HHS Public Access

Author manuscript

Eur Child Adolesc Psychiatry. Author manuscript; available in PMC 2024 May 17.

Published in final edited form as:

Eur Child Adolesc Psychiatry. 2024 May ; 33(5): 1419–1432. doi:10.1007/s00787-023-02251-3.

ADHD-related sex differences in emotional symptoms across development

Alyssa C. De Ronda[2], **Laura Rice**[2], **Yi Zhao**[1], **Keri S. Rosch**[2,3,4], **Stewart H. Mostofsky**[2,4,5], **Karen E. Seymour**[2,4,6]

[1]Department of Biostatistics, Indiana University School of Medicine, 410 West 10th Street, Indianapolis, IN 46202, USA

[2]Center for Neurodevelopmental and Imaging Research, Kennedy Krieger Institute, 716 North Broadway, Baltimore, MD 21205, USA

[3]Department of Neuropsychology, Kennedy Krieger Institute, Baltimore, MD, USA

[4]Department of Psychiatry and Behavioral Sciences, Johns Hopkins University School of Medicine, 716 North Broadway, Baltimore, MD 21205, USA

[5]Department of Neurology, Johns Hopkins University School of Medicine, 716 North Broadway, Baltimore, MD 21205, USA

[6]Department of Mental Health, Johns Hopkins University School of Public Health, 6701 Rockledge Drive, Bethesda, MD 20892, USA

Abstract

To investigate developmental changes in emotion dysregulation (ED) and associated symptoms of emotional lability, irritability, anxiety, and depression, among girls and boys with and without ADHD from childhood through adolescence. Data were collected from a sample of 8–18-year-old children with (n = 264; 76 girls) and without (n= 153; 56 girls) ADHD, with multiple time-points from a subsample of participants (n= 121). Parents and youth completed rating scales assessing child ED, emotional lability, irritability, anxiety, and depression. Mixed effects models were employed to examine effects and interactions of diagnosis, sex [biological sex assigned at birth], age among boys and girls with and without ADHD. Mixed effects analyses showed sexually dimorphic developmental patterns between boys and girls, such that boys with ADHD showed a greater reduction in ED, irritability, and anxiety with age compared to girls with ADHD, whose symptom levels remained elevated relative to TD girls. Depressive symptoms were persistently elevated among girls with ADHD compared to boys with ADHD, whose symptoms decreased with

✉Karen E. Seymour, karen.seymour@nih.gov.

Author contributions KSR, SHM, KSR conceptualized the study, analyzed and interpreted the data, and wrote the manuscript. ACD, LR, and YZ analyzed and interpreted the data and wrote the manuscript.

This work was prepared while Dr. Karen Seymour was employed at Johns Hopkins University and Kennedy Krieger Institute. She is currently employed at the National Institutes of Health, Center for Scientific Review. The opinions expressed in this article are the author's own and do not reflect the view of the National Institutes of Health, the Department of Health and Human Services, or the United States government.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00787-023-02251-3.

Conflict of interest The authors declare no competing interests.

age, relative to same-sex TD peers. While both boys and girls with ADHD showed higher levels of ED during childhood (compared to their sex-matched TD peers), mixed effects analyses revealed substantial sexually dimorphic patterns of emotional symptom change during adolescence: Boys with ADHD showed robust improvements in emotional symptoms from childhood to adolescence while girls with ADHD continued to show high and/or increased levels of ED, emotional lability, irritability, anxiety and depression.

Keywords

Attention-deficit/hyperactivity disorder (ADHD); Developmental patterns; Emotion regulation; Irritability; Comorbidity

Introduction

Emotion dysregulation (ED), demonstrated through emotional lability and negative emotional symptoms such as irritability, depression, and anxiety, is the cause of significant impairment in children with attention-deficit/hyperactivity disorder (ADHD). While ADHD is characterized by developmentally inappropriate levels of inattention, hyperactivity, and impulsivity, ED is also common among children with ADHD with prevalence rates up to 60% in clinical samples [1, 2]. Emotion regulation (ER) refers to, “an individual’s ability to modify an emotional state so as to promote adaptive, goal-oriented behaviors” [3], and is critical for adaptive functioning throughout development. In contrast, ED refers to “(1) emotional expressions and experiences that are excessive in relation to social norms and are context inappropriate; (2) rapid, poorly controlled shifts in emotion (lability); and (3) the anomalous allocation of attention to emotional stimuli” [1]. Examples of ED include emotional lability, poor frustration tolerance, and the presence of negative emotional symptoms such as irritability, anxiety, and depression. In children with ADHD, persistent ED in childhood predicts the development of mood disorders in adolescence and adulthood, and results in higher rates of psychiatric comorbidities, greater social impairment, and greater ADHD symptom persistence [4–7], making it critical to comprehensively understand the developmental patterns of emotional lability, irritability, anxiety, and depression in children with ADHD.

There have been some cross-sectional studies of ED and associated impairments in children with ADHD (see [1, 8, 9] for reviews). Though ED is also present in typically developing (TD) children, children with ADHD are ten ten times more likely to demonstrate symptoms of ED [1, 10]. Emotional lability, a form of ED, is also increased in children with ADHD compared to their TD siblings; children with ADHD are at a six-fold increased risk for displaying significantly elevated levels of emotional lability [11]. Difficulties with ER likely contribute to high levels of negative emotional symptoms such as irritability, depression, and anxiety in children with ADHD [6, 12–15]. Cross-sectional research has shown that among children with ADHD, greater ED is associated with increased rates of psychiatric comorbidities, negative peer and family relationships, poor academic performance, and low self-esteem [9, 16–18]. Specifically, emotional lability was found to be associated with greater severity of core ADHD symptoms, elevated rates of comorbid conditions (e.g.,

oppositional defiant disorder [ODD], depression, anxiety, and substance abuse), and social impairments [4, 19–21]. Therefore, examination of ED within ADHD is critical as studies have shown that negative emotional symptoms have a greater impact on children's wellbeing and self-esteem than core symptoms of ADHD (e.g., hyperactivity and inattention) [22]; moreover, the presence of ED may differentiate treatment response in individuals with ADHD, demonstrating the clinical necessity of understanding the developmental course of ED in children with ADHD.

