

Apgar Scores Are Associated with Attention-Deficit/Hyperactivity Disorder Symptom Severity

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Les scores d'Apgar sont associés à la gravité des symptômes du trouble de déficit de l'attention avec hyperactivité

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Abstract

Objective: Adverse events during pregnancy and delivery have been linked to attention-deficit/hyperactivity disorder (ADHD). Previous studies have investigated Apgar scores, which assess the physical condition of newborns, in relation to the risk of developing ADHD. We propose to go one step further and examine if Apgar scores are associated with ADHD symptom severity in children already diagnosed with ADHD.

Method: ADHD symptoms severity, while off medication, was compared in 2 groups of children with ADHD: those with low (≤ 6 , $n = 52$) and those with higher (≥ 7 , $n = 400$) Apgar scores sequentially recruited from the ADHD clinic.

Results: Children with low Apgar at 1 minute after birth had more severe symptoms as assessed by the externalizing scale of the Child Behaviour Checklist, the Conners' Global Index for Parents, and the *DSM-IV* hyperactivity symptoms count ($P = 0.02$, <0.01 , <0.01 , respectively).

Conclusion: Low 1-minute Apgar scores are associated with a significant increase in ADHD symptom severity. These findings underline the importance of appropriate pregnancy and perinatal care.

Abrégé

Objectif : Les événements indésirables durant la grossesse et l'accouchement ont été liés au trouble de déficit de l'attention avec hyperactivité (TDAH). Des études précédentes ont investigué les scores d'Apgar, qui évaluent la condition physique des nouveau-nés, en relation avec le risque de développer le TDAH. Nous proposons de faire un pas de plus et d'examiner si les scores d'Apgar sont associés à la gravité des symptômes du TDAH chez les enfants qui ont déjà reçu un diagnostic de TDAH.

Méthode : La gravité des symptômes du TDAH, sans prise de médicaments, a été comparée dans deux groupes d'enfants souffrant du TDAH: ceux ayant de faibles scores d'Apgar (≤ 6 , $n = 52$) et ceux chez qui ils sont élevés (≥ 7 , $n = 400$), recrutés séquentiellement dans une clinique de TDAH.

Résultats : Les enfants ayant de faibles scores d'Apgar une minute après la naissance avaient des symptômes plus graves tels qu'évalués par l'échelle d'externalisation de la Child Behaviour Checklist, le Conners' Global Index for Parents et le nombre des symptômes d'hyperactivité du *DSM-IV* ($P = 0,02$; $< 0,01$, $< 0,01$ respectivement).

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Conclusion : Les faibles scores d'Apgar à une minute sont associés à un accroissement significatif de la gravité des symptômes du TDAH. Ces résultats soulignent l'importance de soins obstétricaux et périnataux appropriés.

Keywords

attention-deficit/hyperactivity disorder, Apgar scores, symptom severity, delivery complications

Clinical Implications

Low Apgar scores (≤ 6) at 1 minute are associated with ADHD symptom severity.

- The effect of low Apgar scores on ADHD symptom severity remains small but significant even when several factors known for their association with severity of ADHD symptoms (i.e., maternal smoking during pregnancy, low socioeconomic status, age, and sex) are controlled for.
- Even low transient Apgar scores at 1 minute have long-term consequences in terms of ADHD symptom severity.

Limitations

- The population of the study is not a community epidemiological sample but a group of children who were sequentially referred to an ADHD clinic.
- Although the Apgar has become a standard routine in assessing newborns' conditions, the possibility of interobserver variability subsists despite the guidelines.

Attention-deficit/hyperactivity disorder (ADHD) is a behavioral disorder characterized by age-inappropriate levels of hyperactivity, impulsivity, and inattention. It affects 8% to 12% of school-aged children.¹ Symptoms can affect a child's academic and social skills, especially if left untreated.^{2,3} ADHD may also persist into adulthood,⁴ causing social and economic strain.^{5,6}

Both genetic and environmental factors are known to contribute to the development of ADHD, although the exact mechanisms implicated in its pathogenesis remain unclear. Genetic factors play a substantial role in ADHD, accounting for 76% of the trait's phenotypic variability.⁷ Environmental factors are also significant and may interact with genetic predispositions.⁸ Maternal smoking and alcohol consumption,⁹ stress during pregnancy,¹⁰ and perinatal risk factors¹¹ have been associated with ADHD.

