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Below average motor skills predict victimization from childhood bullies: A study of adults with ADHD

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ABSTRACT

Children with ADHD are frequently clumsy and involved in bullying, both as victims and perpetrators. The relationship between motor skills and bully status is poorly understood. The aim of the current study was to evaluate the effect of motor skills in childhood on bully victimization/perpetration in those with ADHD.

In this cross-sectional study, 403 adults diagnosed with ADHD filled out a questionnaire on their recall of bully victimization, bully perpetration, performance in physical education (PE) (defined as performance below average in i.e., ball dexterity, coordination or agility) as a proxy for motor skills, and academic skills at age 12, as compared to their peers. Of the current sample, 63% remembered being victimized and 31% noted they were perpetrators. Thirty-two percent recalled that they performed below average in PE. Being diagnosed with ADHD and having poor motor skills was strongly associated with bully victimization (OR = 2.63; 95% CI:1.62, 4.27, $p < .001$). Victimization was more common during all measured time periods, from nursery school until the age of 15, among those with poor performance in PE as compared to those without poor performance. No relationship was found between poor motor skills and bully perpetration.

Conclusion: A crucial role of the cerebellum is coordination and the linking of sequenced motor actions through milli-second timing. Aberrations in this ability makes a person present as "different", which was stated as the most common reason for social exclusion by other children. Therefore, subtle clumsiness (presumed by poor performance in PE class) is suggested to mirror deficits in social skills, which is intuitively observed by peers, leading to victimization.

1. Introduction

Recurring physical, relational, or verbal aggressive behaviors involving a power imbalance that are intended to harm are called bullying (Olweus, 1993; Nansel et al., 2001). Boys are more typically bullies than girls. Approximately one third of preadolescent children are occasionally involved in bullying, either as victims or perpetrators. A smaller subset (5–20%), however, will experience victimization throughout school (Pepler et al., 2008).

Risk factors for bully victimization are well documented and include obesity, low socioeconomic status (Campbell et al., 2019), inadequate social skills, internalizing problems, being deemed as "different", and low intelligence (Arseneault, 2018; Olweus, 1978; Hawker and Boulton, 2000; Wang et al., 2014). Peer problems, which are often associated with being bullied (Goodman, 1997), mediate the relationship between poor motor skills and internalizing problems (Gasser-Haas et al., 2020). Genetics also play a role in the risk for bully victimization, accounting for approximately 70% of the variance (Ball et al., 2008; Törn et al., 2015).

Compared to non-bullied children, victimized children have an increased risk for developing physical and psychosomatic disorders (Gini and Pozzoli, 2009; Wolke and Lereya, 2015), anxiety and depressive symptoms (Zwierzynska et al., 2013), personality disorders (Hengartner et al., 2013), engaging in self-harm (Fisher et al., 2012), suicidal behavior (Meltzer et al., 2011), and psychotic symptoms (Schreier et al., 2009). The relationship between childhood victimization and ill-health continues in adulthood (Stapinski et al., 2014; Takizawa et al., 2014; Hong et al., 2020). There are, however, no such increased risks in the perpetrators of bullying (Hong et al., 2020). Children who admit they are bullies, report more externalizing behaviors in childhood than victims and children uninvolved in bullying (Kumpulainen et al., 1999). Also, bullies are more prone to antisocial

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activities in adulthood as compared to the other groups (Sourander et al., 2007; Bender and Lösel, 2011). The subgroup of children who are both bullies and victims, so-called bully/victims, however, tend to have poorer outcomes compared to bullied children (Hong et al., 2020). There is a clear dose-response relationship in bully victimization; namely that the frequency, severity, and duration of the bullying affects long-term outcomes (Zwierzynska et al., 2013; Schreier et al., 2009; Takizawa et al., 2014; Wolke et al., 2001, 2013; Wolke and Lereya, 2014).

