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The Association of Lifestyle Factors and ADHD in Children

Kathleen F. Holton¹, Joel T. Nigg²

¹American University, Washington, DC, USA

²Oregon Health & Science University, Portland, OR, USA

Abstract

Objective—The objective of the study is to examine whether children aged 7 to 11 years with very well-characterized ADHD, recruited from the community, have a similar number of healthy lifestyle behaviors as compared with typically developing children from the same community.

Method—Parents of children with ($n = 184$) and without ($n = 104$) ADHD completed a lifestyle questionnaire asking about water intake, sweetened beverage consumption, multivitamin/supplement use, reading, screen time, physical activity, and sleep. A lifestyle index was formed from these seven domains (0–7), and multivariable ordered logistic regression was used to examine the association of ADHD status and total healthy lifestyle behaviors.

Results—Children with ADHD were almost twice as likely to have fewer healthy behaviors, even after adjustment for age, sex, intelligence quotient (IQ), ADHD medication use, household income, and four comorbid psychiatric disorders (odds ratio [OR] [95% confidence interval] = 1.95 [1.16, 3.30], $p = .01$).

Conclusion—Future research is needed to assess the effects of a combined lifestyle intervention in this group.

Keywords

ADHD; exercise; sleep; diet; screen time

Introduction

ADHD is increasingly associated with poor health outcomes (Nigg, 2013). The characteristics of inattention, impulsivity, and poor planning likely contribute to poor health behaviors, but ADHD may also be influenced by these same behaviors (Nigg, 2013; Nigg & Holton, 2014). Population survey data have suggested that lifestyle behaviors such as media

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Corresponding Author: Kathleen F. Holton, Department of Health Studies, American University, 4400 Massachusetts Ave., NW; Washington, DC 20016, USA. holton@american.edu.

Author Contributions

Kathleen F. Holton designed the lifestyle questionnaire, carried out analyses, drafted the initial manuscript, and approved the final manuscript as submitted. Joel T. Nigg designed the cohort study, coordinated and supervised all data collection, critically reviewed and revised the manuscript, and approved the final manuscript as submitted.

Declaration of Conflicting Interests

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time, physical activity, and sleep disturbance (Lingineni et al., 2012; van Egmond-Frohlich, Weghuber, & de Zwaan, 2012) are individually associated with ADHD.

Undesirable lifestyle factors could contribute directly to inattention and/or hyperactivity symptoms, could lead to other long-term health issues, and could affect scholastic outcomes. Numerous mechanisms exist that could mediate such effects, such as secondary effects on energy level, immune function, and epigenetic change. However, first, it is important to evaluate the association of ADHD with the overall number of healthy lifestyle factors followed. As noted, a handful of national survey studies show an association of ADHD with individual lifestyle factors (Lingineni et al., 2012; Sivertsen et al., 2015; Touchette et al., 2009; van Egmond-Frohlich et al., 2012; Wiles, Northstone, Emmett, & Lewis, 2009), but further research is needed to assess the overall number of healthy lifestyle behaviors followed, while also addressing the limitations of survey research.

Although these studies have the important advantage of population representation, they have not evaluated the potential for combined effects from following multiple healthy lifestyle factors. They also have important limitations. In particular, ADHD is not well characterized, often assessed only by a single survey question about past diagnoses. There is reason to suspect the accuracy of those ADHD assignments. For example, prevalence in some of these surveys for ADHD is more than 10%, yet the best scientific evidence for ADHD true prevalence is in the 2% to 3% range (Erskine et al., 2013). Furthermore, as parents report on both ADHD status and lifestyle, shared source variance may inflate the association of ADHD with lifestyle behaviors in those studies. In addition, comorbidity effects are difficult to evaluate in those studies, because associated disorders such as depression or oppositional defiant disorder also are not able to be thoroughly evaluated. Clinic referrals also have their own biases. Thus, well-characterized case control studies of community-recruited samples are needed which can address these diagnostic issues and attempt to further evaluate the potential association between lifestyle behaviors and ADHD.

The objective of this research was to investigate whether children with carefully characterized ADHD have fewer positive healthy lifestyle choices overall, as compared with children of a similar age without ADHD, in a well-characterized sample not ascertained by clinic referral.