The Apgar score is widely used to assess the physical condition of a newborn immediately after delivery and can be considered an indicator of perinatal adverse events.¹² It is based on objective observation of the 5 signs traditionally used by anesthesiologists to monitor patients' condition: skin complexion, heart rate, reflex irritability, muscle tone, and respiratory effort. Each of these signs is coded on a 2-point Likert scale, and the Apgar score is calculated as the sum of the subscores.

Apgar scores are usually recorded at 1 minute, 5 minutes, and sometimes 10 minutes.¹² Scores of 7 to 10 are considered in the normal range.¹³ The Apgar score can be used to evaluate the newborn's response to resuscitation and may indicate hypoxia and asphyxia, among other complications. Mild perinatal events are relatively frequent, and subtle neurological changes may only be detectable later during child development.¹⁴

Low Apgar scores at 1 and 5 minutes have been associated with an increased risk of neurological and psychiatric disorders such as autism spectrum disorder,^{15,16} internalizing symptoms as indicated by the Child Behaviour Checklist (CBCL) internalizing score,¹⁵ psychosis,^{17,18} and childhood neurological outcomes in general.¹⁹ Interestingly, 5-minute scores of 7 to 9 have been associated with a significantly higher risk of need for mental disorder treatment compared with a perfect score of 10,²⁰ suggesting that despite being considered within the normal range, these suboptimal scores may also have some neurological implications. Apgar scores have also been studied in relation to intelligence quotient (IQ). Low Apgar scores and infant resuscitation have been linked to lower IQ scores^{14,21} and learning difficulties.²²

A review of the literature suggests that low Apgar scores may be linked to the presence of ADHD. Two population-based studies reported that low 5-minute Apgar scores are associated with increased risk of ADHD in children ($N = 237$)²³ and adults ($N = 2323$).²⁴ Furthermore, Li et al.²⁵ found decreasing 5-minute Apgar scores to be associated with an increased ADHD risk (75% increased risk with Apgar 1-4, 63% increased risk with Apgar 5-6, $N = 8234$). The ADHD phenotype was determined using either *International Classification of Diseases, 10th Revision (ICD-10)* diagnosis of hyperkinetic disorder for the former 2 studies or the Register of Medicinal Product Statistics, which includes physician-prescribed methylphenidate, atomoxetine, and modafinil, for the latter. However, ADHD medication registration does not necessarily indicate reliable clinical diagnosis, and diagnoses could also not be independently validated.²⁵

However, other studies did not report an increased risk of ADHD in consideration with low Apgar scores. For example, Krebs et al.²⁶ found no differences in rates of attention deficiency when analyzing data of breech infants with Apgar scores above and below 7 at 5 minutes ($N = 105$). In a much larger study, Silva et al.²⁷ concluded that low Apgar scores are not associated with ADHD ($N = 12,991$). It has also been found that infants who quickly recover from poor birth conditions through resuscitation (suggesting initial low Apgar score) had later no difference in memory, attention, or language test scores compared to infants who were well at birth

($N = 612$).²⁸ Such conflicting evidence calls for further research on Apgar scores relating to ADHD.

Publications have mainly investigated Apgar scores in relation to the risk of developing ADHD, and to the authors' knowledge, no study has examined whether Apgar scores are associated with ADHD symptom severity in children already diagnosed with ADHD. We thus hypothesized that clinically diagnosed ADHD children with a lower Apgar score will exhibit more severe symptoms compared to ADHD children who had a normal Apgar score.

Method

Participants

This study is based on a sample of 452 children with ADHD who have participated in a larger double-blind placebo-controlled crossover methylphenidate trial from 1999 to 2014. In total, 631 unrelated patients were seen during that period, and Apgar scores were available for 452 of them. Participants were sequentially recruited from the ADHD clinic at the Douglas Mental Health University Institute affiliated with McGill University. Pediatricians, family physicians, social workers, and schools referred the children to the clinic. All subjects were diagnosed with ADHD by experienced research child psychiatrists according to the fourth edition of the *Diagnostic and Statistical Manual of Mental Disorders (DSM-IV)* criteria,²⁹ based on school reports, observation of the child, and clinical interviews with the family. To confirm diagnosis and subtypes, as well as assess comorbidities, the Diagnostic Interview Schedule for Children Version IV (DISC-IV)³⁰ was completed with parents. All children agreed to participate in the study, and parents signed informed consent. The study was approved by the Douglas Mental Health University Institute Research and Ethics Board.