Children who tend to be perceived as "different" by other children, namely those with physical disabilities and/or neurodevelopmental disorders (i.e., autism spectrum disorder (ASD), developmental coordination disorder (often seen as severe clumsiness), or attention-deficit/hyperactivity disorder (ADHD)), tend to be particular targets of bullying (Piek et al., 2005; Cappadocia et al., 2012; Schroeder et al., 2014; Øksendal et al., 2019). Notably, these diagnoses are often co-morbid. For example, almost all children with ASD, and approximately half of the children with ADHD, are clumsy (Gillberg and Kadesjö, 2003; Kaiser et al., 2015). Moreover, clumsy children with ADHD are inclined to present with more autistic traits (Reiersen et al., 2008) and have a worse psychosocial outcome compared to those with ADHD alone (Rasmussen and Gillberg, 2000). The clumsy child tends to be overall less accepted by peers (Livesey et al., 2011). In addition, clumsiness and low intelligence are often interrelated and, in consequence, children with learning disabilities show a high risk for motor impairments (Smits-Engelsman and Hill, 2012) and, subsequently, being victimized.

In two large groups of non-clinical subjects, it was demonstrated that poor gross motor skills and/or clumsiness in school, defined as retrospectively self-reported poor performance in physical education (PE), were strongly associated with bully victimization (2730 and 1043 respectively; Bejerot and Humble, 2007; Bejerot et al., 2013), with similar results obtained in a group of 69 university students (Bejerot et al., 2011). Additionally, a strong association between poor motor skills and bully victimization was found in a study of 277 individuals with mental disorders who had been carefully assessed for neurodevelopmental disorders in adulthood (Bejerot and Humble, 2013). Across these four studies, authors found an approximately threefold higher odds of having been bullied if the subject reported below average performance in school PE (Bejerot and Humble, 2013; Bejerot et al., 2011) or was perceived to be clumsy either by parents or on a physical examination (Bejerot and Humble, 2013). Children with higher motor skills tend to be less likely to be victimized and are more often, themselves, the bullies (Jansen et al., 2011).

Despite the robust association demonstrated between motor skills and bully victimization, clumsiness is still an understudied risk factor in the current research on mediating factors for bullying (Olweus, 1978; Schroeder et al., 2014; Armitage, 2021; Brendgen and Poulin, 2018).

In the current study, the relationship between motor skills and bully victimization was investigated in a large, adult ADHD sample. This population is a high-risk group for both being involved in bullying and having been a clumsy child. The same method, i.e., to collect the data through self-reported recalled memories, was used as in previous studies on healthy populations (Bejerot and Humble, 2007; Bejerot et al., 2011, 2013). The presumption is that if the same strong association in the current study on an ADHD population using self-report was found as was demonstrated when using physical examination and parental reports (Bejerot and Humble., 2013), the current results would not only support the relationship in people with ADHD, but would also strongly validate the connection between poor gross motor skills and bully victimization in a healthy population.

The aim of the current study, therefore, was to evaluate the association between retrospectively reported poor performance in PE class, assumed to reflect poor gross motor skills in childhood, and bully victimization and/or perpetration in an adult ADHD population.

2. Methods

2.1. Study design, participants, and enrollment

The current cross-sectional study is part of a large project examining the association between joint hypermobility and psychiatric diagnoses, for which the study size was adapted. The calculation yielded a recommended minimum sample size of 300 (Glans et al., 2021). However, to enable further analyses, the sample size was increased. Participants were recruited from four specialized, combined ADHD/ASD outpatient clinics for adults located in Stockholm and Linköping between May 2015 and February 2020. Given all participants were referrals to the clinics, ADHD and/or ASD diagnoses were already confirmed prior to participation in the study. Participants were asked to complete the research questionnaire immediately prior to the clinical visit. Completion of the questionnaire was followed by a clinical interview to assess psychiatric diagnoses by a clinician (MG). Inclusion criteria were ADHD diagnosis according to the DSM-IV or DSM-5 and being aged 18–65 years. Exclusion criteria were any missing data on gender, reported physical performance at age 12, bully status, bully frequencies and duration, and a co-existing ASD diagnosis. See Fig. 1 for enrollment.

Ethical approval was obtained from the Stockholm Ethical Review Board (approval number 2014/1742–31, 2017/1688–31, and 2017/2140-32). All participants provided written informed consent.

2.2. Measures

The research questionnaire was developed by our research team and included questions on demographics, psychiatric diagnoses, motor skills, academical performance, and bullying status, specified below.