Method

Recruitment and Diagnostic Evaluation

Data are reported for children aged 7 to 11 years classified as having ADHD ($n = 184$) or as typically developing controls ($n = 104$) from a community-recruited observational cohort. Enrollment procedures and details on the multi-informant testing procedures used in this cohort have been reported previously (Musser, Galloway-Long, Frick, & Nigg, 2013; Musser, Karalunas, Dieckmann, Peris, & Nigg, 2016). Children were recruited from public advertisements and direct mass-mailing to all parents in the community with children in the target age range. Parents then completed structured diagnostic interviews (Schedule for Affective Disorders and Schizophrenia for School-Age Children–Epidemiologic Version [KSADS-E]; Orvaschel, 1994) with a trained interviewer who was a master's degree-level

clinician in social work or psychology. Interviewers were carefully trained with periodic quality checks, and their reliability with a master rater was $k > 0.70$ for all disorders evaluated. Parents and teachers each completed normed standardized rating scales: Conners-III parent and teacher ratings (Conners, Sitarenios, Parker, & Epstein, 1998; Purpura & Lonigan, 2009), Strengths and Difficulties Questionnaire (Goodman, 2001), and ADHD Rating Scale (DuPaul, Power, Anastopoulos, & Reid, 1998). Parents also completed an in-house standardized checklist of health conditions which included comorbid conditions of exclusion like psychosis, cerebral palsy, mental retardation, non-correctable vision problems, closed head injury, chronic sleep apnea, narcolepsy, and any neurological disorder such as epilepsy, autism, schizophrenia, or brain tumor. Past treatments and medications were evaluated with a modified Services for Children and Adolescents-Parent Interview (SCAPI) (Jensen et al., 2004). Children completed a short IQ screen (a Wechsler Intelligence Scale for Children–Fourth Edition [WISC-IV] short form comprising vocabulary, information, and block design subtests) and an academic screen (the Wechsler Individual Achievement Test, Second Edition [WIAT-II] reading and math subtests; Wechsler, 2005). They also completed self-reported ratings of mood using the Children's Depression Inventory (Kovacs, 1985) and the Multidimensional Anxiety Scale (March, Parker, Sullivan, Stallings, & Conners, 1997). The clinician interviewed the child, and the psychometrician and clinician each made detailed behavioral observations of children. Then a best estimate diagnostic procedure was implemented. To do this, a diagnostic team consisting of two experienced clinicians, a board certified child psychiatrist, and a licensed clinical child psychologist reviewed all available information listed above to arrive at a judgment about *Diagnostic and Statistical Manual of Mental Disorders* diagnosis of ADHD and other comorbid psychiatric disorders. They made these judgments independently, with inter-rater agreement $k > 0.80$ for ADHD and $k > 0.70$ for all disorders with base rate $> 5\%$ in the sample. Disagreements were resolved by consensus discussion.

Eligibility and Exclusion Criteria

To be eligible for the ADHD group, children had to meet *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; *DSM-IV*; American Psychiatric Association, 1994) or *DSM-5* (5th ed.; American Psychiatric Association, 2013) criteria for ADHD by consensus of the two clinical experts; be free of confounding medical or neurological conditions; free of lifetime or current bipolar disorder or psychosis, current substance use disorder, and current major depressive episode; and could not be taking long-acting psychoactive medications such as anti-depressants. Typically developing comparison children underwent the same evaluation and diagnostic procedure, and had the same rule outs, except they also had to have no prior diagnosis of ADHD or conduct disorder.

This study was approved by the Oregon Health & Science University Institutional Review Board. All parents provided written informed consent, and children provided written informed assent.

Lifestyle Behavior Assessment and Creation of Lifestyle Index

A cross-sectional 35-item lifestyle questionnaire was completed by one parent about the child to measure lifestyle choices known to affect health as reflected in behaviors over the

past month. The questionnaire included queries on water intake, sweetened beverage intake, supplement use, reading, screen time, physical activity, and sleep.

