



# Characterisation of depressive symptoms in young children with and without attention deficit hyperactivity disorder

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Received: 4 September 2018 / Accepted: 27 December 2018 / Published online: 29 January 2019  
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## Abstract

Depressive symptoms and attention deficit hyperactivity disorder (ADHD) are prevalent and commonly co-occur in childhood. To assist with early identification of depression in children with ADHD, we aimed to: (1) use factor analysis to determine whether the construct of depression is measured consistently in those with and without ADHD; and (2) determine whether overall depressive symptoms and specific depressive symptoms were elevated in children with ADHD relative to controls. Participants comprised a community-based sample of 179 children with ADHD (51% Combined presentation, 35% Inattentive presentation) and 212 non-ADHD controls aged 6–8 years. Participants were screened for ADHD and underwent a structured diagnostic interview which confirmed ADHD status and assessed depressive symptoms. The factor structure of depressive symptoms was similar, enabling comparisons between the two groups to be made. Eighteen children with ADHD (10%) and three control participants (1%) experienced either MDD or subthreshold MDD. Children with ADHD experienced more depressive symptoms than controls (Cohen's  $d=1.19$ ,  $p<0.001$ ), with the following symptoms elevated in children with ADHD relative to controls: sadness (32% vs. 14%,  $p<0.001$ ), irritability (52% vs. 19%,  $p<0.001$ ), insomnia (56% vs. 22%,  $p<0.001$ ), psychomotor agitation (53% vs. 9%,  $p<0.001$ ), feeling bad about oneself (50% vs. 24%,  $p<0.001$ ), difficulty concentrating (75% vs. 14%,  $p<0.001$ ) and making decisions (56% vs. 17%,  $p<0.001$ ). This study provides support for the occurrence of depressive symptoms in children with ADHD as young as six and highlights the importance of early assessment for depressive symptoms in children with ADHD.

**Keywords** Attention-deficit/hyperactivity disorder · ADHD · Depression\* · Mood · Comorbidity

## Introduction

Attention deficit hyperactivity disorder (ADHD) is a prevalent neurodevelopmental disorder, affecting approximately 5% of children worldwide [1]. It is estimated that children with ADHD are four times more likely than the general population to experience depression, with lifetime prevalence rates of depressive disorders in children with ADHD ranging from 1.5 to 32% [2–5]. Children with co-occurring ADHD and depression experience greater impairment, morbidity and poorer treatment outcomes when compared to those with either condition alone [6–12]. Similarly, subthreshold symptoms of depression have been found to have a significant impact on emotional, adaptive and psychosocial functioning, suicide risk and depression recurrence [6–12]. To date, the majority of empirical studies in ADHD have focused on investigating the co-occurrence of depression at a diagnostic level, i.e. the presence or absence of depression (for

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**Electronic supplementary material** The online version of this article (<https://doi.org/10.1007/s00787-018-01274-5>) contains supplementary material, which is available to authorized users.

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example, [9]), with fewer studies in young samples of children with ADHD examining the overlap between ADHD and depression using a symptom-based approach. Consequently, it is unclear how depressive symptoms present in young children with ADHD and whether this presentation differs from children without ADHD. Possessing this information will inform the assessment and subsequent management of depressive symptoms in young children with ADHD.

Studies are yet to investigate whether the presentation and expression of depressive symptoms on measurement tools is invariant (i.e. the same) across children with and without ADHD. Although not specifically investigated, the non-specific overlapping symptoms of ADHD and depression and the side effects of medications used to treat ADHD which can mimic depressive symptoms [2, 4, 7], suggests that measurement variance (i.e. differences with regards to depressive symptoms) across children with and without ADHD is likely. The failure to investigate measurement invariance is a glaring omission given that measurement invariance is essential when comparing groups, such as those with ADHD versus controls, as it ensures that the same underlying construct is being measured and that observed differences are not due to group specific measurement effects.

Understanding differences in depression between those with and without ADHD is important given that there are approximately 1,000 unique symptom combinations that qualify for a diagnosis of depression [13]. For example, the Children's Depression Inventory (CDI), the most widely used measure of childhood depression, assesses a large range of childhood depressive symptoms including; externalising symptoms such as misbehaviour, disobedience and aggression; dysphoria including negative affectivity, sadness, irritability; self-deprecation including self-hate, negative body image and feeling unloved, school problems including decline in school performance and social problems including social withdrawal and a lack of friendships [18, 19]. Consequently, it is possible that children with ADHD experience a heterogeneous pattern of symptoms relative to children without ADHD.