2.2.1. Demographic data and psychiatric comorbidities

Demographic data included sex (man/woman), age (years), educational level, occupation status, and psychiatric comorbidities. Highest educational level referred to highest completed level of education and included the responses "university ≥3 years", "university <3 years", "upper secondary school", "vocational training", "compulsory school", and "unfinished compulsory school". Responses on occupation were dichotomized into two categories "employed or studying" or

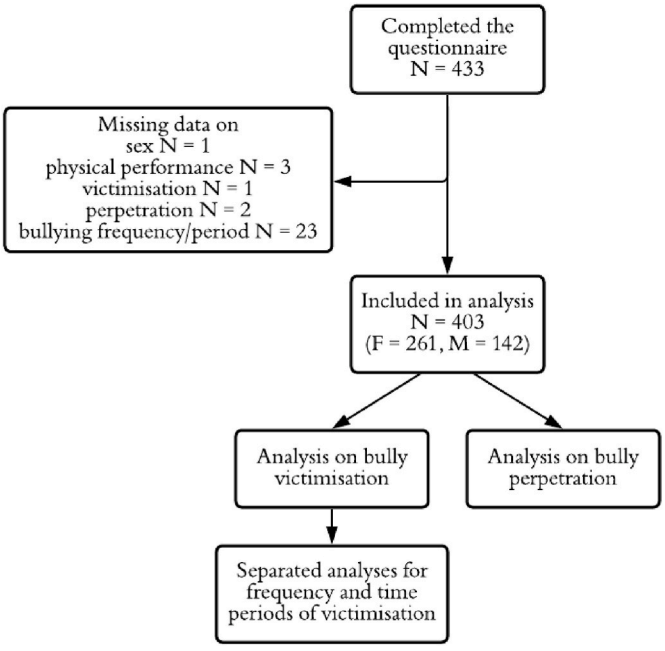

Fig. 1. Flowchart.

"unemployed/no job". Psychiatric comorbidities were recorded by "yes/no" questions on the presence of the following diagnoses (current or previously): ASD, Asperger's syndrome, ADHD/ADD, depression, anxiety disorders, and "any other psychiatric disorder" (with an included free text response). In addition, at the clinical interview, the researchers asked each participant about the presence of lifetime psychiatric disorders.

2.2.2. Poor motor and academic skills

Poor motor and poor academic skills were assessed by the two items "In elementary school, at age 12, was your performance below average in PE (i.e., ball dexterity, coordination, agility)?" and "In elementary school, at age 12, was your performance below average in academic subjects compared to your peers?" Responses were dichotomized into "yes/no", with positive responses used as proxies for poor motor skills and learning disabilities, respectively. Learning disabilities have been previously associated with both low intelligence and poor motor skills and therefore may act as a confounder.

2.2.3. Bullying

The definition of bullying was described with an abbreviated version of the Olweus definition (Olweus, 2006), which states *"… as when someone is exposed to a verbal or physical action causing discomfort in him or her. Bullying also includes when someone is teased repetitively in a way that he or she does not appreciate or when someone is intentionally excluded from activities. But it is not considered bullying if two persons with similar strength and influence argue or fight with each other. Neither is it bullying when someone is teased in a friendly or playful manner"*.

The current study assessed the following three bully variables: 1) bully victimization; 2) bully perpetration; and 3) duration and extent of bully victimization.

Bully victimization was assessed by the two items "Do you feel that you were bullied *to a large extent* at school?" and "Do you feel that you were bullied *to some extent* at school?", with the available responses "Yes" and "No". The two questions were then dichotomized into one variable, where an affirmative response to either of the two items was coded as a "yes" and a non-affirmative response to both items was coded as a "no".

Bully perpetration was assessed by the question "Did you bully others in school?", with the available responses of "Yes, to a large extent", "Yes, a little", and "No". This variable was also dichotomized into "yes" or "no", similar to the bully victimization responses.

Duration and extent of bully victimization were assessed by five questions on the frequency of bully victimization throughout different educational stages, namely "nursery school", "7–9 years", "10–12 years", "13–15 years" and/or "upper secondary school". For example, "How often were you bullied at preschool?" with the available responses of "Never", "It happened only once in a while", "2–3 times monthly", "Approximately once weekly", and "Several times weekly". Participants were only categorized as being victimized if they reported being bullied at least 2–3 times monthly.