Cross-sectional studies suggest there may be important sex differences in the presentation and impact of ED in ADHD. Sobanski et al. [4] showed that girls, compared to boys, with ADHD were more likely to have severe emotional lability. Moreover, the aggravating effects of emotional lability on inattention and anxiety symptoms were stronger in girls with ADHD compared to boys with ADHD [4]. In a cross-sectional study of 12–16-year-old adolescents, results showed that girls with ADHD rated themselves higher in ED compared to boys with ADHD, but showed similar levels to TD girls; however, interestingly, boys with ADHD had higher self-reported ED than TD boys [9]. Findings in the adult ADHD literature mimic results found in children such that in a sample of adults with ADHD, sex predicted emotional lability development in childhood and persistence into adulthood, whereby women were more likely to develop and continue to exhibit emotional lability compared to men [23]. Taken together, these findings highlight the importance of not only diagnostic, but sex comparisons when examining ED in individuals with ADHD.

Despite its importance, few studies have examined age-related changes or sex differences in ED in children with ADHD across childhood and into adolescence. Instead, longitudinal studies have largely focused on DSM diagnoses or symptoms of anxiety, depression or irritability as proxy measures of ED. However, one study using a prospective longitudinal design in a clinical sample of children with ADHD and Deficient Emotional Self-Regulation (DESR; measured using the CBCL DESR profile), results showed that 57% of children with ADHD and DESR at baseline continued to show DESR, were diagnosed with more comorbidities, and exhibited poorer global functioning four years later compared to children with ADHD only and TD children [5]. Similarly, in a 3-year longitudinal study of 137 children with ADHD and 59 TD controls ages 6–17 years-old, results at follow-up showed that the ADHD group demonstrated greater levels of ED, anxiety, and depression than controls [24]. Furthermore, for TD controls the slope of change between baseline and follow-up demonstrated increased symptoms over time whereas the slope of change for the ADHD group showed decreased symptom levels over time. Differences between sexes were not examined. In a retrospective longitudinal study of sleep problems and emotion dysregulation across early childhood (ages birth-7 years-old) in children with and without ADHD, results from when children were 8–9 years old showed that compared to the control group, children with ADHD consistently had elevated emotion dysregulation beginning around ages 2–3 years old which persisted across development [25]. Lastly, in a community sample of 2,232 5-year-old children assessed every 2 years until they were 12, results showed that ADHD and emotional problems were concurrently associated over time, while longitudinal analyses revealed that an early diagnosis of ADHD was associated with emotional problems in preadolescence (after controlling for prior emotional problems and concurrent ADHD symptoms), suggesting that children with early symptoms of ADHD are

at a greater risk of developing difficulties with emotion dysregulation [26]. Taken together, this literature demonstrates that compared to TD children, children with ADHD have higher levels of emotion dysregulation across development, and that ADHD early in development can serve as a precursor for increased ED across time. However, there are notable gaps within this literature including a focus on intraindividual change in ED across time as well as a focus on potential sex differences.

There is also some longitudinal research examining negative emotion related diagnoses or symptoms (e.g., anxiety, depression, irritability) in children with ADHD. In a 16-year follow-up of boys ages 6–17, Biederman and colleagues [5] showed that at follow-up boys with ADHD had increased rates of both mood and anxiety disorders compared to TD controls. The authors conducted a similar longitudinal study in ADHD girls and found similar results of increased levels of mood and anxiety disorders in ADHD girls relative to controls at follow-up [27]. In a study which included both boys and girls, Lahey and colleagues [28], followed children with and without ADHD from ages 4–6 years old through 18 years old and assessed the trajectories of negative emotional symptoms including anxiety and depression. Results showed that children with ADHD exhibited higher levels of anxiety and depression, and lower levels of global functioning than TD children over time. Moreover, in comparison to boys with ADHD, girls with ADHD had poorer outcomes including increased levels of anxiety and depression and decreased adaptive functioning during adolescence compared to boys with ADHD.

Regarding irritability, a prospective longitudinal study of irritability in 696 children ages 6–18 years-old with ADHD found at follow-up (on average 5.4 years later), 64% of the sample reported at least 1 irritability symptom and 23% met diagnostic criteria for Disruptive Mood Dysregulation Disorder (DMDD), a disorder characterized by persistent impairing irritability [6]. Moreover, irritability at baseline was persistent at follow-up and baseline irritability was predictive of depression symptoms at follow-up. Using community detection analysis of temperament profiles in children with ADHD, Karalunas and colleagues [29] showed persistence of ADHD with irritable mood across 3 years, and that prospectively, having ADHD + irritable mood predicted a greater chance of having a new comorbid disorder and anxiety disorders at 2-year follow-up relative to those in the mild or surgent temperament ADHD groups. Finally, a longitudinal examination of irritability trajectories from ages 7–15 in relation to ADHD and genetic risk scores showed that ADHD polygenic risk scores were associated with an increased likelihood of being in the both the high-persistent and increasing irritability trajectory classes [30]. Moreover, childhood ADHD was associated with the greatest likelihood of being in the high-persistent class of irritability.

In sum, the extant literature shows that children with ADHD are at increased risk for the development of anxiety, depression and irritability across time and development. However, much like the longitudinal literature on ED in children with ADHD, there is a paucity of research examining age-related change in symptoms of anxiety, depression or irritability across the critical developmental period of adolescence. Moreover, to date, no studies have examined sex differences in these patterns of negative emotional symptoms across time in the context of ADHD.

Therefore, the objective of the current study was to address these critical gaps in the extant literature using a large dataset including cross-sectional and longitudinal data spanning childhood and adolescence, to examine age-related changes in ED, depression, anxiety and irritability in children with ADHD and the impact of biological sex assigned at birth. It was hypothesized that children with ADHD would demonstrate persistent or increased ED from childhood to adolescence relative to TD controls. Further, based on the cross-sectional literature suggesting increased negative emotional symptoms in girls with ADHD relative to boys, we hypothesized that girls with ADHD would show greater increases in ED and negative emotional symptoms relative to ADHD boys.