Assessments

Subjects' psychiatric symptom severity was assessed off medication using the Connors' Global Index for Parents (CGI-P), the Connors' Global Index for Teachers (CGI-T), and the CBCL. The CGI, a questionnaire containing 10 items used to evaluate ADHD-related behavior, is completed by the parents (CGI-P) and teachers (CGI-T). Both versions have internal reliability coefficients of 0.94.³¹ The CBCL, a questionnaire consisting of 113 items completed by parents only, is used to assess the child's general behavioral and emotional problems. Scores are often divided into internalizing and externalizing subscales. The questionnaire has an internal reliability of 0.93 to 0.96.³² CGI and CBCL raw scores are transformed into standardized T scores, with a population mean of 50. Scores greater than 65 are considered clinically significant. Finally, the number of *DSM-IV* inattention and hyperactivity items that were met according to the DISC-IV parental interview were also investigated.

Apgar scores, used to assess the newborn's physical condition, are given at birth by a clinical health professional,

usually a nurse or physician. Of the Apgar scores, 84% were retrieved from medical files (obstetrical reports), while the remaining 16% were gathered from physicians' psychiatric evaluations and parental demographic questionnaires—all part of our research files.

Statistical Analyses

Subjects were divided into 2 groups based on their Apgar scores. Scores of 7 and above are considered normal, and scores of 6 and below are considered intermediate to low.¹³ This strategy is similar to that used in previous studies.^{14,21,23,24,26} Analyses were restricted to the 1-minute Apgar scores. Although 5-minute Apgar scores were generally available, only 5 of the 452 cases presented an Apgar of 6 and below. This extremely unbalanced group distribution precluded adequate statistical analysis. The primary hypothesis of this study was tested by comparing the severity of ADHD between the 2 groups using an unpaired Student t test. Correlations between Apgar scores as a continuous variable and symptom severity were evaluated using Pearson's r .

In addition to the primary variables reflecting the severity of ADHD, other clinical characteristics were compared between the 2 groups of patients using independent Student t tests and χ^2 . Subsequently, stepwise regression analyses were conducted to determine the unique contribution of Apgar scores when other factors shown to influence symptom severity in the literature (i.e., family income³³ and maternal smoking during pregnancy⁹) were included in the model. Age and sex were also added as predictors for the analysis of the *DSM-IV* ADHD symptom count since this measure is not normalized. P values less than 0.05 were considered statistically significant.

Results

Demographic Characteristics of Participants

Study participants were on average 9 years old and primarily of white European descent (86%; Table 1). Among the 452 participants, 52 had an Apgar score ≤ 6 at birth (low Apgar group). The percentage of males in the low Apgar group was significantly lower (67.3%) compared to the normal Apgar group (81.2%; $P = 0.01$). In addition, a higher proportion of low Apgar children came from families with lower income (49% vs. 31.7%; $P = 0.02$). However, the 2 groups did not differ in terms of child's age and IQ, mother's age at birth, and exposure to alcohol or tobacco during pregnancy.

ADHD Behavioral Symptomatology

Student t tests indicated that children in the low Apgar group had more severe symptoms on the externalizing scale of the CBCL ($P = 0.02$; Table 2) and the CGI-P ($P < 0.01$), and they had more *DSM-IV* hyperactivity symptoms according to the DISC-IV ($P < 0.01$) but did not differ in the other clinical dimensions (internalizing symptoms and inattention symptom count). Since a significant difference was observed on

Table 1. Demographic Characteristics of Children with Attention-Deficit/Hyperactivity Disorder Who Had Normal or Low Apgar at Birth.

	Normal Apgar (n = 400)	Low Apgar (n = 52)	Test Statistics (t or χ^2)	df	P Value
Median Apgar (range)	9 (7-10)	5 (1-6)			
Sex (% males)	81.2	67.3	5.52	1	0.02*
Age	8.9 (1.8)	9.0 (1.7)	0.17	449	0.87
Ethnicity (% white)	86.0	86.5	0.13	1	0.91
Annual family income (% less than \$30,000)	31.7	49.0	5.76	1	0.02*
Mother's age at child birth	28.5 (5.6)	28.5 (5.9)	0.03	413	0.98
Maternal smoking during pregnancy (% exposed)	34.7	39.2	0.40	1	0.53
Maternal alcohol during pregnancy (% exposed)	23.1	21.6	0.58	1	0.81
Full scale IQ	97.0 (13.4)	96.2 (13.8)	0.39	413	0.70

Values are presented as mean (standard deviation) unless otherwise specified.