To our knowledge, only one previous community-based study has compared depressive symptoms between children with ( $n = 34$ , mean age = 10) and without ADHD ( $n = 34$ , mean age = 9.5) [14]. This study, using the CDI found that children with ADHD experienced significantly more depressive symptoms than those without ADHD ( $12.15 \pm 5.38$  vs.  $6.50 \pm 3.74$ ,  $p < 0.001$ ). Anhedonia was the most common symptom in both groups, though those with ADHD experienced significantly more anhedonia than those without ADHD ( $3.89 \pm 2.28$  vs.  $2.53 \pm 1.64$ ,  $p < 0.00$ ). Negative mood ( $2.82 \pm 1.90$  vs.  $1.53 \pm 1.31$ ,  $p < 0.00$ ), feelings of ineffectiveness ( $3.09 \pm 1.73$  vs.  $1.38 \pm 1.56$ ,  $p < 0.001$ ) and negative self-esteem ( $1.53 \pm 1.46$  vs.  $1.76 \pm 0.70$ ,  $p < 0.00$ ) were

also more frequently reported in the ADHD group when compared to the controls. Additionally, 15% of children with ADHD endorsed the statement 'I want to kill myself', with no children from the control group endorsing this item. Whilst this study provides evidence of depressive symptoms in ADHD, the sample was small and the symptoms examined were from the CDI rating scale as opposed to a diagnostic instrument.

Diler and colleagues [15], in a clinical sample, used the K-SADS-PL and the Mood and Feelings Questionnaire to investigate which depressive symptoms best discriminated young people aged 5–17 years with ADHD and depression ( $n = 18$ ) from those with ADHD alone ( $n = 93$ ). They found that social withdrawal (67% vs. 32%), anhedonia (89% vs. 40%), all 14 depressive cognitions (e.g. could never be as good as others 90% vs. 56%, felt unloved 94% vs. 43%, felt no good anymore 89% vs. 42%), psychomotor retardation (67% vs. 27%) and suicidal thoughts (61% vs. 15%) occurred more frequently in children with depression and ADHD than those with ADHD alone. Depressed mood (100% vs. 80%), irritability (100% vs. 85%), concentration difficulties (94% vs. 86%) and appetite (61% vs. 56%) and sleep changes (72% vs. 57%) did not significantly differ across the two groups. These results are limited by the lack of reference to a typically developing comparison group and broad age range [16, 17].

This study aimed to improve understanding of co-occurring depressive symptoms in children with ADHD. Using a community-based sample of young children aged 6–8 years, we sought to first demonstrate measurement invariance across groups and then (i) investigate whether children with ADHD have elevated depressive symptoms compared to non-ADHD controls and whether depressive symptoms differed according to key clinical characteristics for children with ADHD (i.e. ADHD presentation, comorbidity status); and ii) determine the profile of depressive symptoms in children with ADHD relative to non-ADHD controls by identifying which depressive symptoms, if any, discriminated between groups. We hypothesised that children with ADHD would experience significantly more depressive symptoms than non-ADHD controls and that a higher proportion of children with ADHD would endorse each depressive symptom compared to non-ADHD controls.

## Method

### Design

This cross-sectional study involved secondary analysis using baseline data from the Children's Attention Project, a community-based longitudinal study of children with and without ADHD [20]. Ethics approval was obtained from

The Royal Children's Hospital (#31056), the Victorian Department of Education and Early Childhood Development (#2011\_001095) and Deakin University, Melbourne, Australia (#2016-396). Schools were recruited via the Victorian Department of Education and Early Child Development. Baseline data were collected across two consecutive years (2011–2012). The methodology has been previously described [20].

## Participants and procedures

With parental consent, all children aged 6–8 years, in grade one, were screened for ADHD, as per procedures outlined below. Children with an intellectual disability ( $IQ < 70$ ), serious medical condition, moderate–severe sensory impairment, neurological problem or genetic disorder were excluded, as were those whose parents lacked sufficient English to complete study questionnaires. All other children in grade one were eligible. This age group was chosen as the recruitment point as this is the developmental stage where diagnosis becomes more common [20, 21].

Parents and teachers across the 43 participating schools completed the 10-item Conners 3 ADHD Index [22]. As cross-situational impairment is a requirement for a diagnosis of ADHD, children were considered to have screened positive for ADHD if scores on both parent and teacher ADHD Indices were equal to or above the percentile cut off point for age and sex ( $\geq 75$ th percentile for boys and  $\geq 80$ th for girls). Any child reported by parents as having received a diagnosis of ADHD was also regarded as a positive screen. Children were considered to have screened negative for ADHD and eligible for inclusion into the non-ADHD control group if scores on parent and teacher ADHD Indices were less than the above percentile cut off point, exclusion criteria were not met, and there was no reported diagnosis of ADHD. Consenting parents of all children who screened positive and negative and who did not meet exclusion criteria were invited to participate. For each positively screened child, a negatively screened child matched on sex and school was randomly selected.

