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Attention Deficit Hyperactivity Disorder: Birth Season and Epidemiology

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1. Introduction

Attention Deficit Hyperactivity Disorder is a neurodevelopmental disorder that is most frequently diagnosed in the pediatric population. This disorder consists of short-, medium-, and long-term interruptions in development that affect performance and daily activities (Amador et al., 2002). Weiss and Trokenberg (1993) argue that adolescents with Attention Deficit Hyperactivity Disorder show poor scholastic performance, low levels of self-esteem, higher levels of alcohol and drug use, and more difficulties with social functioning when compared to children not diagnosed with Attention Deficit Hyperactivity Disorder.

Given the evidence of difficulties with response inhibition, recent studies have highlighted problems with working memory, attentive faculties (e.g., sustained attention), and response inhibition when faced with interferences (Brito et al., 1999; Déry et al., 1999; Drechsler et al., 2005; Goldberg et al., 2005; Rodríguez et al., 2009; Seidman et al., 2006; Bedard et al., 2007). The fact that these problems appear in childhood, which is a key period for establishing the foundation for future professional exploration, interests, values, attitudes, and vocational abilities (Araújo & Taveira, 2009), conveys the gravity of the situation for a child with Attention Deficit Hyperactivity Disorder.

According to the Secretary of Health in Mexico (2000) and the American Psychiatric Association (2000), the prevalence of Attention Deficit Hyperactivity Disorder is 3-7% in children between 6 and 12 years old. Recent data (World Health Organization, 2005) suggest that the prevalence of Attention Deficit Hyperactivity Disorder in the Mexican child population is 4%, with a girl:boy ratio of 1:5.

A numerous studies have examined risk factors that predispose a child to this disorder. A number of interesting studies have been conducted investigating genetic etiology of Attention Deficit Hyperactivity Disorder (Faraone et al., 1994, 1995; Hudziak et al., 2005; Wallis et al., 2008) that have allowed for the identification of candidate genes associated

with the disorder, such as the repetition of allele 7 on the receptor gene for dopamine (Faraone et al., 2001).

Studies on environmental etiology have examined the following risk factors for Attention Deficit Hyperactivity Disorder: childhood exposure to high levels of lead; cranioencephalic trauma affecting the prefrontal cortex; premature birth; low birth weight; maternal consumption of alcohol or tobacco during pregnancy (Anderson & Doyle, 2004; Taylor et al., 2004); young maternal age (Smidt & Osterlam, 2007); situations of psychosocial adversity; and complications during pregnancy (Biederman et al., 1995).

Some studies (Atladóttir et al., 2007; Brookes et al., 2008; Liederman & Flannery, 1994; Mick et al., 1996; Seeger et al., 2004) conducted with pediatric patients suggest that the season of birth may contribute to the later development of Attention Deficit Hyperactivity Disorder.

From a biological perspective, the seasonal hypothesis argues that the season of birth is representative of risk factors, such as viral infections (Mick et al., 1996). For this reason, season of birth is identified as an operational variable in studies analyzing the seasonal effect on the early development of psychopathy. In spite of evidence supporting this phenomenon in schizophrenia (Bradbury & Millar, 1985; D'Amato et al., 1996; Faustman et al., 1992; Franzek & Beckmann, 1992; Tochigi et al., 2004), cerebral tumors (Brenner et al., 2004), and autism (Stevens et al., 2000), the findings regarding Attention Deficit Hyperactivity Disorder remain uncertain.

Atladóttir et al. (2007) examined seasonal variation in the birth of children with autism spectrum disorder, Tourette syndrome, obsessive-compulsive disorder, and Attention Deficit Hyperactivity Disorder. They did not find substantial variations in birth within the different groups. However, they reported evidence of a relationship between season of birth and Attention Deficit Hyperactivity Disorder (i.e., the highest number of births being in autumn and the lowest in spring). Liederman and Flannery (1994) investigated the relationship between neurodevelopmental disorders and season of birth, concluding that being born in spring and summer increased the risk of developing these disorders, including Attention Deficit Hyperactivity Disorder. Following this line of research, Schneider and Eisenberg (2006) also pointed to summer as the season of birth associated with high rates of Attention Deficit Hyperactivity Disorder.