*Statistically significant at $P < 0.05$.

Table 2. Symptom Severity in Children with Attention-Deficit/Hyperactivity Disorder Who Had Normal or Low Apgar at Birth.

	Normal Apgar (n = 400)	Low Apgar (n = 52)	t Value	df	P Value
CBCL internalizing T score	63.3 (9.8)	65.3 (8.9)	1.39	445	0.17
CBCL externalizing T score	66.8 (10.5)	69.9 (7.8)	2.07	445	0.04*
CGI-P total T score	71.2 (11.6)	76.8 (9.4)	3.20	411	0.001**
CGI-P restless impulsive T score	72.4 (11.2)	76.8 (9.0)	2.61	411	0.009*
CGI-P emotional lability T score	63.3 (13.8)	69.8 (12.1)	3.07	411	0.002*
CGI-T total T score	68.6 (12.2)	71.1 (11.9)	1.40	427	0.16
No. of DSM-IV inattention items	7.0 (2.1)	7.3 (1.9)	.88	442	0.38
No. of DSM-IV hyperactivity items	5.3 (2.7)	6.3 (2.3)	2.48	442	0.01*

Values are presented as mean (standard deviation) unless otherwise specified. CBCL, Child Behaviour Checklist; CGI-P, Connors' Global Index for Parents; CGI-T, Connors' Global Index for Teachers; DSM-IV, fourth edition of the *Diagnostic and Statistical Manual of Mental Disorders*.

*Statistically significant at $P < 0.05$

**Statistically significant at $P < 0.01$

the CGI-P, the 2 scale components were subsequently investigated, and children with low Apgar scores had significantly higher scores on both restless impulsive and emotional lability subscales (both $P \leq 0.01$). Similarly, Apgar scores at 1 minute were negatively correlated with symptom severity according to the CBCL externalizing T scores ($r = -0.10$, $P = 0.04$), CGI-P ($r = 0.17$, $P = 0.001$), and number of DSM-IV hyperactivity symptoms ($r = -0.13$, $P < 0.01$). No correlation between Apgar scores and CBCL internalizing T scores, CGI-T scores, or number of DSM-IV inattentive items was observed.

To confirm the effects of Apgar on ADHD symptom severity, a series of stepwise linear regression analyses were performed where each outcome measure that differed significantly between the 2 groups (i.e., CBCL externalizing, CGI-P total, restless impulsive and emotional lability subscales, number of DSM-IV hyperactivity symptoms; Table 3) was entered in the analysis along with family income and maternal smoking during pregnancy, 2 factors known to have a substantial effect on ADHD severity. When these 2 factors were controlled for, the effect of Apgar on CBCL externalizing symptoms became nonsignificant. However, the effects of Apgar on CGI-P remained significant and, together with family income and maternal smoking during pregnancy, contributed to symptom severity as measured by total CGI-P scores ($P < 0.01$) and by both the restless impulsive ($P = 0.01$) and emotional

Table 3. Stepwise Linear Regression of Symptom Severity in Children with Attention-Deficit/Hyperactivity Disorder.

	B	SE	P Value	R ²
CBCL externalizing T score				
Income	-5.31	1.1	<0.001	0.09
Maternal smoking	3.98	1.1	<0.001	0.12
CGI-P total T score				
Income	-3.04	1.3	0.02	0.04
Apgar	-1.00	0.4	<0.01	0.05
Maternal smoking	3.09	1.3	0.02	0.06
CGI-P total restless impulsive T score				
Income	-3.50	1.2	<0.01	0.03
Apgar	-0.92	0.4	0.01	0.04
CGI-P total emotional lability T score				
Maternal smoking	4.06	1.6	0.01	0.04
Income	-3.53	1.6	0.03	0.05
Apgar	-0.99	0.5	0.03	0.06
No. of DISC-IV hyperactivity items				
Age	-0.36	0.1	<0.001	0.06
Income	-0.87	0.3	<0.01	0.10
Maternal smoking	0.70	0.3	0.01	0.11
Apgar	-0.20	0.1	0.02	0.12
Sex	-0.63	0.3	0.05	0.13