To confirm ADHD status and assess depressive symptoms in both groups, consenting parents completed the Diagnostic Interview Schedule for Children-IV (DISC-IV) [23] either at home or at the child's school according to preference. The DISC-IV was conducted by field staff who had at least a 4-year undergraduate degree in psychology and were blind to the child's screening status. Interviewers were comprehensively trained in DISC-IV administration by a Clinical Psychologist (ES) during a full-day workshop and then completed three practices before commencing fieldwork. All interviewers attended fortnightly supervision meetings to discuss issues around DISC-IV administration and to provide an opportunity to debrief.

The final sample comprised 179 children with ADHD (124 male, 55 female, mean age 7.30) and 212 children without ADHD (135 male, 77 female, mean age 7.33).

## Measures

Socio-demographic measures included questions assessing demographic details of the child (e.g. age, sex, diagnostic status and medication use) and family characteristics (e.g. respondent's relationship to the child, respondent's sex, marital status, employment, education and income).

The Conners 3 ADHD index [22] screened for ADHD symptom severity across the last month via 10-items rated on a 4-point scale ranging from 'not true at all' to 'very much true'. Both parent and teacher report were used. The measure has excellent psychometric properties [22].

The DISC-IV [23], using parent report, assessed ADHD diagnostic status, identified depressive symptoms and any co-occurring mental disorders according to DSM-IV-TR criteria. Depressive symptoms assessed included depressed or irritable mood (Criterion A1), diminished interest or pleasure (Criterion A2), weight loss/gain or appetite change (Criterion A3), insomnia or hypersomnia (Criterion A4), psychomotor agitation or retardation (Criterion A5), fatigue or loss of energy (Criterion A6), worthlessness or guilt (Criterion A7), thinking or concentration problems (Criterion A8), and thoughts of death (Criterion A9) across the last month. The exact questions that assessed the above criteria are listed in Table 3. Symptoms were either endorsed as 'yes' or 'no'. To meet each criterion, parents were required to endorse one of the symptoms within the specific criterion as well as any five of the other criterions. For example, to meet criterion 1 participants were required to experience either a sad or irritable mood along with diminished interest, changes in sleep, psychomotor changes, suicidal ideation and diminished ability to concentrate or think. This meant that participants could endorse items across the criterion whilst still not reaching the threshold for the overall criterion. A diagnosis of Major Depressive Disorder (MDD) was given if children met criteria for MDD according to the DSM-IV-TR. Specifically, they had to experience five or more symptoms across the last 2 weeks that represented a change of functioning and caused impairment or significant distress and were not due to other conditions. A diagnosis of subthreshold MDD was made in accordance to the DISC-IV algorithms which states that at least half of the criteria must be met and/or impairment from symptoms indicated. The DISC-IV is widely used and has sound psychometric qualities [23].

## Data analysis

To examine whether the measurement of depression is represented similarly across those with and without ADHD, we used factor analysis to assess the measurement invariance of all depressive symptoms in children with ADHD relative to non-ADHD controls. Factor analysis was conducted in Mplus v7.11 [24, 25]. The weighted least squares mean and variance adjustment estimator was used for analysis due to the ordered categorical nature of the item scaling on the depression measure [25]. Model fit was evaluated in accordance with Hu and Bentler [26]; non-significant goodness-of-fit test ( $p > 0.05$ ), comparative fit index (CFI)  $\geq 0.95$ , and root-mean-square-error of approximation (RMSEA)  $\leq 0.06$ . Invariance of the measurement of depression across the two groups (i.e. ADHD vs non-ADHD control) was examined using a three step approach (with THETA parameterisation) specified in Muthén and Muthén [25] and reviewed in detail in Putnick and Bornstein [27] and Mutchen and Asparouhov [28]. Briefly, step 1 involved examining whether the same number of factors were observed across groups (i.e. thresholds and factor loadings were left free across groups, residual variances were fixed to one and factor means to zero in both groups). Step 2 investigated whether the two groups responded to each specific item in the same way (i.e. full metric invariance; involved constraining thresholds and factor loadings to be equal across groups). Step 3 involved relaxing parameters found to be different between the groups (i.e. partial metric invariance; based on modification indices that identified the largest source of misfit). Nested model comparisons were compared using the DIFFTEST function in Mplus. Due to the stringent procedure for managing missing data, whereby participants were contacted and the missing information completed, there was no missing data within the final dataset.