Method

Participants

Participants included 417 children ages 8–18 years old, 264 children with ADHD (76 girls) and 153 TD controls (56 girls). Recruitment for this study changed over time as additional funding became available such that participants were initially recruited in childhood (ages 8–12) and then a subset of participants were invited for a follow-up visit between the ages 12–17 (at least 1 year after their initial 8–12-year-old visit) in addition to recruitment of new adolescent participants (ages 12–17) with and without childhood ADHD. Most participants (n = 322) had their initial baseline visit between ages 8–12 years. As this was not initially designed as a longitudinal study, there is variability across participants in the time between the follow-up visits, with 25% (n = 103) of the sample completing a single follow-up visit and 4% (n = 18) completing two follow-up visits (see Fig. 1 showing the age distribution for single and multiple visits among diagnosis and sex subgroups). Time between visits ranged from 1.05–6.37 years (mean = 3.0, mode = 2.33). This approach is similar to an accelerated longitudinal design in which participants vary in their age at the initial assessment and the time between assessments. Participants parents reported their child's biological sex at birth and we refer to girls and boys (rather than females and males) to emphasize the developmental nature of our sample as recommended in published guidelines [31]. Participants were recruited from local schools and community centers. Sample demographics and characteristics stratified by participants in the cross-sectional (i.e., single visit) and longitudinal (i.e., multiple visits at least 1 year apart) subgroups are included in Supplementary Table 2.

Procedures

Prior to engaging in study procedures, parents of all participants provided written consent. All parents completed an initial telephone screen to determine eligibility. Children with a history of intellectual disability, seizures, traumatic brain injury or other neurological illnesses were excluded from participation.

If participants were eligible after the telephone screen, parents completed the Diagnostic Interview for Children and Adolescents (DICA-IV; n = 59) or the Kiddie Schedule for Affective Disorders and Schizophrenia (K-SADS; n = 324). Additionally, the ADHD Rating Scale (ADHD-RS) and the Conners Rating Scale were used to confirm diagnosis and to provide dimensional measures of ADHD symptom severity.

Participants were included in the ADHD group if they: (1) met DSM-5 criteria for an ADHD diagnosis on either the DICA-IV or K-SADS and (2) received a T-score of 60 or higher on Conners Rating Scale or a score of 2 or 3 (i.e., symptoms rated as occurring often or very often) on at least 6/9 items on the Inattentive or Hyperactivity/Impulsivity scales of the ADHD-RS. Master's level clinicians conducted all diagnostic interviews and integrated information from rating scales to inform diagnoses under the supervision of licensed doctoral level clinical psychologists. Children with ADHD were allowed to meet criteria for comorbid psychiatric diagnoses on the diagnostic interview at baseline and follow-up visits (Table 1). Children taking stimulant medication were asked to withhold medication on the day prior to and day of testing. Children taking psychotropic medications other than stimulant medication (n = 23 ADHD boys, n = 9 ADHD girls, n = 1 TD boy, n = 1 TD girl) did not discontinue their medication during testing. Parents were instructed to make ratings based on their children's symptoms off medication.

Participants were included in the TD control group if they: (1) did not meet criteria for any psychiatric disorders at the initial visit on the diagnostic interview, (2) remained below clinically significant scores on the ADHD rating scales (resulting in significantly lower symptoms of ADHD compared to participants in the ADHD group, see Table 1), and (3) did not have an immediate family member with ADHD. TD participants were able to meet criteria for anxiety or depressive disorders at the follow-up visits.

Emotion symptom rating scales

ED was assessed using parent- and youth-rated symptom scales. The total number of responses varied across scales, so sample sizes are reported for each measure separately (see Supplemental Table 3 for the sample size for each diagnosis by sex subgroup for each rating scale for participants with single versus multiple visits). When available, T-scores are examined (adjusted for age and sex) to provide an indication of symptom severity with greater clinical utility than raw scores may provide.

Conner's Rating Scales (-Revised, 3rd Edition) [32]—The Conners was completed by a parent at baseline (n = 332), and follow-up visits (n = 88). The Emotional Lability subscale was examined which assesses rapid and/or extreme changes in emotion often expressed as irritability or anger, with higher age- and sex-adjusted total t-scores indicating greater difficulties with emotional lability.

Affective Reactivity Index (ARI) [33]—The ARI parent- and child-report were completed by parents and participants at baseline (parent n = 331, child n = 316), and follow-up visits (parent n = 90, child n = 87). The ARI parent- and child-report is a brief, 7-item rating scale that assesses symptoms and impairment associated with childhood irritability over the past six months. The measure contains six symptom items that examine the child's threshold for irritability, and the frequency and duration of irritable/angry feelings and behaviors. Items are rated on a three-point scale (Not True, Somewhat True, or Certainly True) with higher scores indicating higher rates of irritability. Prior research using the ARI in both clinical and community samples has demonstrated good internal consistency, strong validity, and a single-factor structure [33–36].

Children's Depression Inventory, 2nd Edition (CDI-2) [37]—The CDI-2 was completed by participants at baseline (n = 281), and follow-up visits (n = 90). This is a widely used 28-item self-report inventory designed for children ages 7–17. The CDI-2 asks about depressive symptoms within the last 2 weeks and is scored on a 3-point scale ranging from 0 (absence of the symptom) to 3 (presence of symptom at a severe level). Age- and sex-adjusted total t-scores were used; higher scores indicate more severe symptoms. Several studies have shown strong psychometric properties of the CDI including good internal consistency (α = 0.71–0.89) and well-established content validity [37].