Seeger et al. (2004) suggest that children with a copy of allele DRD4 7 who are born in the spring and summer have a greater risk of developing Attention Deficit Hyperactivity Disorder with conduct disorder. Studies focusing on pediatric patients with Attention Deficit Hyperactivity Disorder as the only diagnosis show a similar relationship between the repeated allele 7 of the DRD4 gene and Attention Deficit Hyperactivity Disorder without the association or interrelation with season of birth.

In a landmark study, Mick et al. (1996) did not find significant differences between the season of birth patterns of patients with Attention Deficit Hyperactivity Disorder and control subjects. Although, they suggested that there was a season of birth pattern with regard to subtypes, in that September births were highly related to diagnoses of Attention Deficit Hyperactivity Disorder with learning disabilities, Attention Deficit Hyperactivity Disorder with psychiatric comorbidity, and Attention Deficit Hyperactivity Disorder with family history of the disorder.

The conclusions regarding season of birth and Attention Deficit Hyperactivity Disorder are divergent, and none of the published studies limited their research to the Latin-American population.

The objective of the present study is to determine if the season of birth effect, which is based on the hypothesis of seasonality that is observed in some psychopathologies, is applicable to children with Attention Deficit Hyperactivity Disorder in the Mexican population. This study will investigate whether the season of birth implies a risk for later development of child Attention Deficit Hyperactivity Disorder. If it does, observing this relationship between season of birth and Attention Deficit Hyperactivity Disorder would allow for the prediction of a determined subtype of the disorder. Following research on schizophrenia and autism, this study will attempt to confirm the relationship between season of birth and child Attention Deficit Hyperactivity Disorder.

The analyses that will be conducted incorporate the variables of age and gender as possible modifiers of this effect. The inclusion of both variables will allow the presentation of epidemiological data regarding child Attention Deficit Hyperactivity Disorder in the Mexican clinical population.

2. Method

2.1 Subjects

The criteria for inclusion in this sample were the following: a) the age of the patient was between 6 to 12 years, b) the complete information on the patient's birth dates and ages was available, c) the patient's birth place was within the state of Jalisco (Mexico), d) the patient's clinical history was available in the healthcare center, and e) the patient had a suspected diagnosis of Attention Deficit Hyperactivity Disorder.

This study recruited patients being seen during the evening shift in the Neuroscience unit of the Neuroscience Department at the University Center for Health Sciences at the University of Guadalajara (Jalisco, Mexico). The patients were seeking care for behavioral problems or poor scholastic performance, as identified by their parents and/or teachers.

A total of 286 patients between the ages of 6 and 12 years were evaluated; the average age was 8.34 years ($SD=.106$). Boys accounted for 78.00% ($n=223$) of the sample, and girls accounted for 22.00% ($n=63$) of the sample.

Regarding to the distribution of season of birth in the total sample ($N=286$), 23.80% of patients born in winter, 24.50% born in summer, 25.20% born in autumn and the remaining 26.60% of patients born in spring (see fig. 1).

The diagnostic process indicated that Attention Deficit Hyperactivity Disorder was present in 86.70% ($n=248$) of the cases.

Patients diagnosed with Attention Deficit Hyperactivity Disorder showed the following subtype distribution: 8.10% for the Hyperactivity/Impulsivity subtype, 27.10% for the Inattentive subtype and the remaining 64.80% for the Combined subtype.

With this sample size, there was a total precision of .058, with a confidence level of 95%, which is below the assumed maximum indeterminacy ($\pi=.5$).