2.3. Statistical analyses

For descriptive purposes and comparisons between victimized and non-victimized participants, continuous variables (age) were analyzed by a Student *t*-test and categorical variables were analyzed by a Pearson's X^2 test. Logistic regression models were used to evaluate the influence of poor motor skills on bully victimization and bully perpetration, separately, while adjusting for poor academic skills and sex. Multicollinearity was tested by determining the variance inflation factor, with a threshold of 2.5. P-values were set at 2-sided, and a significance level was set at $p < .05$. SPSS Version 27 software was used for all analyses.

3. Results

A total of 403 participants with ADHD (142 men and 261 women) met the overall inclusion and exclusion criteria of the study (Fig. 1). In Table 1, characteristics of the total study population as well as comparisons between victimized and non-victimized patients are presented. Sex, age, bully perpetrator status, educational level, occupational status, and psychiatric diagnoses other than ADHD did not differ between the victimized and non-victimized groups. On the other hand, the victimized group demonstrated a non-significant trend toward lower recalled academic performance at age 12 and poor motor skills were also more frequently reported in the victimized group. Missing data were evenly distributed between the victimized and non-victimized participants.

3.1. Bully status distribution

Of the total sample, 63% (n = 255) reported being victimized in childhood (66% amongst men and 62% amongst women). The proportion of bully perpetrators (defined as both pure bullies and bully/victims) was 31% (n = 125, 45% amongst men and 23% amongst women).

Detailed bully status according to four categories.

Detailed bully status distribution, when considering four possible categories (i.e., pure victims, pure bullies, bully/victims, and bystanders), was as follows: 43% (n = 173) were pure victims, 11% (n = 43) were pure bullies, 20% (n = 82) were bully/victims, and 26% (n = 105) were bystanders, not participating in bullying. Amongst men, pure victims were 34% (n = 48), pure bullies 13% (n = 19), bully/victims 32% (n = 45) and bystanders 21% (n = 30). Amongst women, pure victims were 48% (n = 125), pure bullies 9% (n = 24), bully/victims 14% (n = 37) and bystanders 29% (n = 75).

Table 1
Characteristics of the study population. Comparisons are made between victimized and non-victimized individuals with ADHD.

Characteristics	Total	Victimized	Non-victimized	
Number of subjects, n (%)	403 (100)	255 (63.3)	148 (36.7)	p < .001
men, n	142	93	49	
women, n	261	162	99	
Age, (SD)	33.4 (11.4)	34.3 (11.6)	32.9 (11.3)	p = .249
Below average in PE at 12 yrs, n (%)	130 (32.3)	101 (39.6)	29 (19.6)	p < .001
Below average academically at 12 yrs, n (%)	173 (42.9)	118 (46.3)	55 (37.2)	p = .075
Bully perpetrators[a], n (%)	125 (31.0)	82 (32.2)	43 (29.1)	p = .516
Psychiatric comorbidity, n (%)	295 (73.2)	188 (73.7)	107 (72.3)	p = .755
Employed or student[b]	239 (59.3)	148 (58.0)	91 (61.5)	p = .420
Highest educational level[c], n (%)				p = .848
University ≥3 years	73 (18.1)	47 (18.8)	25 (16.9)	
University <3 years	27 (6.7)	15 (5.9)	12 (8.1)	
Upper secondary school	134 (33.3)	87 (34.1)	47 (31.8)	
Vocational training	31 (7.7)	17 (6.7)	14 (9.5)	
Compulsory school	39 (9.7)	24 (9.4)	15 (10.1)	
Unfinished compulsory school	8 (2.0)	5 (2.0)	3 (2.0)	

Abbreviations: yrs. = years; SD = standard deviation; PE = physical education.
Note: Age analyzed by a Student t-test and categorical variables by a Pearson Chi-squared test. P-values are 2-sided.
[a] Bully perpetrator includes both bullies and bully-victims.
[b] Missing data on occupation, n = 91.
[c] Missing data on highest educational level, n = 91.