The lifestyle questionnaire was used to form a lifestyle index constructed to represent current health behavior recommendations, as follows. A representative question (or questions) for each of the seven lifestyle factors was identified *a priori* for this purpose (below). These were summed to form an index score from 0 to 7. One point was given for each positive lifestyle choice, so a high score would indicate a healthy lifestyle. In the case of sugar sweetened beverages, three questions were used to encompass consumption of either soda, sugar sweetened juice, or energy drinks (like Gatorade). The lifestyle factors included in the index were water consumption (0 = <3 cups/day, 1 = 3 cups/day), other non-juice beverage intake (soda/sweetened juice-like drinks/energy drinks; 1 = 1 cup/week, 0 = >1 cup/week), multivitamin use (1 = yes, 0 = no), reading (0 = 1 hr/day, 1 = >1 hr/day), screen time (1 = <2 hr/day, 0 = 2 hr/day), physical activity (0 = <1 hr/day, 1 = 1 hr/day), and sleep (0 = <10 hr of sleep/night, 1 = 10 hr of sleep/night). These were based on current recommendations for children between the ages of 7 and 11 years when available as follows: The American Academy of Pediatrics recommends <1 to 2 hr of total screen time/day (American Academy of Pediatrics, 2013), 1 hr/day of physical activity for children, and limiting the consumption of sugar sweetened beverages (Daniels, Hassink, & Committee on Nutrition, 2015). The U.S. Department of Health and Human Services (2008) also recommends that children get 1 hr of physical activity/day. The National Sleep Foundation recommends that children aged 6 to 13 years get between 9 and 11 hr of sleep per night (Hirshkowitz et al., 2015); we used the average of 10 hr as the cutoff for adequate sleep. The U.S. Department of Agriculture (USDA) recommends that boys and girls consume approximately 1.7 L (7 cups)/day of water from 4 to 8 years old, and 2.1 to 2.4 L (8–10 cups)/day for girls and boys (respectively) from 9 to 13 years old (Medicine, 2005). Water is consumed not only directly but also indirectly in other beverages such as milk and juice. For this study, we examined whether parents reported that their children drank 3 cups of water/day, assuming that children were likely to be getting water from other sources as well. This cutoff of three cups/day can be used to assess the willingness of a child to drink water as opposed to other beverages.

The exceptions here were as follows. No consensus or authoritative recommendations have been given on an exact cutoff for non-juice sweetened beverage intake. We chose to use one cup/week as a cutoff using this as infrequent consumption as a “treat” rather than daily consumption where intake was more likely to affect health. Similarly, no recommendations exist for multivitamin use by children; however, since multivitamin use could compensate for poor dietary intake in children, we decided to include this in the measure.

Data Reduction and Data Analysis

Statistical analyses were conducted using SAS® 9.4. Simple descriptive data for individual variables from the lifestyle questionnaire are provided for descriptive purposes. Categorical variables were compared by ADHD status (no/yes) using the chi-square statistic, or Fisher’s exact test where appropriate. Continuous variables were compared according to ADHD status using student *t* tests, and non-normally distributed variables were analyzed with the

non-parametric Wilcoxon Rank Sum test. Spearman rank correlation coefficients were computed to assess the correlation between teacher and parental raw scores and the lifestyle index, and Pearson correlation coefficients were estimated for the individual components of the lifestyle index. Multivariable ordered logistic regression was used to estimate the odds of having a lower Lifestyle Index score while controlling for covariates (ordered logistic regression estimates probabilities cumulated over the lower ordered values). Potential confounders (covariates) included sex, age, IQ, stimulant use (note that other psychoactive medications were exclusionary), comorbid psychiatric conditions (composite of all anxiety disorders, oppositional defiant disorder, conduct disorder, and mood disorders), and total household income of the child's primary residence (as a proxy for socioeconomic status [SES]). Secondary analyses examined the association of the lifestyle index variable with the inattention and hyperactivity symptom domains, by substituting individual parental and teacher raw scores from the Conners-III, for the ADHD variable.

Results

Table 1 provides clinical and demographic description of the groups, which reflects the expected features of our community-based recruitment strategy. Groups were of similar age, race, and ethnicity. Consistent with community prevalence rates, children with ADHD, as compared with controls, were more likely to be male and to have oppositional defiant or anxiety disorders. The ADHD group had a lower estimated IQ than the typically developing controls, although both groups had above average IQ. With regard to the *DSM-IV* subtypes and *DSM-5* presentations, most youth with ADHD met criteria for a combined presentation (71%), followed by inattentive (25%) and hyperactive-impulsive (4%) presentations.

Multivariable ordered logistic regression results shown in Table 2 demonstrate that children with ADHD were almost twice as likely to have a low lifestyle index score compared with those without ADHD. These results remained robust even after adjustment for age, sex, IQ, ADHD medication, and various comorbid disorders. When further including adjustment for all four comorbid psychiatric diagnoses (mood disorder, anxiety disorder, oppositional defiant disorder, and conduct disorder), the multivariable adjusted odds ratio (OR) (95% confidence interval [CI]) was 1.95 [1.16, 3.29]; $p < .01$, and additional adjustment for total household income (as a measure of SES) did not materially change these estimates, with a multivariable adjusted OR [95% CI] that was practically unchanged at 1.95 [1.16, 3.30]; $p < .01$. Thus, these covariates did not account for the observation that children with ADHD were about twice as likely as comparison youth to have unhealthy lifestyle behavior scores.