Multidimensional Anxiety Scale for Children, 2nd Edition (MASC-2) [38]—The MASC-2 was completed by parents and participants at baseline (parent n = 267, child n = 280), and follow-up visits (parent n = 79, child n = 86). The MASC-2 assess the presence of symptoms related to anxiety disorders in children ages 8 to 19 years old. For this study, MASC-2 Total t-score was used to assess anxiety symptoms with higher scores indicating greater difficulties with anxiety. The MASC-2 has shown good convergent validity [39, 40] as well as strong internal consistency (α self-report = 0.73–0.89; α parent-report =0.70–0.90; [41].

Data analytic plan

Effects of diagnosis, sex, and age on emotional symptoms—To investigate how negative emotional symptoms differ between girls and boys with and without ADHD, and to account for variability across participant timepoints while levering all available data for this mixed cross-sectional/longitudinal sample, linear mixed effect models were implemented across age, correcting for age effects (sex and diagnosis effects across age; Eq. 1) and as a function of age (age-related sex and diagnosis effects; Eq. 2). However, we also present results restricted to participants with longitudinal data in the Supplementary Materials (including Tables 4–6 and Figs. 10–17). Model parameters were estimated for each emotional symptom rating scale separately as they assess different aspects of emotional functioning. Subsequently, separate post-hoc tests were conducted for each significant two-way interaction among the subgroups to clarify the directionality of the observed effects, and Tukey's method was employed to correct for multiple comparisons. A random effect was included in the models to account for the within-subject variation for participants with multiple visits.

The use of linear mixed effect models allows for the inclusion of multiple time points per participant while accounting for the unbalanced data structure of irregular time intervals between the study visits [42], allowing us to include all available data for our developmental sample. While both quadratic and linear models were examined for age, linear models provided a better fit and are reported. Modeling and visualization were performed in R using the linear mixed effects package *lme4* [43]. Generalized Ability Index (GAI) and socio-economic status (SES) both were included as nuisance covariates in all models. Results collapsed across age (Diagnosis × Sex interaction) are reported first, followed by results as a function of age (Diagnosis × Sex × Age, Diagnosis × Age, Sex × Age). Results are reported in terms of beta estimates (β), p-values (p), and effect sizes (d). Effect sizes

were calculated according to Eq. 3 [44]. Descriptive statistics (Table 1) were compared across diagnosis by sex subgroups using two-sided t tests with independent variance.

$$Response\ Measure \sim Sex * Diagnosis + Sex + Diagnosis + Age + SES + GAI + Random\ Effect\ of\ Participant$$

Equation 1 :

$$Response\ Measure \sim Sex * Diagnosis * Age + Sex * Diagnosis + Sex * Age + Age * Sex + Sex + Diagnosis + Age + SES + GAI + Random\ Effect\ of\ Participant$$

Equation 2 :

$$d = \frac{difference\ between\ the\ means}{\sqrt{cariance\ intercept_{participant} + variance_{residual}}}$$

Equation 3 :

Outlier detection and normality test—Scores greater than three standard deviations above the sample Diagnosis × Sex mean (i.e., TD boys, ADHD girls) were defined as outliers and removed from the data [ARI-P (n = 4), ARI-S (n = 1), Conners Emotional Lability subscale (n = 3), CDI–2 (n = 6), MASC–2 P (n = 2), and MASC–2 S (n = 1)]. Shapiro–Wilk tests of normality were significant for all measures (except for ADHD girls MASC–2 Self Total T-score) and visual inspection of histograms within the diagnosis by sex subgroups revealed non-normal distributions. Therefore, the bestNormalize function in R was used to identify the best transformations for the data and apply these transformations prior to analysis.

Results

Participants

Diagnostic groups did not differ in age ($p = 0.352$) or race (% White, $p = 0.674$) at baseline (Table 1). However, TD participants had higher SES ($p = 0.002$) and higher GAI scores ($p < 0.001$) at baseline; therefore, these variables were included as covariates in all analyses. At baseline, girls with ADHD showed higher symptoms of inattention ($p = 0.035$) but similar levels of hyperactivity/impulsivity ($p = 0.327$) as measured by Conners age- and sex-adjusted T-scores. At baseline, girls and boys with ADHD did not differ in comorbid diagnoses of oppositional defiant disorder ($p = 0.187$) or depressive disorders ($p = 0.327$), whereas anxiety disorders were more prevalent in girls with ADHD ($p = 0.020$) and more boys with ADHD were treated with stimulant medication ($p = 0.009$; Table 1), but did not differ in treatment with other psychotropic medications. Diagnostic groups did not differ in the amount of time between visits ($p = 0.320$). Additional information regarding demographic and clinical characteristics of participants with single versus multiple timepoints are provided in the Supplementary Table S1.

Conners emotional lability subscale: parent ratings—Collapsed across age, there were significant main effects of sex (Boys > Girls; $\beta = -0.315$, $p = 0.034$, $d = 0.366$) and diagnosis (ADHD > TD; $\beta = 0.820$, $p < 0.001$, $d = 0.952$), with no evidence of a diagnosis × sex interaction. Age-related analyses revealed a Diagnosis × Age interaction ($\beta = -0.138$, $p < 0.001$, $d = 0.163$). Subgroup comparisons (Fig. 2) revealed that boys with ADHD showed greater improvement in emotional lability with age compared to TD boys ($\beta = -0.144$, $p < 0.001$, $d = 0.173$) and compared to girls with ADHD ($\beta = -0.106$, $p = 0.011$, $d = 0.115$), whereas age-related change in emotional lability did not differ among girls with ADHD and TD girls, or TD boys and girls.

Affective reactivity index: parent ratings—Collapsed across age, there was a main effect of diagnosis (ADHD > TD; $\beta = 0.930$, $p < 0.001$, $d = 1.03$), with no evidence of a main effect of sex or a diagnosis × sex interaction. Age-related analyses revealed a Diagnosis × Age interaction ($\beta = -0.098$, $p = 0.014$, $d = 0.109$), but no significant Diagnosis × Sex × Age interaction. Subgroup comparisons (Fig. 3) revealed that boys with ADHD showed greater improvement in Affective Reactivity Index parent ratings with age compared to TD boys ($\beta = -0.106$, $p = 0.005$, $d = 0.114$) and compared to girls with ADHD ($\beta = -0.114$, $p = 0.008$, $d = 0.110$), whereas age-related change was similar among girls with ADHD and TD girls, as well as TD boys and girls.