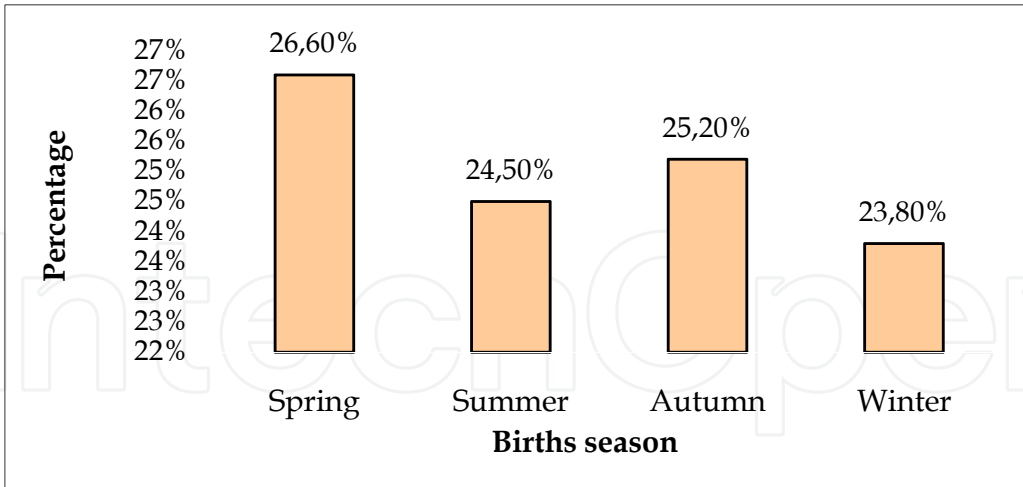


Fig. 1. Season of birth distribution (N=286).

2.2 Instruments

Diagnostic determinations were conducted using various sources of information.

First, a retrospective analysis of the patient’s clinical history was performed, which included patient data, personal and familial history, the reason for the consultation, and the diagnostic hypothesis.

Complementing this analysis and in compliance with the healthcare centers’ protocol, a medical history was taken from the primary caregiver, which included questions regarding perinatal, motor, visual, and auditory development, language and communication, social interaction, independence, and variables related to sleep.

Additionally, a clinical exam of the patient was performed. Finally, the DSM-IV-TR (American Psychiatric Association, 2000) diagnostic criteria for Attention Deficit Hyperactivity Disorder were applied. The information obtained from these sources was used to confirm whether there were positive cases of Attention Deficit Hyperactivity Disorder.

2.3 Procedure

Prior to the patient’s visit, a review of the corresponding clinical history, which was archived in the healthcare center, was performed. With this information, patient inclusion in the study was determined.

The selected sample underwent a diagnostic process confirming the diagnosis of Attention Deficit Hyperactivity Disorder, which was conducted using medical history interviews with the primary caregiver, as well as through a clinical evaluation of the patient.

Finally, the diagnostic criteria for Attention Deficit Hyperactivity Disorder from the DSM-IV-TR (American Psychiatric Association, 2000) were applied, and patients were classified according to whether they had Attention Deficit Hyperactivity Disorder or not, and Attention Deficit Hyperactivity Disorder subtypes (i.e., hyperactive/impulsive, inattentive,

or combined). The interview, clinical evaluation, and application of diagnostic criteria were completed in one session.

A team of two doctors and two neuropsychologists performed all of the evaluations. All of the members of the team were trained in this process, and empirical evidence showed sufficient concordant criteria conditions between evaluators ($\varphi = .86$).

All of the primary caregivers were informed of the confidentiality of the data, and informed consent was granted for participation in the study. The evaluations were performed between January 2001 and February 2006.

2.4 Data analysis

We performed a preliminary phase of univariate analysis to detect possible anomalies in the distribution of the variables.

This phase was followed by the description of variables (i.e., season of birth, age, gender, presence of Attention Deficit Hyperactivity Disorder and Attention Deficit Hyperactivity Disorder subtypes).

Then, goodness-of-fit tests to analyze the distribution of births in the different seasons of the year and bivariate tests of independence were performed, examining associations of interest that would support the subsequent interpretation of the logistic model.

Binary and multinomial logistic regression models were used. The possible classifications for the diagnosis of Attention Deficit Hyperactivity Disorder (i.e., binary model) and its subtypes (i.e., multinomial model) were studied.

Finally, we decided to focus on the following question: is there a seasonal difference in ADHD? We included gender on the analyses in order to analyze possible differences into the season of born between boys and girls diagnosed with Attention Deficit Hyperactivity Disorder.

The analyses were performed with the program PASW Statistics 17 using the *enter* method. An initial set α value of .05 was adjusted "a posteriori" in accordance with Bonferroni to a value of .03.

3. Results

Table 1 presents the observed distributions of gender and the season of birth according to the presence of Attention Deficit Hyperactivity Disorder and the observed distribution by subtypes of the disorder in positive cases.