A secondary analysis was performed to assess whether these lifestyle characteristics were more strongly correlated with inattention or with hyperactivity symptom domains. Both teacher and parental domain scores (obtained from their ADHD rating scale) were negatively correlated with the Lifestyle Index. For inattention, the correlation for teachers was $\rho = -.21$ ($p < .001$), and for parents, it was $\rho = -.15$ ($p = .008$). For hyperactivity-impulsivity, the teacher effect was $\rho = -.16$ ($p = .01$) and the parent effect was $\rho = -.12$ ($p = .04$). This suggests that the association was similar for the two domains within reporter. In the multivariable regression analysis predicting the dichotomous lifestyle index, the teacher sub-scores remained robustly related to the lifestyle index. For every 1 point increase on the

teacher inattention or hyperactivity score, the odds of having less healthy lifestyle behaviors increased by 4%, OR [95% CI] = 1.04 [1.01, 1.07], $p = .01$ for inattention, and 1.04 [1.01, 1.08], $p = .02$ for hyper-activity. Thus, associations were not explainable by shared source variance (parent rating on both lifestyle and symptoms), because teacher ratings of symptoms were also similarly associated with parent-rated child lifestyle behaviors.

For completeness, and to generate exploratory hypotheses for further study, Table 3 provides responses to the entire questionnaire, although because those individual findings are susceptible to family-wise Type I error, our conclusions emphasize the lifestyle index. This table shows uncorrected univariate associations of ADHD with specific lifestyle behaviors. Children with ADHD were more likely to consume artificially sweetened juice, were more likely to be taking a multivitamin or an omega-3 fatty acid supplement, less likely to report reading for >1 hr/day, more likely to report 2 hr of screen time per day, and to report fewer hours of physical activity during the week, than controls. Parents of children with ADHD more often thought caffeine had some effect on their child than parents of normally developing children, yet were almost evenly split on whether caffeine “improved” or “worsened” their child’s behavior. Parents of children with ADHD, as compared with parents of controls, were much more likely to report that their children have difficulty falling asleep (45% vs. 9%, respectively, $p < .0001$), to report concern about their child’s sleep habits, and to fear that sleep problems may be leading to behavior issues. Sleep problems were related to ADHD even when restricting the analysis to only those *not* currently taking stimulant medication (where 33% of parents of ADHD children vs. 9% of parents of controls reported children having trouble falling asleep, $p < .0001$).

Finally, correlations for the components of the lifestyle index were analyzed to evaluate whether some healthy behaviors may help influence other healthy behaviors. Adequate water intake correlated with infrequent consumption of other sweetened beverages, reading >1 hr/day was correlated with meeting the screen time recommendations, and meeting the screen time recommendations also correlated with infrequent consumption of sweetened beverages. Other health behaviors were slightly correlated with meeting the sleep recommendation, at $p < .10$, including infrequent consumption of sweetened beverages and getting 1 hr/day of physical activity.

Discussion

Prior literature has examined individual lifestyle factors with ADHD, but the *overall number* of healthy lifestyle behaviors engaged in by children with ADHD has not been addressed. Furthermore, those survey data require confirmation in samples with carefully characterized ADHD and control of comorbid disorders. Survey studies in particular, such as data from the National Survey of Children’s Health (NSCH; Lingineni et al., 2012), confirm that some of these individual effects are likely generalizable at a population level. However, healthy behaviors need to be looked at in aggregate as overall healthy lifestyle may be much more impactful than the contribution of only one or two health behaviors individually; and confirmation in studies that can use a more rigorous characterization of ADHD is necessary. The present study adds to this literature in two ways: (a) by examining the overall number of key lifestyle behaviors followed by children with ADHD as compared with controls, while

(b) using children with very well-characterized ADHD and comorbid disorders, recruited from the community. Using a composite lifestyle index, we confirmed a robust association of ADHD with a less healthy lifestyle, as defined by the children following fewer healthy lifestyle behaviors than control children of the same age. These results held even after adjustment for multiple confounding factors, including age, sex, IQ, ADHD medication, comorbid psychiatric conditions, and household income (as a measure of SES). Confirmation using teacher ratings of ADHD symptoms provides assurance that effects are not attributable to shared source variance. Thus, these results underscore the importance of considering unhealthy lifestyle behaviors as a feature of ADHD that may be an important target for preventive or secondary intervention.