Variables are presented in the order they were added to the equation when significantly contributing to predict outcome. Income: <30,000\$ vs. $\geq 30,000$ \$. Apgar: Apgar score at 1 minute. Maternal smoking during pregnancy: never exposed vs. exposed at least once. Sex: male vs. female. R² = adjusted R² when the predictor is added to the model. CBCL, Child Behaviour Checklist; CGI-P, Connors' Global Index for Parents; CGI-T, Connors' Global Index for Teachers; DISC-IV, Diagnostic Interview Schedule for Children Version IV.

lability subscales ($P = 0.03$). The models predicted 6% of the total variance in total CGI-P scores (adjusted $R^2 = .06$, $F_{(3, 371)} = 9.47$, $P < 0.001$), 4% in the restless impulsive subscale (adjusted $R^2 = .04$, $F_{(2, 372)} = 8.87$, $P < 0.001$), and 6% in the emotional lability subscale (adjusted $R^2 = .06$, $F_{(3, 371)} = 8.73$, $P < 0.001$). In all 3 cases, Apgar scores contributed to explain 1% of the variance. Finally, Apgar scores, together with family income, maternal smoking during pregnancy, and child's age and sex, significantly contributed to predict the number of *DSM-IV* hyperactivity symptoms ($P = 0.01$). The model predicted 13% of the variance in *DSM-IV* hyperactivity symptoms (adjusted $R^2 = .13$, $F_{(5, 397)} = 12.7$, $P < 0.001$). Again, Apgar scores contributed to explain 1% of the variance.

When the data were reanalyzed excluding the 5 children who also had Apgar scores ≤ 6 at 5 minutes, the results were similar, highlighting that even transient low scores at 1 minute are enough to lead to an increase in ADHD symptomatology.

Discussion

The primary objective of our study was to determine whether low Apgar scores contribute to ADHD symptom severity. Here we report a statistically significant association between low Apgar scores at 1 minute and increased ADHD DISC-IV hyperactivity and CGI-P score, even when controlling for other factors known to influence the severity of ADHD symptoms, such as low family income and maternal smoking during pregnancy.

To our knowledge, this is the first study to examine Apgar scores and ADHD symptom severity. Our results are consistent with those reporting an association between low Apgar scores and ADHD risk. To our knowledge, Chandola et al.³⁴ have conducted the only other study examining 1-minute Apgar scores and hyperactivity referral and found low scores to be linked to hyperactivity. However, studies generally do not investigate 1-minute Apgar scores, focusing instead on the 5-minute scores. Most of them found a significant association between low 5-minute Apgar scores and ADHD diagnosis,²²⁻²⁵ although contradicting findings have also been reported.²⁸ Still, the way Apgar scores were divided into categories varied widely between studies, which could contribute to the inconsistency between findings.

Similar to the Gustafsson and Källén study²³ that evaluated the fraction of population ADHD attributable to perinatal factors at 2.8%, we found that Apgar scores contributed only to a small portion of the variance explained in ADHD symptomatology (low R^2). This may be understood in that perinatal complications are just one of the many possible etiological factors implicated in ADHD (other factors include genetic predisposition, smoking and alcohol during pregnancy, maternal stress during pregnancy, etc.). The clinical implication is that, even though Apgar scores account for a relatively low attributable risk for symptom severity,

early problems in the birth process are nonetheless implicated in ADHD severity. Given the high prevalence of ADHD and that good obstetrical health care can improve Apgar scores, our findings may have major repercussions for public health.

The small number of patients who continued to have a low 5-minute Apgar score indicates that most patients included in the present study improved over the next 5 minutes after birth as only 5 retained an Apgar score ≤ 6 at 5 minutes. One should keep in mind that there might be more leeway for improvement for 1-minute Apgar scores than later scores. That is to say, a low score at 1 minute may not be as worrisome as a low score at 5 minutes. For example, a newborn with acidosis, which is usually quickly reversible, may have a low Apgar at 1 minute but a normal score at 5 minutes.³⁵ Consequently, the fact that our results indicate that even transient low Apgar scores at 1 minute have long-term consequences in terms of ADHD symptom severity is highly informative. Moreover, low 1-minute Apgar scores have been linked to autism spectrum disorders,^{15,36} and 1- and 5-minute Apgar scores are significantly lower in subjects with schizophrenia.¹⁸