The goodness-of-fit test, which evaluated the distribution of births in the four seasons of the year for the whole sample, was not significant ($\chi^2=.490$; d.f.=3; $p=.921$). Significant differences regarding the relationship between the presence of Attention Deficit Hyperactivity Disorder and the season of birth were not observed ($\chi^2=1.281$; d.f.=3; $p=.734$). Therefore, this first bivariate analysis did not show empirical evidence supporting the hypothesis of seasonality.

| | | Attention Deficit Hyperactivity Disorder diagnosis | |
|--|-----------------------|--|--------|
| | | Yes | No |
| Gender | Boys (n=223) | 89.69% | 10.31% |
| | Girls (n=63) | 76.19% | 23.81% |
| Season of birth | Spring (n=76) | 85.53% | 14.47% |
| | Summer (n=70) | 90.00% | 10.00% |
| | Autumn (n=72) | 87.50% | 12.50% |
| | Winter (n=68) | 83.82% | 16.18% |
| Attention Deficit Hyperactivity Disorder Subtype (n = 248) | Combined | 64.78% | |
| | Hyperactive-Impulsive | 27.12% | |
| | Inattentive | 8.10% | |

Table 1. Observed distribution of gender and season of birth according to presence or absence of Attention Deficit Hyperactivity Disorder and observed distribution of subtypes of the disorder.

Following Seeger et al. (2004), the season of birth was recoded according to whether the photoperiod of the pregnancy was long (i.e., births in autumn or winter) or short (i.e., spring and summer). The relationship between the photoperiod of the pregnancy and the presence of Attention Deficit Hyperactivity Disorder was not statistically significant ($\chi^2=.238$; d.f.=1; $p=.728$). Given that the climate of the state of Jalisco is characterized by the presence and absence of rain, seasonality was defined in these terms to analyze its relationship with the presence of Attention Deficit Hyperactivity Disorder and to assess if the results are in accord with the two earlier analyses. The analysis of the relationship between the presence of the disorder and the season dichotomized by the presence or absence of rain proved to be equally insignificant ($\chi^2=.999$; d.f.=1; $p=.318$).

There was statistical significance in the relationship between gender and Attention Deficit Hyperactivity Disorder ($\chi^2=7.765$; d.f.=1; $p=.005$; $\phi=.459$) and between gender and Attention Deficit Hyperactivity Disorder subtypes ($\chi^2=7.423$; d.f.=1; $p=.006$). The relationship between gender and Attention Deficit Hyperactivity Disorder subtypes was moderate ($\phi=.44$) with fewer boys in the Hyperactive-Impulsive and Inattentive subtypes. There were also more girls than anticipated classified in these subtypes. The combined subtype was most clearly linked to gender, as it was most often diagnosed in boys.

Given the significance of gender in these early analyses, a stricter examination of the effect of gender was performed using the stratified estimation of the odds ratio.

In this analysis, the Mantel-Haenszel statistic proved significant ($\chi_{M-H} = 6.615$; d.f.= 1; $p = .010$). The results are presented in Table 2. As is shown in this table, there is a significant relationship between gender and Attention Deficit Hyperactivity Disorder, with the likelihood ratio of females to males ranging between 1.319 and 5.598. With regard to the absence of the disorder, there was a considerable advantage in favor of the girls (CI to 95%=1.283-4.153), indicating a greater number of girls in the group without Attention Deficit Hyperactivity Disorder than boys. This suggests that being a female acts as a protective factor against the presence of Attention Deficit Hyperactivity Disorder. In the Attention Deficit Hyperactivity Disorder group, a tendency toward significance was found, with a greater number of boys being diagnosed with Attention Deficit Hyperactivity Disorder than girls.

| Source | Value | CI (95%) |
|---|-------|-------------|
| Odds ratio for gender (girls/boys) | 2.717 | 1.319-5.598 |
| Attention Deficit Hyperactivity Disorder diagnosis=No | 2.308 | 1.283-4.153 |
| Attention Deficit Hyperactivity Disorder diagnosis= Yes | .850 | .735-.982 |

CI: confidence interval at a 95% level.

Table 2. Analysis of the odds ratio stratified by gender and presence of Attention Deficit Hyperactivity Disorder.

In the quantitative variables analysis, a possible effect between age and Attention Deficit Hyperactivity Disorder was studied. The average age of participants diagnosed with Attention Deficit Hyperactivity Disorder ($n_1=248$) was 8.28 years ($SD=1.768$), and the average age of patients with a negative diagnosis ($n_2=38$) was 8.67 years ($SD=1.979$). The difference between the averages was not significant ($t=1.549$; $d.f.=284$; $p=.122$); thus, differences between age and final diagnosis (i.e., the positive or negative presence of Attention Deficit Hyperactivity Disorder) are not evident.