Affective reactivity index: child ratings—Collapsed across age, there was a significant main effect of diagnosis (ADHD>TD; β=0.545, p<0.001, d=0.578), but no main effect of sex or Diagnosis × Sex interaction. Age-related analyses revealed a Diagnosis × Age interaction ($\beta = -0.133$, $p = 0.004$, d=0.144) but no significant Diagnosis × Sex × Age interaction. Subgroup comparisons (Fig. 4) revealed that boys with ADHD showed greater improvement in Affective Reactivity Index child ratings with age compared to TD boys (β= −0.132, $p = 0.004$, $d = 0.141$) and compared to girls with ADHD (β = −0.153, $p = 0.002$, d=0.150), whereas age-related change was similar among girls with ADHD and TD girls, as well as TD boys and girls.

Children's depression inventory–2: parent ratings—Collapsed across age, there was a significant main effect of diagnosis (ADHD>TD; β=0.421, $p = 0.003$, d=0.442) and a Diagnosis × Sex interaction ($\beta = 0.539$, $p = 0.020$, d=0.567), whereby girls with ADHD had higher depression scores than boys with ADHD (β=0.440, p=0.002, d=0.472), but there was no difference between TD girls and boys. Additionally, both girls (β=0.999, p<0.001, d=1.06) and boys β=0.398, $p = 0.006$, d=0.415) with ADHD had higher depression scores than their TD peers. Age-related analyses revealed a significant Diagnosis × Age interaction (β= −1.125, $p = 0.011$, d=0.133), but no evidence of a Diagnosis × Sex × Age interaction. Subgroup comparisons (Fig. 5) revealed that boys with ADHD showed greater improvement in depression self-ratings with age compared to TD boys (β= −0.124, p=0.012, d=0.131) but not compared to girls with ADHD. Similarly, girls with ADHD showed greater improvement with age compared to TD girls (β= −0.123, p=0.046, d=0.133). Age-related changes were similar among TD boys and girls, and there was a significant main effect of age within this group (β=0.080, p=0.043, d=0.086), whereby depressive symptoms increased across age.

Multidimensional anxiety scale for children–2: parent ratings—Collapsed across age, there was a significant main effect of diagnosis (ADHD >TD; β= 0.349, p=0.012, d=0.368), although there was no main effect of sex or Diagnosis × Sex interaction. Age-related analyses revealed significant Diagnosis × Age (β= − 0.124, p = 0.012, d=0.132), Sex × Diagnosis (β= − 2.12, p=0.033, d=2.26), and Diagnosis × Sex × Age interactions (β = 0.191, p=0.017, d=0.204). Subgroup comparisons (Fig. 6) revealed that boys with ADHD showed greater improvement in anxiety ratings with age compared to TD boys (β= − 0.125, p = 0.011, d=0.132) and compared to girls with ADHD (β= − 0.145, p=0.008, d=0.146), whereas age-related change was similar among girls with ADHD and TD girls, and TD boys and girls.

Multidimensional anxiety scale for children–2: child ratings

Collapsed across age, there was a significant main effect of diagnosis (ADHD>TD; β=0.357, p=0.012, d=0.364) but no main effect of sex or Diagnosis × Sex interaction. Age-related analyses revealed a Diagnosis × Age interaction (β= − 0.101, p = 0.048, d=0.104), but no Diagnosis × Sex × Age interaction. Subgroup comparisons (Fig. 7) revealed that boys with ADHD showed greater improvement in anxiety ratings compared to girls with ADHD (β= − 0.130, p=0.015, d=0.129) and trended toward greater improvement with age compared to TD boys (β= −0.097, p=0.060, d=0.099), whereas age-related change was similar among girls with ADHD and TD girls, and TD boys and girls.

Discussion

This study expands on the ADHD literature by examining age-related changes in and the impact of sex on ED and negative emotional symptoms such as irritability, depression, and anxiety in children with and without ADHD from childhood through adolescence. Results showed children with ADHD had higher scores of ED compared to their sex-matched TD peers. More specifically, children with ADHD had higher levels of parent-reported ED and emotional lability, parent- and self-reported irritability, parent- and self-reported anxiety, and parent-reported depression compared to their sex-matched TD peers. Age-related analyses revealed that boys with ADHD showed significant improvements in ED such that by adolescence, boys with and without ADHD had similar levels of ED, irritability, and anxiety, and lower levels of depression. High levels of irritability persisted from childhood to adolescence for girls with ADHD, while TD girls showed increasing levels of irritability over time. Girls with ADHD and TD girls both showed increasing levels of anxiety, while boys with ADHD saw improvement compared to girls with ADHD and TD peers. Interestingly, girls with ADHD showed decreasing levels of depression across development, while TD girls showed increasing levels. However, the depressive symptoms endorsed by girls with and without ADHD remained clinically significant, suggesting adolescent girls are at the greatest risk of developing depressive disorders.

Boys and girls with ADHD show sexually dimorphic patterns of ED across development. Specifically, our results show that symptoms of ED tend to decrease in boys with ADHD, while girls with ADHD continue to experience persistently high levels of negative emotional symptoms. Our results mirror the longitudinal findings of Hinshaw and colleagues, who

have conducted extensive work in girls with ADHD. For example, using prospective longitudinal data, Owen et al. found that into adolescence fewer than half of the girls with ADHD were below the study threshold for externalizing (42.1%) and internalizing problems (49.2%) compared to 91.3% and 85.2% in TD girls. Moreover, only 16% of girls with ADHD, compared to 86% of the TD girls, were considered "positively adjusted" during adolescence [45]. Follow-up studies with this sample have shown that into young adulthood, girls with ADHD are more likely to experience higher levels of anxiety, depression, suicidality, and self-harm than TD girls [46], 2012). While the work of Hinshaw and colleagues only examined developmental patterns in girls with and without ADHD, our study had the advantage of examining sex difference in girls and boys with and without ADHD. Taken together with our results, this literature suggests that girls with ADHD are at increased risk for a host of deleterious outcomes compared to their TD peers and to boys with ADHD. Our results suggest that girls with ADHD may require additional prevention and intervention efforts to prevent the worsening of negative emotional symptoms in adolescence. Although our findings contribute to the burgeoning literature on this topic, more longitudinal studies of sex differences in ADHD are necessary to determine the differential associations between ED on ADHD symptoms, global functioning, and functional outcomes, and to examine how childhood levels ED predict functional impairment later in life.