3.2. Poor motor skills rates

Of the total sample, 130 (28% of the men and 35% of the women) recalled that they were below average in PE as compared to their peers at 12 years of age.

3.3. Poor motor skills and association with bully victimization

Of those 130 participants who reported below average performance in PE, 78% (88% of the men and 73% of the women) had been victimized, compared to 56% (57% of the men and 56% of the women) of those who did not report below average performance in PE.

Results of the logistic regression models on the effect of poor motor skills on bully victimization are presented in Table 2. There was no indication of multicollinearity. Poor motor skills demonstrated a significant influence on bully victimization in both the unadjusted and the adjusted models. Sex stratified analyses on the association of poor motor skills and bully victimization showed an unadjusted odd ratio of 5.31 (95% CI: 1.92, 14.7, $p \leq .001$) amongst men and 2.15 (unadjusted, CI: 1.23, 3.75, $p = .007$) amongst women.

3.4. Poor motor skills and association with bully perpetration

Amongst the 130 participants who reported below average in PE, 32% (50% of the men and 23% of the women) were perpetrators, similar to the 31% (43% of the men and 23% of the women) of those with at least average performance in PE who were perpetrators.

Results of the logistic regression models on the effect of poor motor skills on bully perpetration are presented in Table 3. There was no indication of multicollinearity. There was no significant influence of poor motor skills on bully perpetration in the unadjusted nor in the adjusted model. However, in the adjusted model, both poor academic skills and being male revealed a significant influence on bully perpetration, with adjusted odds ratios of 1.89 (95% CI: 1.21, 2.94) and 2.62 (95% CI: 1.68, 4.08), respectively. The non-significant influence remained in the sex-stratified analyses on poor motor skills and bully perpetration, with unadjusted odds ratios of 1.32 (95% CI: 0.63, 2.74, $p = .46$) amongst men and 0.98 (95% CI: 0.55, 1.82, $p = .99$) amongst women.

3.5. Poor motor skills and duration of bully victimization

Peer victimization, defined as being bullied at least twice monthly according to the Olweus definition, was significantly more common during all time periods, from nursery school until age 15, amongst participants who reported below average performance in PE class at age 12 compared to those who reported at least average performance (Fig. 2).

4. Discussion

In the current study that included 403 adults with ADHD, poor motor skills, defined as below average performance in school PE class, and bully victimization in childhood are strongly related, whereas this association was non-existent among the bully perpetrators. These findings are consistent with previous research showing a high risk for bully victimization in individuals with poor motor skills and neurodevelopmental problems (Törn et al., 2015; Gini and Pozzoli, 2009; Brendgen and Poulin, 2018; Øksendal et al., 2019). Additionally, these results support previous findings by producing an almost identical odds ratio for bully victimization in non-clinical populations who acknowledged having performed below average in school PE class (Bejerot and Humble, 2007; Bejerot et al., 2011, 2013). Furthermore, the current study suggests that self-reported recollection on performance in PE class and victimization in childhood are useful and simple measures for estimating motor skills and bullying, in alignment with previous reports (Bejerot and Humble, 2007; Bejerot et al., 2013). Consistent with expectations, individuals with ADHD acknowledged poor performance in PE class almost twice as often (32%) compared to a previously studied non-clinical population (18.6%, Bejerot et al., 2013). Notably, some interesting differences in PE performance between sexes was also found, suggesting that fewer boys perform below average in school PE class than girls, or alternatively, males tend to retrospectively overestimate their own PE performance compared to females (poor performance in PE reported by males and females with ADHD was reported at 28% and 35%, respectively, and by non-clinically diagnosed males and females at 12.8% and 19.8%, respectively). Bully perpetration was slightly more common among males with ADHD (43%) than among non-clinically diagnosed males (37.4%, Bejerot et al., 2013), but was equally common among females across the two studies, with 23% of the women admitting to being a bully.