As in the earlier analysis, the possible effect of age of girls and boys with Attention Deficit Hyperactivity Disorder was studied. The average age for boys with a positive diagnosis ($n_1=200$) was 8.27 years ($SD=1.767$). In the group of girls diagnosed with Attention Deficit Hyperactivity Disorder ($n_2=48$), the average age was 8.31 years ($SD=1.788$). The difference between the average age of the groups was not significant ($t=.149$; $d.f.=246$; $p=.881$).

Binary and multinomial logistic regression models were analyzed.

The goal of the binary logistic model was to determine if a subset of variables was a good predictor of the presence of child Attention Deficit Hyperactivity Disorder. The variables of season of birth, age, and gender were included in this model. Although earlier bivariate analyses did not indicate the significance of season of birth and age, it was necessary to include these variables in this model to observe the aggregate behavior of the selected variables.

The reference categories established for gender and season of birth were female gender (World Health Organization, 2005) and winter, respectively. This season was identified due to it being the only one for which there was not a reported increase in birthrate according to previous studies examining the relationship between Attention Deficit Hyperactivity Disorder and season of birth (Atladóttir et al., 2007; Liederman & Flannery, 1994; Mick et al., 1996; Seeger et al., 2004).

The values for the binary logistic model are shown in table 3.

Statistical significance was reached for the gender variable ($\beta=1.035$; $d.f.=1$; $p=.006$), suggesting that being male allowed for a classification prediction for the patients in the positive case group.

These results obtained through the use of the logistic regression model confirmed the values found in the odds ratio analysis, in which gender was found to be close to being statistically significant ($p=.054$).

As was indicated previously, a multinomial logistic regression model was used to analyze whether some of the variables allowed for a correct classification prediction for patients diagnosed with Attention Deficit Hyperactivity Disorder of a determined subtype. This analysis indicated that none of the variables introduced in the model reached statistical significance.

| Source | Coefficient | Standard Error | Wald Test | d.f. | P-value | OR= e^{β} | CI (95%) |
|---------------------|-------------|----------------|-----------|------|---------|-----------------|-------------|
| Constant | 2.742 | .993 | 7.624 | 1 | .006 | 15.512 | * |
| Season | | | | | | | |
| Season ¹ | -.405 | .504 | .645 | 1 | .422 | .667 | .249-1.791 |
| Season ² | .015 | .553 | .001 | 1 | .979 | 1.015 | .344-2.998 |
| Season ³ | -.562 | .509 | 1.217 | 1 | .270 | .570 | .210-1.547 |
| Gender | 1.035 | .377 | 7.555 | 1 | .006 | 2.816 | 1.346-5.893 |
| Age | -.158 | .098 | 2.615 | 1 | .106 | .854 | .705-1.034 |

d.f. degrees of freedom, OR: odds ratio and CI: confidence interval at a 95% level.

Season¹: Spring-Winter

Season²: Summer-Winter

Season³: Autumn-Winter

Table 3. Results of estimates of the coefficients of binary logistic regression for predicting the diagnosis of Attention Deficit Hyperactivity Disorder.

Finally, a chi-square test was performed in order to focus on the following question: is there a seasonal difference in ADHD girls and boys? No statistically differences were found between the season of born of girls and boys with an Attention Deficit Hyperactivity Disorder ($\chi^2=1.099$; d.f.=3; $p=.777$). Hence, there was not a seasonal difference in Attention Deficit Hyperactivity Disorder.

4. Conclusion

This study’s objective (i.e., the exploration of the effect of seasonality on child Attention Deficit Hyperactivity Disorder) lead to the use of an analytic model with a reduced number of variables. This provided epidemiological data regarding Attention Deficit Hyperactivity Disorder in Jalisco pediatric patients.

The most relevant result was the greater number of positive cases of child Attention Deficit Hyperactivity Disorder among the clinical patients who met the criteria for inclusion (86.7%).

With regard to gender, an increased presence of Attention Deficit Hyperactivity Disorder in boys was observed, which corresponds to existing theories (American Psychiatric Association, 2000; Froehlich et al., 2008; World Health Organization, 2005). From an epidemiological perspective, being female emerges as a factor that protects against the development of Attention Deficit Hyperactivity Disorder.