An important next step is to better understand the factors contributing to differential change in emotional symptoms across development among girls and boys with and without ADHD. First, there may be biologically based explanations related to the sexually dimorphic patterns of brain development between boys and girls with ADHD which may underlie the observed sex differences in ED when considered in the context of development. In a cross-sectional study examining frontal lobe cortical morphology, Dirlikov et al. found widespread surface area (SA) reductions in the functional subsections of the prefrontal cortex in girls with ADHD compared to TD girls, while boys with and without ADHD showed similar prefrontal cortical SA [47]. Similarly, prefrontal white matter abnormalities in the orbitofrontal cortex (associated with emotion regulation) were observed in girls, but not boys, with ADHD when compared to their TD peers [48, 49]. Taken together with our findings, the protracted neuroanatomical development observed in girls with ADHD may underlie the development and persistence of ED. However, longitudinal studies that combine neuroimaging and behavioral data are necessary to investigate this complex dynamic.

Alternatively, girls with ADHD may be showing greater persistence or increased emotional symptoms into adolescence as a function of societal factors, including gender socialization and gendered treatment of children by their parents, teachers, and peers, or referral and diagnostic biases. Specifically, it has been suggested that ADHD diagnostic criteria are biased toward a "male presentation" of the disorder, with females thereby less likely to meet full diagnostic criteria [50]. Consistent with this view, it has been shown that parents perceive ADHD symptom criteria as being descriptive of boys [51]. The observed sex differences in referral and diagnosis has often been attributed to females with ADHD being more likely to present with inattentive symptoms, which may be easy to miss and less disruptive, rather than more disruptive hyperactive/impulsive symptoms, which occur more in males [52]. Consequently, clinicians may have a higher threshold for diagnosing ADHD

in girls [53] and may be more likely to do so when girls present with greater ADHD symptom severity and disruptive behavior. Furthermore, if symptoms of ADHD are more characteristic of “typical boy” behavior, females who display ADHD symptoms, particularly hyperactivity and impulsivity, may experience greater peer rejection as these behaviors are less socially acceptable for their gender.

The extent to which these different emotional trajectories for girls and boys with ADHD are due to biological (sex) or societal (gender) factors is an understudied area of growing interest, as discussed in a recent review on this topic [54]. Recent findings from the large, national cohort in the Adolescent Brain Cognitive Development [55] study suggest that differences in emotional, behavioral, and cognitive profiles in 9–10 year-old children may be due to gender rather than sex. They came to this conclusion based on the finding that sex differences in these domains were only observed in children with a history of an ADHD diagnosis at the time of study enrollment and not observed in children who screened positive for ADHD during the study. However, they failed to consider the age of diagnosis (i.e., greater severity when diagnosed at a younger age) and variability in diagnostic procedures (i.e., licensed clinical professional rather than parent self-administered computerized interview), which likely impact these results. In addition, their findings suggest greater internalizing problems in boys than girls at the age of 9–10, which is inconsistent with our results and does not speak to the emergence of affective problems into adolescence, as shown in our results. Thus, in future research it will be important to examine the independent and interactive influences of biological sex and socially-constructed gender to improve our understanding of sex differences in ADHD and in risk for adverse outcomes in youth with ADHD.

Our results have several important clinical implications. Children with ADHD exhibited elevated symptoms of irritability, anxiety, and depression relative to their TD peers, indicating that additional prevention and intervention efforts beyond those focused on ADHD symptoms are necessary to address the development of ED and prevent deleterious outcomes [56–58]. Additionally, the current findings contribute to our understanding of how ED develops over time. Despite overall emotional improvements in boys with ADHD compared to their sex-matched TD peers, girls with ADHD continued to experience elevated negative emotional symptoms through adolescence. Thus, clinicians should consider using mood-related screening tools in childhood to help identify youth most at risk for developing psychopathology. It is also recommended that evidence-based interventions, such as cognitive behavioral strategies, be provided in childhood to children with ADHD who exhibit elevated levels of ED to help at-risk youth identify and overcome negative emotion; thereby, lessening the ED gap in adolescence between girls with ADHD and their peers. Given the association between ED, psychiatric comorbidities, and social and functional impairments [9, 16–18], early intervention focused on both ADHD-related cognitive deficits and ED could yield greater functional improvements than interventions solely focused on ADHD symptom behavior.

A few important limitations should be considered. First, our data were largely cross-sectional, and of the longitudinal data, participants often only had two timepoints, preventing us from modeling within-person symptom trajectories. This, coupled with a lower number

of female participants, may have contributed to the stronger effects found in boys compared to girls. As additional longitudinal data are collected, it will be important to re-evaluate these developmental patterns. Second, we did not gather information from all participants regarding gender identity and our analyses are solely based on parent-report of biological sex assigned at birth. Among our adolescent sample, we did begin to collect gender data over the past few years of the study, but this was only available for 73 participants of whom, the majority are cisgender with only four adolescent participants identifying as non-binary or transgender. Therefore, it will be important for future research aiming to understand the impact of sex and gender on emotional functioning gather information on gender-based variables (i.e., identify, expression, etc.) to be considered in their analyses. Finally, our study was limited to parent- and self-report measures of ED, whereas multi-method assessments involving performance-based measures of different aspects of emotion regulation and examination of neuroimaging data revealing the role of brain structure and function may be important to improving our understanding of ADHD-related sex differences in emotional symptom trajectories.