A linear regression, in which total depressive symptoms were regressed onto a grouping variable (i.e. ADHD vs. non-ADHD control), was used to examine whether children with ADHD experienced elevated depressive symptoms compared to non-ADHD controls. Analysis of Variance was used to compare depressive symptoms across the three ADHD presentations: Combined, Inattentive, Hyperactivity/Impulsivity, while linear regression was used to examine whether depressive symptoms differed in children with ADHD by comorbid anxiety and externalising disorder status. To examine group differences at the symptom level, a series of logistic regressions and adjusted regressions (adjusting for child sex, medication use, parental relationship status, income and education) were planned. However, due to the low number of children with depressive symptoms, these were not possible. Consequently, Chi square analyses comparing the prevalence of each depressive symptom across the groups and Fishers exact tests were conducted to

ensure accuracy despite the small cell counts. Analyses were repeated excluding children with ADHD who met MDD criteria to determine whether depressive symptoms are more prevalent in ADHD irrespective of MDD diagnosis. Analyses were also repeated specifically comparing depressive symptoms between children with ADHD by medication use status. Standard significant tests, set at 0.05, were used. Cohen's  $d$  was used to report effect sizes; with 0.2 indicating a small relationship, 0.4 indicating a moderate relationship, and 0.8 indicating a strong relationship [29]. All analyses were conducted using Stata 13.0 [30].

## Results

### Sample characteristics

Compared to non-ADHD controls, children with ADHD were more likely to experience internalising (25% ADHD vs. non-ADHD 5%) and externalising (54% vs. 8%) disorders (Table 1). Fifteen participants in the ADHD group met sub-threshold criteria for MDD and three met criteria for MDD, compared to two who met subthreshold criteria for MDD and only one child who met criteria for MDD in the control group. Twenty-one percent of the ADHD group were taking medication for behavioural or emotional difficulties compared with none in the control group. Only one participant was using an antidepressant; SSRI Citalopram. Although other family characteristics were relatively similar across the groups, more parents in the non-ADHD control group than in the ADHD group had completed high school (85% vs. 69%) and university (67% vs. 46%). Further, more parents in the non-ADHD control group earned more than \$90,000 per year (46% vs. 23%).

### Factor structure and invariance of depressive symptoms in those with ADHD versus non-ADHD controls

Step 1 of the invariance testing demonstrated that a single depression factor fit the individual depressive symptom items in both the ADHD and non-ADHD control group,  $\chi^2(340) = 371.78$ ,  $p = 0.11$ , RMSEA = 0.02, CFI = 0.96 and TLI = 0.96. Moving beyond the number of factors underlying the data, step 2 of the analysis demonstrated that restricting the factor loadings and item thresholds to full equivalence across both groups resulted in a significantly worse fit,  $\chi^2(359) = 459.91$ ,  $p = 0.00$ , RMSEA = 0.038, CFI = 0.89 and TLI = 0.88;  $\chi^2_{\text{diff test}}(19) = 104.02$ ,  $p < 0.001$ . Consequently, full metric invariance did not hold between the ADHD and the non-ADHD control group. Step 3 explored whether there was partial metric invariance between the groups by examining which items were causing model misfit and then

**Table 1** Sample demographic characteristics

Sample characteristics	ADHD N=179 Freq (%)	Non-ADHD controls N=212 Freq (%)	p value
Age, M (SD)	7.30 (SD 0.45)	7.33 (SD 0.38)	0.414 <sup>a</sup>
Sex (N)	–	–	0.283 <sup>b</sup>
Male	124 (69%)	135 (63%)	–
Female	55 (30%)	77 (36%)	–
Diagnosis	–	–	–
ADHD Combined	93 (51%)	–	–
ADHD Hyperactive	22 (12%)	–	–
ADHD Inattentive	64 (35%)	–	–
MDD	3 (2%)	1 (0.5%)	–
Subthreshold MDD	15 (8%)	2 (1%)	< 0.001 <sup>b</sup>
Comorbid internalising disorders	44 (25%)	10 (5%)	< 0.001 <sup>a</sup>
Comorbid externalising disorders	97 (54%)	17 (8%)	< 0.001 <sup>a</sup>
Medication for learning, behavioural, emotional difficulties	36 (21%)	1 (0%)	< 0.001 <sup>b</sup>
Methylphenidate	23 (14%)	0	< 0.001 <sup>b</sup>
Clonidine	6 (3%)	0	0.008 <sup>b</sup>
Risperidone	3 (1%)	0	0.092 <sup>b</sup>
Melatonin	5 (2%)	0	0.018 <sup>b</sup>
Other <sup>c</sup>	3 (1%)	0	0.092 <sup>b</sup>
Family characteristics	–	–	–
Respondent's relationship to child	–	–	0.604 <sup>a</sup>
Biological parent	162 (97%)	198 (98%)	–
Foster parent	1 (0%)	0	–
Other legal guardian	4 (2%)	4 (1%)	–
Respondent's sex	–	–	0.226 <sup>a</sup>
Male	8 (4%)	16 (7%)	–
Female	159 (95%)	186 (92%)	–
Primary caregiver has partner	132 (79%)	184 (92%)	< 0.001 <sup>a</sup>
Respondent's education level	–	–	–
Completed high school	116 (69%)	173 (85%)	< 0.001 <sup>a</sup>
Completed university	52 (46%)	107 (67%)	< 0.001 <sup>a</sup>
Income	–	–	< 0.001 <sup>a</sup>
Below \$30,000 per year	28 (17%)	22 (11%)	–
\$30,001–\$60,000 per year	44 (26%)	38 (19%)	–
\$60,001–\$90,000 per year	45 (27%)	46 (23%)	–
Above \$90,001 per year	47 (28%)	93 (46%)	–