Specific aspects of this index are worthy of some elaboration. First, water consumption is a simple, yet often overlooked, aspect of children's health. Children with ADHD were marginally less likely to consume 3 cups/day of water than controls (28% vs. 38%, $p = .06$). It is important to note that both groups had very low water consumption in this study, so all children may benefit from counseling on increased water consumption.

Another aspect of beverage consumption which differed between groups in this study was consumption of artificially sweetened juice drinks. Children with ADHD consumed greater amounts of artificially sweetened juice than controls. The higher consumption of artificially sweetened drinks could potentially contribute to ADHD symptoms; however, it could also be due to parents believing that lowering sugar consumption may result in reduced ADHD symptoms. There have been reports of ADHD-like symptoms following the consumption of artificial sweeteners like aspartame (Bradstock et al., 1986), though other industry-funded studies failed to show a similar association (Shaywitz et al., 1994; Wolraich et al., 1994). More research is needed to determine whether there are effects of artificial sweeteners on ADHD.

On the contrary, parents of children with ADHD were *more* likely to report giving their child a multivitamin or a fish oil supplement. This may be related to media reports about micronutrient (Bener, Kamal, Bener, & Bhugra, 2014; Rucklidge & Kaplan, 2014) and fatty acid (Bloch & Qawasmi, 2011; Gow, Hibbeln, & Parletta, 2015; Hawkey & Nigg, 2014) deficiencies in children with ADHD, or due to increased access to health care providers who may make this recommendation. This reflects a positive lifestyle change as many children with ADHD may not be getting adequate nutrition (Howard et al., 2011).

Although not commonly thought of as a health behavior, reading can offset screen time, improve academic success, and, in turn, improve health literacy (Hersh, Salzman, & Snyderman, 2015); thus, we decided to include this measure in our index. We observed that children with ADHD were less likely to read for >1 hr/day than control children. It is common for children with ADHD to struggle with reading and spelling (Czamara et al., 2013), which suggests that more time spent on reading in the home on a daily basis may be beneficial for learning. Furthermore, reading at bedtime can replace screen time activities and help with good sleep hygiene rituals.

We also observed that 48% of children with ADHD, as compared with 35% of control children, reported 2 hr of screen time on an average school day, $p = .02$. The rapidly growing use of screens by children of all ages, from TV and gaming in older children, to use of iPads by infants <1 year of age, is of increasing concern. A recent meta-analysis confirms a small but reliable association of screen time with increased symptoms of ADHD, which appears, based on a small number of experimental and prospective studies, to have a causal component (Nikkelen, Valkenburg, Huizinga, & Bushman, 2014). Furthermore, a child having a TV in his or her bedroom has been associated with increased overall screen time by approximately 32% (Lo, Waring, Pagoto, & Lemon, 2015), and the presence of a television in the bedroom has been associated with increased sleep problems as well (Mistry, Minkovitz, Strobino, & Borzekowski, 2007). Current guidelines from the American Academy of Pediatrics recommend <1 hr to 2 hr of total screen time/day and removal of TVs from the bedroom (American Academy of Pediatrics, 2013), although new guidelines are expected in late 2016. It is important to note a limitation of the screen time data from this survey. Because parents do not directly observe all screen time that may occur during the day, some screen time such as that occurring on handheld devices during school hours and screen time on computers at school are probably not being reflected in screen time estimates. However, as this limitation applies to both ADHD children and controls, it is unlikely to have biased the results presented here.

Television use and screen time also seem to co-occur with reduced physical activity. For example, data from the NSCH demonstrated that nationally, children and adolescents aged 5 to 17 years with ADHD were 32% more likely to watch TV 1 hr/day (OR [95% CI] = 1.32 [1.03, 1.70]), and were 20% less likely to participate in sports (OR [95% CI] = 0.80 [0.65, 0.98]), than children or adolescents without ADHD (Lingineni et al., 2012). German researchers have also shown that ADHD symptoms were positively associated with TV viewing; however, conversely, they reported a positive association with total physical activity (van Egmond-Frohlich et al., 2012). Our data support the prior findings from the NSCH study, with increased screen time ($p = .02$) and decreased sports participation ($p = .003$) reported by parents of children with ADHD as compared with typically developing children.