Few studies examined Apgar scores and externalizing versus internalizing symptoms. Externalizing behaviors are directed outward and include hyperactivity, while internalizing behaviors are directed towards the self and include depression and anxiety.^{37,38} Indredavik et al.¹⁵ examined perinatal risks and various psychiatric outcomes and found 5-minute Apgar scores to be associated with higher CBCL internalizing scores in a preterm low birthweight or term small for gestational age population, while we found 1-minute scores to be associated with higher CBCL externalizing scores. Although further research would be needed to properly establish a relationship, these contrasting findings suggest that initial 1-minute scores may predict externalizing symptoms, while later 5-minute scores predict internalizing symptoms.

It is important to note that, proportionally, more girls have low Apgar scores than boys in our ADHD sample. Newborn males are considered more fragile than newborn females.³⁹ In the literature, males have been shown to have on average lower Apgar scores⁴⁰ but also have higher rates of perinatal death.⁴¹ We can therefore hypothesize that there is a greater chance for girls with low Apgar scores to survive and develop relatively normally, thus accounting for the difference in sex distribution in our sample groups. Also, it will be important to explore whether sex plays a role in epigenetic changes that may occur due to adverse perinatal events indicated by low Apgar scores. The income difference, with the low Apgar score group having a lower average income, is to be expected. Lower socioeconomic status and low income have already been linked to suboptimal perinatal care and outcomes.⁴² For instance, Odd et al.⁴³ observed that poor birth condition and low Apgar scores (< 7) at 1 and 5 minutes were more prevalent among mothers of lower socioeconomic status.

In our study, low 1-minute Apgar scores were associated with ADHD symptom severity, suggesting that acute delivery events may contribute to long-term ADHD symptoms. Conversely, it has been suggested that 5-minute Apgar scores less than 7 may be linked to mental disorders due to events or conditions prior to birth, as opposed to the delivery itself.^{20,44} One-minute Apgar scores often reflect acute perinatal events compromising oxygen availability, which may influence neurodevelopmental pathways relating to ADHD. For instance, perinatal anoxia has been shown to affect mesocortical dopamine function and increase hyperactivity in animal studies.⁴⁵ Furthermore, the basal ganglia, which are very sensitive to hypoxic conditions,³⁶ are important in the dopaminergic pathways,⁴⁶ which are hypothesized to play an important role in the pathogenesis of ADHD. Nonetheless, the Apgar score alone cannot confirm newborn hypoxia,¹³ since it can also be influenced by, among other things, prematurity, drugs, trauma, infections, congenital anomalies, and hypovolemia.^{47,48} Thus, the link between low Apgar score and ADHD symptomatology may implicate a variety of pathways.

Strengths and Limitations

Our large sample size ($N = 452$) is a notable strength of this study. Clinical diagnosis of ADHD by experienced child psychiatrists also constitutes a significant strength, reducing the likelihood of false-positive or false-negative diagnoses. In addition, the evaluation of symptoms was performed while the children were not taking any medication. Also, Apgar scores are mostly free from recall bias, since they have been attributed by a trained professional at birth and have been primarily retrieved from medical birth files. Although the Apgar has become a standard routine in assessing the newborn's condition,⁴⁹ the possibility of interobserver variability subsists despite the guidelines.⁵⁰

Conclusion

Results of this study suggest that low 1-minute Apgar scores are associated with increased ADHD symptom severity. Apgar scores at 1 minute should accordingly be considered relevant to long-term behavioral outcomes. These findings have substantial public health implications, emphasizing the importance of appropriate perinatal care. Apgar scores can be viewed as an adequate summary of obstetrical complications, and proper monitoring of the mothers throughout delivery is essential to prevent complications that could harm the newborn's physical and physiological state.

To take our findings further, it would be interesting to investigate how specific perinatal events are linked to ADHD symptom severity. Should symptoms be linked to a specific perinatal event, taking the proper precautions to ensure that the newborn is of optimum physical state may be more manageable. It would also be of interest to explore how specific epigenetic changes may occur following events

associated with low Apgar scores and if low Apgar is associated with severity of ADHD symptoms only in children who carry specific risk alleles.

Clinical Trial Registration Number: NCT00483106.

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