<sup>a</sup>Standard significance test for independent *t* tests<sup>b</sup>Fisher's exact *p* value<sup>c</sup>1 SSRI (Citalopram), 1 Lovan, 1, 1 anxiety tablet (not specified)

allowing parameters involving these items to vary freely between groups. After inspection of modification indices, the thresholds of items 'grumpy/irritable', 'did not enjoy anything', 'insomnia', 'hypersomnia', 'restlessness', 'trouble keeping mind on school work' and 'difficulty making decisions' were allowed to vary freely between groups. After freeing these parameters, the partial metric invariance model was found to have good fit,  $\chi^2(352) = 386.13$ ,  $p = 0.10$ , RMSEA = 0.02, CFI = 0.96 and TLI = 0.96, and

was not significantly different from the model presented in Step 1,  $\chi^2_{\text{diff test}}(12) = 16.39$ ,  $p = 0.17$ . These analyses demonstrate partial metric invariance between the ADHD and non-ADHD control group and thus it is appropriate to conduct further analysis on the presentation of symptoms across the two groups and interpret any group differences in symptoms (e.g. 'grumpy/irritable', 'did not enjoy anything', 'insomnia', 'hypersomnia', 'restlessness', 'trouble keeping mind on school work' and 'difficulty making decisions') as

representing true group differences on the latent depression variable. See Table 2 for the factor loadings demonstrating measurement invariance across the two groups.

### Prevalence of depressive symptoms in children with ADHD versus those without

When regressing depressive symptoms on to group, children with ADHD experienced more depressive symptoms ( $M = 5.6$ ,  $SD = 3.5$ , range = 0–17) than non-ADHD controls ( $M = 2.0$ ,  $SD = 2.5$ , range = 0–16;  $F(1, 389) = 136.61$ ,  $p < 0.001$ ) with an  $R^2$  of 0.26 and mean difference of  $-3.58$ , 95% CI  $-4.19$ ;  $-2.98$  between the two groups. A large between groups effect size (Cohen's  $d = 1.19$ ) was also found.

Although mean depressive symptoms were highest in the ADHD Combined presentation ( $M = 6.0$ ,  $SD = 3.5$ ), followed

by Inattentive ( $M = 5.3$ ,  $SD = 3.6$ ) and Hyperactivity/Impulsivity ( $M = 4.9$ ,  $SD = 3.5$ ) presentations, differences between groups were non-significant [ $F(2, 176) = 1.24$ ,  $p = 0.29$ ]. Depressive symptoms were higher in children with ADHD and an anxiety disorder ( $M = 8.0$ ,  $SD = 3.9$ ) compared to children with ADHD without an anxiety disorder ( $M = 4.8$ ,  $SD = 3.1$ ;  $p < 0.001$ ). Similarly, depressive symptoms were higher in children with ADHD with an externalising disorder ( $M = 6.7$ ,  $SD = 3.6$ ) compared to children with ADHD without an externalising disorder ( $M = 4.3$ ,  $SD = 3.1$ ;  $p < 0.001$ ).