To our knowledge, less than a handful of current studies conducted by other research groups have examined the connection between poor gross motor skills and victimization among children with neurodevelopmental disorders (Törn et al., 2015; Øksendal et al., 2019; Jansen et al., 2011; Stephenson and Chesson, 2008). Although findings are similar across studies, the explanations are remarkably different. Jansen et al. (2011) suggested that impaired motor skills may lead to poor psychosocial functioning and anxiety in adolescence, which thereby increases the likelihood for becoming victimized. However, children with poor motor coordination are at risk for other problems seemingly unrelated to poor motor skills; for instance, they are less able to accurately recognize emotions than other children (Cummins et al., 2005). It seems unlikely, then, that this disability is caused by peer problems. Rather it may explain victimization. In another study, bullying involvement was associated with altered cortical morphology (Muetzel et al., 2019). In targets of frequent bullying, the fusiform gyrus, which is involved in facial processing and theory of mind, showed a thicker cortex. According to the authors, victimization may have caused the morphological changes (Muetzel et al., 2019). We propose that the

Table 2
Results of the logistic regression model on poor motor skills' effect on bully victimization.

Variable	Unadjusted models						Adjusted models					
	B	SE	Wald	*df*	p	Unadjusted odds ratio (95% CI)	B	SE	Wald	*df*	p	Adjusted odds ratio (95% CI)
Poor motor skills[a]	0.99	0.24	16.5	1	<.001	2.69 (1.67–4.34)	0.97	0.25	15.4	1	<.001	2.63 (1.62–4.27)
Poor academic skills[b]							0.24	0.22	1.24	1	.266	1.28 (0.83–1.96)
Sex, male							0.19	0.22	0.75	1	.386	1.22 (0.78–1.89)
Model	$\chi^2(1) = 17.96$, $p < .001$					Nagelkerke $R^2 = 6.0\%$	$\chi^2(3) = 20.15$, $p < .001$					Nagelkerke $R^2 = 6.7\%$

Abbreviations: CI, confidence interval; df = degrees of freedom; SE = standard error.
Note: Adjusted models have been controlled for poor academic skills and sex. Poor motor skills represent motor skills compared to not poor motor skills. Poor academic skills represent poor academic skills compared to not poor academic skills. Sex represents men compared to women.
[a] Poor motor skills is defined as self-estimated performance below average in physical education at age 12 years.
[b] Poor academic skills is defined as self-estimated performance below average in theoretical subjects in school at age 12 years.

Table 3
Results of the logistic regression model on poor motor skills' effect on bully perpetration.

Variable	Unadjusted models						Adjusted models					
	B	SE	Wald	*df*	*p*	Unadjusted odds ratio (95% CI)	B	SE	Wald	*df*	*p*	Adjusted odds ratio (95% CI)
Poor motor skills[a]	0.04	0.23	0.02	1	.876	1.04 (0.66–1.63)	.005	0.24	.000	1	.984	1.01 (0.63–1.61)
Poor academic skills[b]							.635	0.23	7.89	1	.005	1.89 (1.21–2.94)
Sex, male							.962	0.23	18.0	1	<.001	2.62 (1.68–4.08)
Model	$\chi^2(1) = 0.024$, $p = .876$					Nagelkerke $R^2 = 0.0\%$	$\chi^2(3) = 27.96$, $p < .001$					Nagelkerke $R^2 = 9.4\%$

Abbreviations: CI, confidence interval; df = degrees of freedom; SE = standard error.
Note: Adjusted models have been controlled for poor academic skills and sex. Poor motor skills represents poor motor skills compared to not poor motor skills. Poor academic skills represents poor academic skills compared to not poor academic skills. Sex represents men compared to women. P-values are 2-sided.
[a] Poor motor skills is defined as self-estimated performance below average in physical education at age 12 years.
[b] Poor academic skills is defined as self-estimated performance below average in theoretical subjects in school at age 12 years.