Physical activity in itself is important for attention, mood, and ADHD symptoms, as shown by a rapidly growing literature (Archer & Kostrzewa, 2012; Cerrillo-Urbina et al., 2015; Gapin & Etnier, 2010; Ziereis & Jansen, 2015). For reviews, see the following (Halperin, Berwid, & O'Neill, 2014; Neudecker, Mewes, Reimers, & Woll, 2015). Exercise appears to be particularly important for the normal development of executive function (Guiney & Machado, 2013; Hillman, 2014), a key driver of symptoms of inattention and disorganization in ADHD. The reverse could also be true. For example, children with ADHD may avoid sports participation due to negative social interactions in the team environment (Lee, Causgrove Dunn, & Holt, 2014), although physical activity benefits could be attained through individual sports or active play as well. Current recommendations from the U.S. Department of Health and Human Services (2008) are for school-age children to get 1 hr of physical activity per day. There is scholarly interest in whether this activity should include complex motor learning to maximize benefits for neural and executive development (Myer et al., 2015), whether it should be of moderate–high intensity to benefit ADHD-related symptoms (Gapin & Etnier, 2010), and whether it needs to include complex motor

movements to be beneficial (Myer et al., 2015). These are all important questions which need to be addressed in future research.

We observed a strong association between ADHD and poor sleep in this study, which was not attributed solely to stimulant medication use. This finding supports previous research which has been summarized in multiple review studies looking at the association of ADHD with impaired sleep (Corkum, Tannock, & Moldofsky, 1998; Spruyt & Gozal, 2011). Again, effects could well be bidirectional. Poor sleep has been associated with psychological and cognitive impairments (Brand & Kirov, 2011) including inattention. At the same time, children with ADHD are well known to have difficulty with sleep-related and bedtime behaviors. Our findings confirm prior reports that sleep, as a critical healthy lifestyle behavior, is not being met adequately in these children.

As lifestyle choices like screen time right before bed, caffeine intake, and physical activity can all affect sleep, these factors should be considered, in addition to stimulant medication use, when assessing contributors to sleep problems in ADHD. Benefits of improved sleep hygiene were noted in a recent study where pediatricians taught parents (through handouts) about sleep hygiene issues like using a set bedtime, maintaining bedtime routines, removal of all media from the bedroom, and avoiding caffeine consumption. Results from this study showed improvements in ADHD symptoms, sleep, and health-related quality of life (Hiscock et al., 2015). The current recommendation for children aged 6 to 13 years is to aim for 9 to 11 hr of sleep/night (Hirshkowitz et al., 2015).

It is important to note that the lifestyle factors examined in this article are inter-related, in that healthy behaviors may influence one another; and children with one unhealthy behavior may have unhealthy behaviors in other areas as well. For example, physical activity increases thirst (making water intake more attractive), can offset screen time, and improves sleep. Similarly, removal of caffeinated beverages prevents their diuretic effect, can help increase water intake (as an alternative beverage), and can prevent sleep disturbance. Reading can replace screen time and can help sleep hygiene rituals. Correlations of the components of the lifestyle index support this idea. Any clinical program certainly will need to look at the integrated healthy behavior picture. For this reason, the present study considered a global composite of healthy behaviors. However, at a practical level, as clinicians are well aware, too many recommendations can overwhelm parents. Thus, it is necessary to balance the idea of one step at a time changes (which may have positive cascade effects) versus the cases where it is easier to put a new overall schedule of activity in place with multiple changes at once (like improving sleep hygiene with a combined approach).

A key contribution of this study is that it expands on current survey data by reporting on the overall number of healthy lifestyle behaviors using a sample in which ADHD diagnosis, as well as comorbid conditions, were independently confirmed and jointly analyzed in a community-recruited sample. Survey data are typically limited by reliance on parental report of all variables. Here, we used parent and teacher report to establish ADHD diagnosis, and confirmed that a lower lifestyle index score was associated with teacher-rated inattention and hyperactivity. Thus, effects are not attributable to reporting bias from parents. Finally, to our

knowledge, this is the first study to examine whether the overall number of healthy lifestyle behaviors differs between children with ADHD and typically developing control children.

This research is limited by the fact that it is a cross-sectional survey. Surveys do not allow for in-depth assessment of each lifestyle behavior such as directly monitoring physical activity. Similarly, we cannot assess causality with a cross-sectional design, and bidirectional effects are quite likely in many instances. It is possible that ADHD leads to less healthy behaviors, due perhaps to impulsivity, inattention, dysphoric mood, family disorganization, or other factors. It is also possible that poor health behaviors contribute to, or exacerbate, ADHD. As it becomes more clear that the association of ADHD with lifestyle behaviors is robust, the importance of evaluating potential benefits of lifestyle intervention on ADHD continues to grow. At the same time, ample evidence indicates that there is reason to hope that lifestyle changes may help children with ADHD to improve. However, a further concern is preventing negative secondary health problems in children with ADHD, regardless of effects on attention per se.