### Presentation of depressive symptoms in those with ADHD and non-ADHD controls

As per Table 3 and Fig. 1, a number of depressive symptoms were elevated in children with ADHD compared

**Table 2** Factor loadings demonstrating invariance for each symptom of depression in children with ADHD and non-ADHD controls

Diagnostic criterion and related symptoms of depression	ADHD $N = 179$	Non-ADHD controls $N = 212$
Criterion 1: depressed or irritable mood		
Sad/depressed	0.97	0.97
Grumpy/irritable	0.75	0.75
Criterion 2: diminished interest or pleasure		
Did not enjoy anything/not interested	2.12	2.12
Criterion 3: weight loss/gain or appetite changes		
Lost weight	0.70	0.70
Loss of appetite	1.14	1.14
Gained weight	0.42	0.42
Felt hungrier/ate more	0.74	0.74
Criterion 4: change in sleep		
Trouble sleeping (insomnia)	0.44	0.44
Slept more (hypersomnia)	1.43	1.43
Criterion 5: psychomotor agitation or retardation		
Slowed down walking/talking	0.90	0.90
Felt restless	0.64	0.64
Criterion 6: fatigue or loss of energy		
Less energy than usual	1.11	1.11
Doing little things made them tired	1.44	1.44
Felt as if their arms and legs were heavy	0.77	0.77
Criterion 7: worthlessness or guilt		
Blamed self for bad things	–	–
Felt bad about self	0.81	0.81
Criterion 8: thinking or concentration problems or indecision		
Could not think as clearly/fast	1.17	1.17
Trouble keeping the mind on school/work	0.57	0.57
Hard to make decisions	0.62	0.62
Criterion 9: thoughts of death, suicidal ideation, suicide		
Often thought about death/dying	0.50	0.50
Thought seriously about killing self	1.62	1.62
Tried to kill self	–	–

**Table 3** Frequency of symptoms of depression in children with ADHD and non-ADHD controls

Diagnostic criterion and related symptoms of depression	ADHD N=179 Freq (%)	Non-ADHD controls N=212 Freq (%)	Fisher's exact <i>p</i> value
Criterion 1: depressed or irritable mood	11(6%)	1 (0.5%)	0.002
Sad/depressed	58 (32%)	29 (14%)	< 0.001
Grumpy/irritable	94 (53%)	42 (20%)	< 0.001
Criterion 2: Diminished interest or pleasure	5 (3%)	1 (0.5%)	0.09
Did not enjoy anything/not interested	29 (16%)	16 (8%)	0.01
Criterion 3: Weight loss/gain or appetite changes	4 (2%)	0	0.04
Loss of weight	18 (10%)	4 (2%)	0.001
Loss of appetite	31 (17%)	15 (7%)	0.002
Gained weight	6 (3%)	7 (3%)	1.000
Felt hungrier/ate more	46 (26%)	43 (20%)	0.23
Criterion 4: Change in Sleep	1 (1%)	0	0.46
Trouble sleeping (insomnia)	102 (57%)	48 (23%)	< 0.001
Slept more (hypersomnia)	5 (3%)	5 (2%)	1.00
Criterion 5: psychomotor agitation or retardation	–	–	–
Slowed down walking/talking	5 (3%)	2 (1%)	0.25
Felt restless	95 (53%)	20 (9%)	< 0.001
Criterion 6: Fatigue or loss of energy	1 (1%)	0	0.46
Less energy than usual	27 (15%)	17 (8%)	0.04
Doing little things made them tired	16 (9%)	7 (3%)	0.03
Felt as if their arms and legs were heavy	23 (13%)	4 (2%)	< 0.001
Criterion 7: worthlessness or guilt	2 (1%)	1 (0.5%)	0.59
Blamed self for bad things	30 (17%)	12 (6%)	< 0.001
Felt bad about self	91 (51%)	51 (24%)	< 0.001
Criterion 8: Thinking or concentration problems or indecision	1 (1%)	0	0.46
Inability to think as clearly/fast	27 (15%)	8 (4%)	< 0.001
Trouble keeping focused	135 (75%)	30 (14%)	< 0.001
Difficulty making decisions	102 (57%)	38 (18%)	< 0.001
Criterion 9: thoughts of death, suicidal ideation, suicide	2 (1%)	0	0.21
Often thought about death/dying	50 (28%)	29 (14%)	0.001
Thought seriously about killing self	10 (6%)	1 (0.5%)	0.003
Tried to kill self	3 (2%)	0	0.095

with non-ADHD controls. Sadness/depressed mood (32% vs. 14%,  $p < 0.001$ ), grumpy/irritability (53% vs. 20%,  $p < 0.001$ ), insomnia (57% vs. 23%,  $p < 0.001$ ), feeling restless (53% vs. 9%,  $p < 0.001$ ), trouble keeping focused (75% vs. 14%,  $p < 0.001$ ) and difficulty making decisions (57% vs. 18%,  $p < 0.001$ ) were the highest occurring symptoms in children with ADHD and were significantly different to controls. Anhedonia, loss of weight and appetite, restlessness, fatigue after doing little, less energy than usual, heaviness of limbs, blaming self for bad thing, thoughts about dying and suicidal ideation also significantly differed across the two groups.