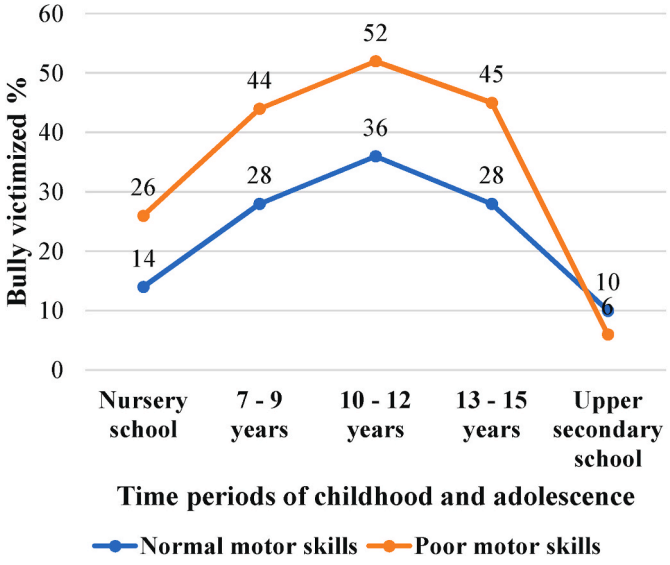

Fig. 2. Peer victimization, defined as bullied at least twice monthly, in 403 patients with ADHD in different time periods of childhood and adolescence, separated by poor motor skills according to self-reported performance in physical education at 12 years of age.
$^{**}X^2$ $(df = 1) = 9.6$, $p = .002$; X^2 $(df = 1) = 9.8$, $p = .002$. $^{***}X^2$ $(df = 1) = 10.2$, $p = .001$; X^2 $(df = 1) = 12.2$, $p < .001$.

direction of causality in that study is reversed.

In a large Norwegian population-based study, the odds for being bullied were calculated in 5-year-olds with various disabilities (Øksendal et al., 2019). Notably, the odds for being bullied among the children with motor developmental problems, which, on the surface have less of an impact on social skills than hearing or visual difficulties, was nevertheless threefold in comparison. The risk of being bullied is skyrocketing for socially inept children with ASD (Øksendal et al., 2019). Moreover, a relationship between motor impairments and poor social function in autistic boys has previously been reported, which further supports this association (Holloway et al., 2018).

Our explanation for the strong association between bully victimization and poor motor skills is that social skills are closely linked to motor skills (both gross and fine motor skills) and that good social skills require profound motor skills. Motor skills are involved in nearly all social interactions, given that communication is based on gaze, facial expression, postures, intonation, pitch and prosody, beyond what actually is said between people. Therefore, poorly integrated motor skills correspond to similarly poorly integrated social skills. Subtle deficits in social skills are often hard to measure, but we argue that these deficits are nevertheless intuitively observed by peers. Even subtle social skills deficits are prone to be perceived as being "different" by other children, resulting in rejection. Being viewed as "different" by other children is noted to be the most common reason for social exclusion (Guerra et al., 2011). Although children with ADHD are typically less socially inept than children with ASD, deficits in social cognition are well recognized clinical phenomena in ADHD, as well (for a review see Marotta et al., 2017).

Seemingly, the detection threshold for perceiving someone as "different" is low. The exclusion of the "different" person has been suggested to have evolutionary foundations for selection and dominance (Volk et al., 2012). Accordingly, boys with superior motor skills are more often pure bullies (Jansen et al., 2011). It is worth noting that, presumably, to be a pure bully in childhood (as opposed to being a bully/victim) is not a sign of pathology.

We also argue that poor motor skills share the same biological roots as social "oddness", are prevalent across all neurodevelopmental disorders, and continue into "normality". The cerebellum, primarily known for its role in coordination and regulation of movements, is also involved in social and cognitive functions (Van Overwalle et al., 2020). Motor and social skills are connected through a joint central control in the cerebellum (Stoodley and Schmahmann, 2010). This provides a cerebellum-based pathophysiologic explanation for the occurrence of both poor motor and social skills in neurodevelopmental disorders. One of the crucial roles of cerebellum is the coordination and connection of sequenced motor actions through milli-second timing (Van Overwalle et al., 2020). Communication involves cerebellar controlled, fine-tuned motor actions to produce coordinated and timed conversation (Van Overwalle et al., 2020). Minor, unsynchronized verbal and non-verbal cues are presumed signals on which other children react, perhaps on a subliminal level, and cause a presumably instinctive rejection. Consequently, cerebellar function is suggested to be of crucial importance in the risk of being persistently and harmfully bullied. Notably, a previous study by Williams et al. (1992) demonstrated that clumsy children tend to have timing control problems. The authors proposed a dysfunction in a central timekeeping mechanism, plausibly situated in the cerebellum.