In conclusion, our results revealed that boys and girls with ADHD have higher levels of ED compared to their sex-matched TD peers, consistent with prior research. Novel, age-related results revealed sexually dimorphic developmental patterns of ED, showing that boys with ADHD demonstrate improvement from childhood through adolescence, while levels of ED remained elevated for girls with ADHD. Our findings suggest that girls with ADHD may be at greater risk for developing psychiatric, social, and functional problems later in life due to the developmental pattern of ED and signify a developmental window to deploy interventions and treatment to mitigate negative outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Funding

This research was supported by the National Institutes of Health (SM: R01MH078160 and R01MH085328; KR: K23MH101322 and R03MH119457; KES: K23MH107734 and the Brain and Behavior Foundation NARSAD Young Investigator’s Award awarded to Dr. Seymour).

References

1. Shaw P, Stringaris A, Nigg J, Leibenluft E (2014) Emotion dysregulation in attention deficit hyperactivity disorder. Am J Psychiatry 171(3):276–293. 10.1176/appi.ajp.2013.13070966 [PubMed: 24480998]
2. August GJ, Realmuto GM, MacDonald AW, Nugent SM, Crosby R (1996) Prevalence of ADHD and comorbid disorders among elementary school children screened for disruptive behavior. J Abnorm Child Psychol 24(5):571–595. 10.1007/BF01670101 [PubMed: 8956085]
3. Thompson RA (1994) Emotion regulation: a theme in search of definition. Monogr Soc Res Child Dev 59(2–3):25–52 [PubMed: 7984164]
4. Sobanski E et al. (2010) Emotional lability in children and adolescents with attention deficit/hyperactivity disorder (ADHD): clinical correlates and familial prevalence. J Child Psychol Psychiatry 51(8):915–923. 10.1111/j.1469-7610.2010.02217.x [PubMed: 20132417]

5. Biederman J, Spencer TJ, Petty C (2012) Longitudinal course of deficient emotional self-regulation CBCL profile in youth with ADHD: prospective controlled study. Neuropsychiatr Treat 8:267–276. 10.2147/NDT.S29670
6. Eyre O, Riglin L, Leibenluft E, Stringaris A, Collishaw S, Thapar A (2019) Irritability in ADHD: association with later depression symptoms. Eur Child Adolesc Psychiatry 28(10):1375–1384. 10.1007/s00787-019-01303-x [PubMed: 30834985]
7. Galera C et al. (2020) Developmental profiles of childhood attention-deficit/hyperactivity disorder and irritability: association with adolescent mental health, functional impairment, and suicidal outcomes. J Child Psychol Psychiatry 62(2):232–243. 10.1111/jcpp.l3270 [PubMed: 32474921]
8. Graziano PA, Garcia A (2016) Attention-deficit hyperactivity disorder and children's emotion dysregulation: a meta-analysis. Clin Psychol Rev 46:106–123. 10.1016/j.cpr.2016.04.00l [PubMed: 27180913]
9. Bunford N, Evans SW, Langberg JM (2018) Emotion dysregulation is associated with social impairment among young adolescents with ADHD. J Atten Disord 22(1):66–82. 10.1177/1087054714527793 [PubMed: 24681899]
10. Sjowall D, Roth L, Lindqvist S, Thorell LB (2013) Multiple deficits in ADHD: executive dysfunction, delay aversion, reaction time variability, and emotional deficits. J Child Psychol Psychiatry 54(6):619–627. 10.1111/jcpp.12006 [PubMed: 23061803]
11. Anastopoulos AD, Smith TF, Garrett ME (2011) Self-regulation of emotion, functional impairment, and comorbidity among childrenwith AD/HD. J Atten Disord 15(7):583–592. 10.1177/1087054710370567 [PubMed: 20686097]
12. Gillberg C, Gillberg IC, Rasmussen P (2004) Co–existing disorders in ADHD –implications for diagnosisand intervention. Eur Child Adolesc Psychiatry. 10.1007/s00787-004-1008-4
13. Jensen CM, Steinhausen H-C (2015) Comorbid mental disorders in children and adolescents with attention-deficit/hyperactivity disorder in a large nationwide study. ADHD Atten Deficit Hyperact Disord 7(1):27–38. 10.1007/s12402-014-0142-1
14. Jensen PS, Hinshaw SP, Kraemer HC (2001) ADHD comorbidity findings from the MTA study: comparing comorbid subgroups. J Am Acad Child Adolesc Psychiatry 40(2):147–158. 10.1097/00004583-200102000-00009 [PubMed: 11211363]
15. Spencer TJ, Biederman J, Mick E (2007) Attention-deficit/hyperactivity disorder: diagnosis, lifespan, comorbidities, and neurobiology. J Pediatr Psychol 32(6):631–642. 10.1093/jpepsy/jsm005 [PubMed: 17556405]
16. Mick E, Spencer T, Wozniak J, Biederman J (2005) Heterogeneity of irritability in attention-deficit/hyperactivity disorder subjects with and without mood disorders. Biol Psychiatry 58(7):576–582. 10.1016/j.biopsych.2005.05.037 [PubMed: 16084859]
17. Rosen PJ, Walerius DM, Fogleman ND, Factor PI (2015) The association of emotional lability and emotional and behavioral difficulties among children with and without ADHD. ADHD Atten Deficit Hyperact Disord 7(4):281–294. 10.1007/S12402-015-0175-0
18. Seymour KE, Chronis-Tuscano A, Halldorsdottir T, Stupica B, Owens K, Sacks T (2012) Emotion regulation mediates the relationship between ADHD and depressive symptoms in youth. J Abnorm Child Psychol 40(4):595–606. 10.1007/S10802-011-9593-4 [PubMed: 22113705]
19. Hinshaw SP (2003) Impulsivity, emotion regulation, and developmental psychopathology: specificity versus generality of linkages. Ann N Acad Sci 1008(1):149–159. 10.1196/annals.1301.016
20. Spencer TJ, Faraone SV, Surman CB (2011) Toward defining deficient emotional self-regulation in children with attention-deficit/hyperactivity disorder using the child behavior checklist: a controlled study. Postgrad Med 123(5):50–59 [PubMed: 21904086]
21. J WM, C CL (2000) Social Functioning and emotional regulation in the attention deficit hyperactivity disorder subtypes. J Clin Child Psychol 29(1):30–42. 10.1207/S15374424jccp2901_4 [PubMed: 10693030]
22. Riley AW et al. (2006) Factors related to health-related quality of life (HRQoL) among children with ADHD in Europe at entry into treatment. Eur Child Adolesc Psychiatry 15(S1):i38–i45. 10.1007/s00787-006-1006-9 [PubMed: 17177014]