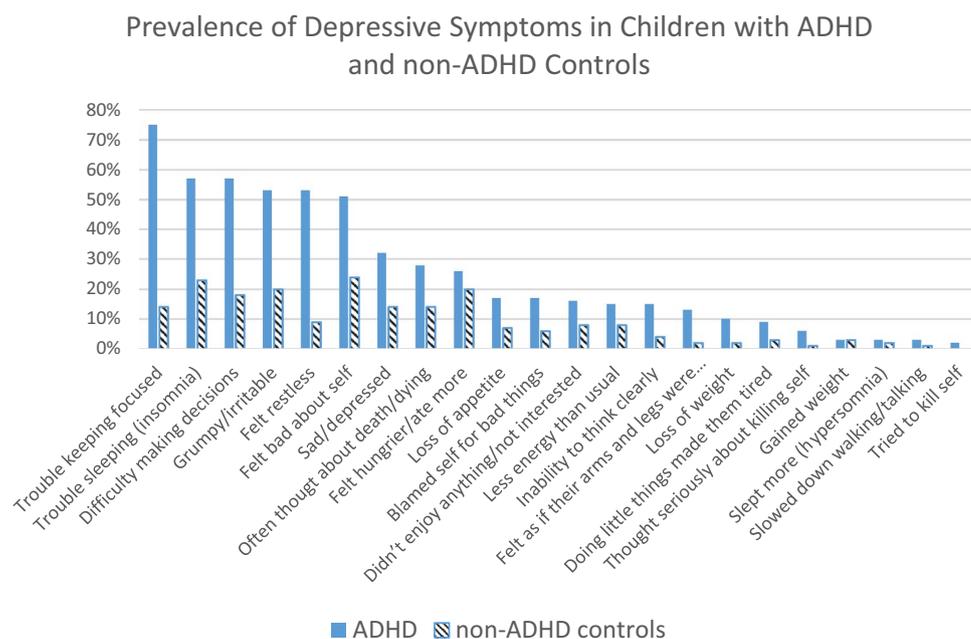
When those with MDD were excluded from the analysis the following depressive symptoms were no longer significantly different; criterion 1 (from  $p = 0.002$  to  $p = 0.379$ ), anhedonia ( $p = 0.0001$  to  $p = 0.08$ ), less energy than usual ( $p = 0.04$  to

$p = 0.251$ ) and fatigue after doing little ( $p = 0.03$  to  $p = 0.056$ ). Attempts at suicide became significant ( $p = 0.095$  to  $p = 0.048$ ). We also examined whether symptoms in children with ADHD differed between those on medication versus those who were not. These analyses suggested that the prevalence of depressive symptoms did not differ by medication use, with the exception of “often thinking about death/dying” which was higher in the medication group (50%) compared to the no medication group (22%). See supplementary materials, Table 4.

## Discussion

This study builds upon the limited body of research examining depressive symptoms in children with ADHD by extending findings to a large, community-based sample of

**Fig. 1** Prevalence of depressive symptoms in children with ADHD and non-ADHD controls



young, pre-adolescent children with and without ADHD. The factor structure of depressive symptoms was found to be similar across the two groups. We found strong evidence of elevated depressive symptoms in young children with ADHD compared to non-ADHD controls, with irritability, insomnia, psychomotor agitation, feeling bad about oneself, difficulty concentrating and making decisions the most common symptoms experienced by young children with ADHD.

Findings indicated that the factor structure of MDD is similar for children with and without ADHD. Specifically, we found that a one-factor structure was observed in both groups, and that partial measurement invariance was demonstrated across groups. This provides evidence that the presentation of MDD for both children aged 6–8 with ADHD and those without is unidimensional and items are being interpreted similarly by both groups. This is an important first step when comparing groups across symptoms such as MDD as it ensures that it is not simply measurement error that is influencing group differences. As such, demonstration of partial metric invariance provides a strong basis for group comparisons across depressive symptoms.

The present study sought to determine whether young children with ADHD have elevated depressive symptoms compared to non-ADHD controls. As expected, results confirm that young children across all three presentations of ADHD experienced more depressive symptoms than non-ADHD controls. This is consistent with previous research findings suggesting that children with ADHD compared to those without experience greater depressive symptoms [14, 31, 32]. We extend previous research by indicating that children with ADHD as young as six are approximately three and a half times more likely to experience depressive

symptoms than their non-ADHD counterparts, highlighting the need for screening for depression in children with ADHD from a young age. We also demonstrate that in young children with ADHD the occurrence of anxiety and externalising disorders is associated with an increase in depressive symptoms relative to those with ADHD alone. This finding suggests that there is a subpopulation of children with ADHD who are at a higher risk of developing depressive symptoms. Whilst previous research indicates that the occurrence of depression is not due to “false positives” [7], given the increase in the presentation of depressive symptoms in those with multiple disorders, future research should investigate whether the presence of depressive symptoms is due to the potential demoralisation that many children with ADHD and co-occurring disorders experience. This research would also benefit from investigating associated risk trajectories and functional impairment using a longitudinal design.