No known physical or environmental risk factor for bully victimization is on par with the impact of clumsiness; the clumsy child has an approximately threefold elevated risk to be victimized compared to the non-clumsy counterpart. Furthermore, the current study confirmed an earlier finding that demonstrated clumsiness to be associated with more pervasive victimization (Jansen et al., 2011), which is particularly harmful. Importantly, poor motor skills often precede the bullying events and are unaffected by the bullying itself, in contrast to emotional and behavioral problems. Since motor skills are such a robust risk factor, communication and vigilance should be funneled. If the clumsy child has friends and shows no social deficits, there is no need to worry, but if there are peer problems, teachers and parents should be ready to intervene.

In contrast to the challenges of measuring subtle social skill disabilities, impaired motor skills are easily detected by physical examination or by reported performance in PE.

4.1. Limitations

There are several limitations to this study. First is the reliance on recalled self-reported data on bullying, which may introduce bias; adults may underestimate or exaggerate memories of bullying and victimization. However, the questionnaire provided an established definition of bullying in order to establish a framework to relate to. Furthermore, experiences of severe emotional distress, like the humiliation from bullying, are known to create memories that persist throughout the lifespan. Victimized individuals are inclined to remember the perpetrators and whether bullying was enduring or not (Rivers, 2001; Bifulco et al., 2014). While some victimized children may deny or belittle ongoing victimization, presumably because of shame or denial, that bias is unlikely in adulthood. Therefore, an adult's retrospective self-report of peer victimization may, in fact, be more reliable than a child's self-report.

Second, not all known possible risk factors for bully victimization and perpetration were included in the multivariate analyses. This is because of the study itself, which was primarily designed for the assessment of joint hypermobility among individuals diagnosed with ADHD (Glans et al., 2021). The opportunity to also assess motor skills among the participants, however, was utilized to analyze the data for the current study. In retrospect, having not focused on bullying during recruitment may have offered protection from selection bias and thereby increase the generalizability of the current results. Moreover, in a previous study, being overweight, socioeconomic status, and being part of a minority group had lower prediction value for victimization than reported poor performance in PE class (Bejerot et al., 2013).

Third, there were no questions on the participants' fine motor skills. This is difficult to assess with a few questions, because signs of poor fine motor skill performance in childhood tend to be forgotten. However, given that fine and gross motor skills are strongly associated (Øksendal et al., 2021), poor fine motor skills among participants with poor gross motor skills can be expected.

Finally, we did not ask whether the participants had superior gross motor skills, only if they were below normal. Also, due to small numbers, the bully/victims and pure bullies were grouped into one single group. Subsequently, we cannot draw any conclusions on bully perpetrations among participants with ADHD and superior motor skills.

4.2. Conclusions

The current study supports a strong association between reported poor gross motor skills and bully victimization, consistent with previous publications. Poor motor skills may reflect an underlying social awkwardness, which increases one's vulnerability to victimization. While it should not be expected that these vulnerable children will become socially skilled through physical exercises, adapted individualized exercises may be beneficial to improve muscle strength, coordination, and self-assurance. Group sports are typically difficult for a clumsy child, but they often excel in singles sports such as biking and swimming. Physical activity is associated with reduced problematic behaviors including bullying, presumably by improving sleep quality among children with ADHD (Li et al., 2021). School personnel should be attentive to the vulnerable child and assist in finding topics that interest them and can be shared by other children, to avoid loneliness and bully victimization.

Children and adolescents ought to be educated on factors that affect human behaviors, such as the slow maturation of the brain's frontal lobe and how it impacts thoughtful reflections and the inhibition of impulses, as well as the innate evolutionary impulses that make us engage in behaviors that enhance our own chance to flourish, sometimes by harming others. If children are protected from becoming bully perpetrators with this education, they will not need to struggle later in life with regrets for having victimized vulnerable children.

Author statement

Susanne Bejerot: Conceptualization, Methodology, Writing – Review and Editing, Lovisa Ståtenhag: Writing original draft, Formal analysis, Martin Glans: Conceptualization, Methodology, Investigation, Data curation, Formal analysis.

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