Conclusion

Children with ADHD are less likely to engage in healthy lifestyle behaviors than non-ADHD youth. Although causal effects are not fully known, children with ADHD may benefit from improved lifestyle choices. Healthy behavior change could be an important target of conversation between clinicians and parents during appointments, and future research is warranted to examine the effects of a combined lifestyle intervention, using detailed and accurate assessments of each lifestyle behavior, on children with ADHD.

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Biographies

Kathleen F. Holton is an Assistant Professor at American University in Washington, DC. Dr. Holton is a Nutritional Neuroscientist who studies the negative effects of food additive exposure and the positive protective effects of micronutrients and health behaviors on ADHD.

Joel T. Nigg is the Director of the Division of Psychology and Professor of Psychiatry, Pediatrics, and Behavioral Neuroscience at Oregon Health & Science University in Portland, OR. Dr. Nigg’s research focuses on the underlying mechanisms and causes of ADHD across the lifespan.

Table 1

Descriptive and Clinical Characteristics of Sample.

	Control (<i>n</i> = 104)	ADHD (<i>n</i> = 184)	
	Number (%)		<i>p</i> value^a
% male	60 (58%)	131 (71%)	.02
% non-Hispanic White	82 (79%)	138 (75%)	.46
% stimulant use	0	91 (49%)	NA
Comorbid psychiatric disorders			
Oppositional defiant disorder	2 (2%)	26 (14%)	.0004 ^b
Mood disorder	1 (1%)	7 (4%)	.27 ^b
Anxiety disorder	8 (8%)	49 (27%)	<.001
Conduct disorder	0	2 (1%)	NA
<i>Mean (SD)</i>			
Age at visit	10.4 (1.4)	10.3 (1.5)	.37
Estimated full scale IQ ^c	115 (13)	109 (14)	<.0001

^aChi-square tests.^bFisher's exact test.^cIQ estimated from a 3-subtest short form of the Wechsler Intelligence Scale for Children–Fourth Edition.

Table 2

The Likelihood of Having a Lower Lifestyle Index

	ADHD OR [95%, CI]	p value
Unadjusted estimate	2.01 [1.30, 3.10]	.002
Age and sex adjusted	2.19 [1.41, 3.40]	.0005
Multivariable adjusted		
• Age, sex, IQ	2.09 [1.33, 3.29]	.001
Multivariable adjusted		
• Age, sex, IQ, ADHD medication	1.76 [1.05, 2.94]	.03
• Above + Mood disorder	1.80 [1.08, 3.01]	.02
• Above + Any anxiety	1.73 [1.03, 2.91]	.04
• Above + Opposition defiant disorder	1.92 [1.14, 3.22]	.01
• Above + Conduct disorder	1.76 [1.05, 2.93]	.03
• Above + All four comorbid diagnoses	1.95 [1.16, 3.29]	.01
Final Multivariable Adjusted Model *		
• Above + Household income	1.95 [1.16, 3.30]	.01

Note. OR = odds ratio; CI = confidence interval.

* indicating below the table that the final model is adjusted for age, sex, IQ, ADHD medications, all 4 comorbid disorders, and household income.

Table 3Answers to Lifestyle Questionnaire Based on ADHD Status ($N = 288$).

	No ADHD ($n = 104$)	ADHD ($n = 184$)	<i>p</i> value
Water intake			
2 glasses/day	64 (62%)	133 (72%)	.06
3 glasses/day	40 (38%)	51 (28%)	
Soda intake			
0–1 glass/week	83 (80%)	130 (71%)	.09
2 glasses/week	21 (20%)	54 (29%)	
Drinks caffeinated soda	17 (20%)	37 (23%)	.56
Drinks diet soda	12 (14%)	21 (13%)	.84
Tea intake			
Never	71 (68%)	130 (71%)	.67
Sometimes	33 (32%)	54 (29%)	
Drinks caffeinated tea	13 (38%)	32 (56%)	.10
Is the tea sweetened?			
No	14 (44%)	12 (25%)	.12 ^a
Yes, with sugar	16 (50%)	27 (56%)	
Yes, artificially sweetened	2 (6%)	9 (19%)	
Energy drink intake			
Never	103 (99%)	179 (97%)	.42 ^a
Sometimes	1 (1%)	5 (3%)	
How does your child respond to caffeine?			
No change in behavior	63 (87%)	80 (62%)	.0002 ^a
Positively affects	2 (3%)	24 (18%)	
Behavior			
Negatively affects behavior	7 (10%)	26 (20%)	
Sugar sweetened juice intake			
Never	18 (17%)	25 (14%)	.48
1 glass/week	52 (50%)	87 (47%)	
2 glasses/week	34 (33%)	72 (39%)	
Artificially sweetened juice intake			
0–1 glass/week	95 (91%)	151 (82%)	.03
2 glasses/week	9 (9%)	33 (18%)	
Does your child have	8 (8%)	14 (8%)	.99
diagnosed food allergies?			
Is your child following a	6 (6%)	18 (10%)	.24
special diet?			
Does your child have celiac disease?			
No	104 (100%)	184 (100%)	NA
Does your child have GI complaints 2 times/week or more?			
No	101 (97%)	166 (90%)	.03 ^a