Children with ADHD experienced many elevated depressive symptoms including depressed mood, irritability, anhedonia, loss of weight and appetite, restlessness, fatigue, loss of energy and insomnia. They also experienced more concentration difficulties, depressive cognitions such as blaming oneself and feeling bad about oneself and more suicidal ideation than non-ADHD controls. Overall, the highest occurring symptom was trouble with keeping focused on school work (75% vs. 14%). The non-ADHD group did not experience any symptoms at a higher rate than the ADHD group, though this is likely explained by the near absence of depression within the non-ADHD group. These findings provide support for LeBlanc and Morin [14] who also found that the depressive symptoms that occurred more frequently in children with ADHD compared to those without included

depressed or irritable mood, anhedonia, feeling bad about oneself along with thoughts about killing oneself. Whilst the children with ADHD across both studies experienced more thoughts about killing oneself than those without ADHD, only 5% of the current sample endorsed this item in comparison to 15% endorsed within the LeBlanc and Morin sample. This is likely due to the wider age range included in LeBlanc and Morin. Findings within this study extend on LeBlanc and Morin by indicating that somatic symptoms such as fatigue and loss of appetite are also more common in children with ADHD than those without. Interestingly, across both studies, gaining weight, feeling hungrier or eating more, sleeping more and psychomotor retardation along with suicide attempts were not found to discriminate those with and without ADHD, indicating that they may not be as important when assessing for MDD in young children.

A noteworthy limitation in all research investigating the co-occurrence of ADHD and MDD is the overlapping symptoms of ADHD and MDD and more specifically the inability to determine which disorder they apply to. Whilst difficulty keeping focused, making decisions and restlessness were among the most commonly occurring symptoms in children with ADHD, there were a number of depressive symptoms, such as sadness and irritability, independent of ADHD criteria, which were elevated in children with ADHD suggesting that the co-occurrence is not simply due to overlapping symptoms. Further whilst some of the depressive symptoms may have been attributable to treatment side effects, findings suggest that medication had little impact on the presentation of symptoms. The results suggest that the above symptoms are important in discriminating depressive symptoms in children with ADHD and thus should be assessed in clinical assessment of young children with ADHD.

This is the first study to specifically examine which depressive symptoms occur more frequently in young children aged 6–8 with and without ADHD. It incorporates the use of gold standard structured diagnostic interviews, which align with DSM and ICD diagnosis of depression. Despite these strengths, there are a number of weaknesses. The cross-sectional nature of the study limits the ability to draw conclusions regarding the temporal course of depressive symptoms in children with and without ADHD. Despite the potential impact of caregiver's mental health difficulties on reports, this was not controlled for. Future research would benefit from adjusting for caregiver mental health as this would ensure results are not skewed by the caregivers' mental state. A further limitation was the relatively small number of girls within the sample. Finally, most of the sample presented with no or mild depressive symptoms and thus results may only generalise to this community-based age group and those with less severe depression.

This research contributes to an understanding of the presentation of depressive symptoms in young children

with and without ADHD. The factor structure was found to be unidimensional across both groups, indicating that the same assessment tools can be utilised for those with and without ADHD. It highlights the co-occurrence of depressive symptoms in those with ADHD, above that found in matched peers without ADHD as well as the young age at which depressive symptoms present. It also highlights the depressive symptoms that may be of particular importance in children with ADHD, including sadness, anhedonia, psychomotor agitation, thoughts about killing oneself and feeling bad and blaming oneself. Understanding how depression presents in children with ADHD, particularly at an early age, provides opportunities for early identification and treatment.

**Acknowledgements** This paper used data from the Children's Attention Project. This project was funded by the Australian National Health and Medical Research Council (NHMRC; project grant 1008522), the Collier Foundation, and the Murdoch Children's Research Institute (MCRI). Associate Professor Sciberras' position is funded by an NHMRC Career Development Fellowship in Population Health 1110688 and a veski Inspiring Women's Fellowship. Associate Professor Efron is supported by Clinician Scientist Fellowship, MCRI and Claire Ingrid Joseph by an Australian Government Research Training Program Scholarship.

## Compliance with ethical standards

**Conflict of interest** On behalf of all authors, the corresponding author states there is no conflict of interest.

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