCD can be more definitively ruled out.

#### **Support and treatment**

As it has been suggested that medication may support the improvement of motor skills in ADHD [2] but is not currently used for treatment of DCD [12], we considered the relationship between medication and parent-reported symptoms in an exploratory manner. While a majority of parents (63%) reported their children had or were using medication for ADHD at the time of testing, there were no differences in reported DCD and ADHD symptoms between parents of children who had or had not used medication. Future studies should examine the direct impact of ADHD medication on motor skills and co-occurring DCD via child-reports and objective tests.

Beyond medication, about half of participants (49%) reported that their child had attended or were attending psychotherapy to support managing their symptoms, and a quarter (26%) of participants reported attending occupational therapy. The varying forms of treatment explored by participants could be due to heterogeneity of ADHD symptoms [26] as well as constraints in access to therapy (e.g., long-waiting lists, financial burden). Notably, the participants in our study had children already diagnosed with ADHD, but access to diagnosis before treatment can be challenging in of itself [27]. Future studies should examine the impact and accessibility of various forms of diagnosis and treatment on ADHD and co-occurring DCD.

#### **Limitations and future directions**

The present study extends the scarce evidence surrounding motor difficulties in ADHD, however, there are some limitations. While the parent-report nature of the study is informative and commonly used (e.g [20]), subjective reporting may be biased, especially because potential familial conflicts surrounding ADHD may influence parent-reports [28]. Future studies should supplement parent-reports with others, such as teacher reports or those from the children directly. Furthermore, our sample is inclusive of various age groups across childhood, but future research should examine the prevalence of DCD or probable DCD in a group of adults with ADHD to identify if the present patterns are consistent across the lifespan.

A strength of the study is that we were able to reach a large group of parent participants, representing three German-speaking countries, by using an online survey. The intention of this study was to preliminarily assess the relevance of motor skills and potential DCD symptoms with parent-report measures, and we acknowledge this is a first step toward the goal of objectively confirming DCD in ADHD groups in German-speaking countries. It must still be clarified that the parent-report DCD-Q cannot confirm a diagnosis, and therefore, the present study cannot definitively assess the prevalence of DCD in our sample beyond previously diagnosed cases. Future research should aim to closely identify the rates of misdiagnosis and prevalence for ADHD and DCD in general, and across various cultural groups. Furthermore, future studies should examine prevalence of DCD across several measures, including objective motor tests such as the MABC-2 or BOT-2, with clinicians who can confirm a DCD diagnosis.

Finally, there was an over-representation of parents of boys in our sample compared to epidemiological benchmarks [29]. In the future, there should be more gender-specific research on ADHD since the risk of over-diagnosis of ADHD is more than two times higher for boys than girls [30]. Understanding gender differences and potential bias in detection of ADHD is crucial for improving diagnosis [31].

## Conclusions

Overall, a majority of parents in the present study reported motor difficulties consistent with DCD in their children with ADHD through questionnaires despite only some indicating that the diagnostic criteria for DCD was relevant to their children. This suggests that motor difficulties and potential co-occurrence with DCD may be underestimated and misunderstood in children with ADHD and warrants future research to confirm the prevalence of DCD in ADHD. Our results support the increasing notion that motor screening and interventions should be considered as a standard of care for ADHD.

## Author contributions

Emily J. Meachon: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. Julian P. Schaider: Conceptualization, Data curation, Investigation, Methodology, Software, Writing – original draft, Writing – review & editing. Georg W. Alpers: Conceptualization, Investigation, Methodology, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing. All authors: Earlier versions of this work were presented at the 5th Assembly of the International Motor Development Research Consortium and the 38th Symposium of Clinical Psychology and Psychotherapy of the German Psychological Society.

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## Data availability

A dataset for the paper can be accessed at MADATA at the following link: <https://doi.org/10.7801/468>.

## Declarations

### Ethics approval and consent to participate

The study was approved by the Ethics Committee of the University of Mannheim. All participants gave informed consent to take part in the study.

### Consent for publication

Not applicable.

### Competing interests

The authors declare no competing interests.

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