The investigation of Attention Deficit Hyperactivity Disorder subtypes indicated a higher number of positive cases in the combined subtype, followed by the hyperactive-impulsive subtype, whereas the inattentive subtype was the least prevalent, which corresponds to findings by Cormier (2008). In accord with results presented by Froehlich et al. (2008), the combined subtype appeared to be clearly linked to gender, in that the number of boys diagnosed with Attention Deficit Hyperactivity Disorder combined subtype was significantly greater than the number of girls diagnosed with this subtype. The two remaining subtypes did not appear to be linked to gender. This finding is consistent with an American Psychiatric Association (2000) report that the inattentive subtype is the least likely to be linked with the gender of a patient compared with the other subtypes.

The absence of a significant relationship between age and diagnosis did not provide insight into the determining variables that can help to predict an Attention Deficit Hyperactivity Disorder diagnosis with greater validity.

Given the controversial over-diagnosis of this disorder, it would be of great clinical value to know whether certain variables provide better diagnostic certainty (for example, to know whether a diagnosis is more trustworthy at a particular age). The existing scientific literature highlights the imprecision of evaluations conducted with preschool children (American Psychiatric Association, 2000; Smidt & Osterlam, 2007), although we cannot verify this because preschoolers were excluded from the present study for that very reason.

Although not statistically significant, the average age for girls with Attention Deficit Hyperactivity Disorder was slightly higher than the average age for boys, which suggests that the negative diagnoses in girls' early years does not exclude Attention Deficit Hyperactivity Disorder development in later years. This finding contributes to the stipulated importance of clinical follow-up studies.

In addition to the epidemiological data provided, it is possible to offer some considerations regarding the principal objective of this study: the exploration of a possible seasonal effect on the later development of child Attention Deficit Hyperactivity Disorder. The results indicated the absence of a seasonal effect for this sample of Jalisco pediatric patients.

Similar negative results were found regarding the four seasons of the year, the duration of the photoperiod of the pregnancy, and the climatic dichotomy in this area (e.g., it is characterized by the presence or absence of rain). In the present study, we could not determine if the effect of season of birth on Attention Deficit Hyperactivity Disorder was not plausible in general or if it was only not plausible in the area that was studied.

This nuance is relevant given that the results could be explained by a particular climatic homogeneity in the manner discussed by D'Amato et al. (1996). That is to say, the seasonal variable categories are not mutually exclusive. With this statement, we are not referring to a methodological artifact derived from categorization but, rather, to a seasonal climate in the studied region that has little variation.

Another possible explanation is based on the possibility that the seasonal effect is modulated by other variables and does not present itself in a direct manner, which is how we approached it. Future research should assess the possibility of including variables, like genetic type. That is to say, it should assess the seasonal effect on subjects who present determined genetic characteristics that have an empirically proven relationship to Attention Deficit Hyperactivity Disorder.

The present study does not provide evidence supporting a seasonal effect on child Attention Deficit Hyperactivity Disorder in the Jalisco population. Although some of the data is convincing, future studies that introduce other mediating variables or that are conducted in other regions will provide more information on this topic.

5. Acknowledgment

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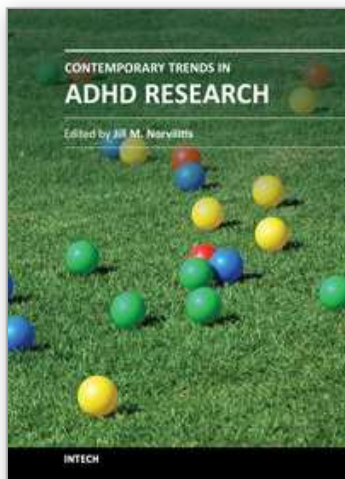
must also be said that this research has been made possible by a fellowship of the *Comission for Universities and Research from the Generalitat de Catalunya's Department of Innovation, Universities and Enterprise*.

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With many children and adults affected by Attention Deficit Hyperactivity Disorder, researchers strive to understand the underpinnings of ADHD and associated factors on both a basic and applied level. The goal of this volume is to explore some of the broad array of research in the field of ADHD. The 12 chapters cover a variety of topics as varied as postural control, endocrine dysfunction, juvenile justice, and academic outcomes. These chapters will provide valuable insights for students reading about ADHD for the first time, researchers wishing to learn about the latest advances, and practitioners seeking new insight in the field.

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