	No ADHD (n = 104)	ADHD (n = 184)	p value
Yes	3 (3%)	18 (10%)	
Does your child ever take a multivitamin?			
No	54 (52%)	73 (40%)	.04
Yes	50 (48%)	111 (60%)	
Does your child take other vitamins as well?			
No	85 (82%)	137 (75%)	.21
Yes	19 (18%)	45 (25%)	
Does your child take an omega-3 supplement?			
No	92 (89%)	139 (77%)	.01
Yes	11 (11%)	41 (23%)	
Does your child take an amino acid supplement?			
No	104 (100%)	181 (99%)	NA
Yes	0	2 (1%)	
Does your child take an herbal supplement?			
No	98 (94%)	165 (90%)	.23
Yes	6 (6%)	18 (10%)	
Do any of these supplements contain gelatin?			
No	47 (64%)	83 (53%)	.12
Yes	27 (36%)	75 (47%)	
On an average school day, how many hours does your child read?			
1 hr	75 (72%)	153 (83%)	.03
>1 hr	29 (28%)	31 (17%)	
On an average school day, how many hours does your child work on homework?			
None	1 (1%)	9 (5%)	.15 ^a
1 hr	89 (86%)	144 (78%)	
2 hr	14 (13%)	31 (17%)	
On an average school day, how many hours does your child have screen time (movies, Internet, video games, etc.)?			
0–1 hr	68 (65%)	95 (52%)	.02
2 hr	36 (35%)	89 (48%)	
On an average weekend, how many hours does your child have screen time (movies, Internet, video games, etc.)?			
0–5 hr	63 (61%)	105 (57%)	.12 ^a
6–10 hr	38 (37%)	61 (33%)	
11 hr	3 (3%)	17 (9%)	
In the past week, on average, how many hours was your child physically active?			
1–4 hr	31 (30%)	72 (39%)	.07
5–6 hr	22 (21%)	47 (26%)	
7 hr	51 (49%)	65 (35%)	
In the past week, on average, how many hours was your child in Physical Education (P.E.) class?			

	No ADHD (n = 104)	ADHD (n = 184)	p value
None	4 (4%)	18 (10%)	.29 ^a
1 hr	35 (36%)	57 (33%)	
2–3 hr	44 (46%)	80 (46%)	
4 hr	13 (14%)	18 (10%)	
In the past year, how many months was your child competing in sports?			
Never	16 (15%)	44 (24%)	.003
1–4 months	16 (15%)	51 (28%)	
5–8 months	27 (26%)	44 (24%)	
9–12 months	45 (43%)	45 (24%)	
Child has health conditions limiting sports participation	3 (3%)	12 (7%)	.27
Most frequently reported health condition			
Asthma	2 (2%)	14 (6%)	
Average hours of sleep per night			
8 hr	19 (18%)	52 (28%)	.17
9 hr	52 (50%)	81 (44%)	
10 hr	33 (32%)	51 (28%)	
Difficulty falling asleep			
No	95 (91%)	102 (55%)	<.0001
Yes	9 (9%)	82 (45%)	
Difficulty sleeping through the night			
No	99 (95%)	164 (89%)	.08
Yes	5 (5%)	20 (11%)	
Parental concern about child's sleep habits			
No	101 (97%)	152 (83%)	.0001 ^a
Yes	3 (3%)	32 (17%)	
Parental worry that poor sleep is leading to behavior change			
No	99 (95%)	152 (83%)	.003 ^a
Yes	5 (5%)	31 (17%)	

Note. GI = gastrointestinal.

^aFisher's exact test.