23. Gisbert L, Richarte V, Corrales M (2018) The impact of emotional lability symptoms during childhood in adults with ADHD. J Atten Disord 22(6):581–590. 10.l177/1087054717719534 [PubMed: 28760090]
24. Tallberg P, Svanberg K, Hallin A-L, Rastam M, Gustafsson P, Perrin S (2022) The three-year outcome of emotional symptoms in clinically referred youth with ADHD and their relationship to neuropsychological functions. Scand J Child Adolesc Psychiatry Psychol 10(1):72–86. 10.2478/sjcapp-2022-0008
25. Quach JL, Nguyen CD, Williams KE, Sciberras E (2018) Bidirectional associations between child sleep problems and internalizing and externalizing difficulties from preschool to early adolescence. JAMA Pediatr. 172(2):e174363. 10.1001/jamapediatrics.2017.4363 [PubMed: 29204659]
26. Stern A, Agnew-Blais JC, Danese A (2020) Associations between ADHD and emotional problems from childhood to young adulthood: a longitudinal genetically sensitive study. J Child Psychol Psychiatry, 10.1111/jcpp.13217
27. Biederman J et al. (2010) Adult psychiatric outcomes of girls with attention deficit hyperactivity disorder: 11-year follow-up in a longitudinal case-control study. Am J Psychiatry 167(4):409–417. 10.1176/appi.ajp.2009.09050736 [PubMed: 20080984]
28. Lahey BB, Lee SS, Sibley MH, Applegate B, Molina BSG, Pelham WE (2016) Predictors of adolescent outcomes among 4–6 year old children with attention-deficit/hyperactivity disorder. J Abnorm Psychol 125(2):168–181. 10.1037/abn0000086 [PubMed: 26854503]
29. Karalunas SL, Gustafsson HC, Fair D, Musser ED, Nigg JT (2019) Do we need an irritable subtype of ADHD? Replication and extension of a promising temperament profile approach to ADHD subtyping. Psychol Assess 31(2):236–247. 10.1037/pas0000664 [PubMed: 30359050]
30. Riglin L et al. (2017) Investigating the genetic underpinnings of early-life irritability. Transl Psychiatry 7(9):e1241. 10.1038/tp.2017.212 [PubMed: 28949337]
31. Heidari S, Babor TF, De Castro P, Tort S, Curno M (2016) Sex and gender equity in research: rationale for the SAGER guidelines and recommended use. Res Integr Peer Rev 1(1):2. 10.1186/S41073-016-0007-6 [PubMed: 29451543]
32. Conners CK (2008) Conners third edition (Conners 3). Los Angel. CA West. Psychol. Serv.
33. Stringaris A et al. (2012) The affective reactivity index: a concise irritability scale for clinical and research settings. J Child Psychol Psychiatry 53(11):1109–1117 [PubMed: 22574736]
34. DeSousa DA, Stringaris A, Leibenluft E, Koller SH, Manfro GG, Salum GA (2013) Cross-cultural adaptation and preliminary psychometric properties of the affective reactivity index in Brazilian youth: implications for DSM-5 measured irritability. Trends Psychiatry Psychother 35(3):171–180. 10.1590/S2237-60892013000300004 [PubMed: 25923389]
35. Mulraney MA, Melvin GA, Tonge BJ (2014) Psychometric properties of the affective reactivity index in Australian adults and adolescents. Psychol Assess 26(1):148–155. 10.1037/a0034891 [PubMed: 24188148]
36. Tseng W-L et al. (2017) Test-retest reliability and validity of a frustration paradigm and irritability measures. J Affect Disord 212:38–45. 10.1016/j.jad.2017.01.024 [PubMed: 28135689]
37. Kovacs M (1992) Children's depression inventory: manual. Multi-Health Systems North Tonawanda, NY
38. March JS, Parker JDA (2004) The multidimensional anxiety scale for children (MASC). The use of psychological testing for treatment planning and outcomes assessment: Instruments for children and adolescents. Lawrence Erlbaum Associates Publishers, pp 39–62
39. March JS, Parker JD, Sullivan K, Stallings P, Conners CK (1997) The multidimensional anxiety scale for children (MASC): factor structure, reliability, and validity. J Am Acad Child Adolesc Psychiatry 36(4):554–565. 10.1097/00004583-199704000-00019 [PubMed: 9100431]
40. Thor Olason D, Blondahl Sighvatsson M, Smari J (2004) Psychometric properties of the multidimensional anxiety scale for children (MASC) among icelandic schoolchildren. Scand J Psychol. 45(5):429–436. 10.1111/j.1467-9450.2004.00424.x [PubMed: 15535811]
41. Baldwin JS, Dadds MR (2007) Reliability and validity of parent and child versions of the multidimensional anxiety scale for children in community samples. J Am Acad Child Adolesc Psychiatry 46(2):252–260. 10.1097/01.chi.0000246065.93200.al [PubMed: 17242629]

42. Ibrahim JG, Molenberghs G (2009) Missing data methods in longitudinal studies: a review. TEST 18(1):1–43. 10.1007/sl1749-009-0138-x [PubMed: 21218187]
43. Bates D, Mächler M, Bolker B, Walker S (2015) Fitting linear mixed-effects models using lme4". J Stat Softw. 10.18637/jss.v067.i01
44. Brysbaert M, Stevens M (2018) Power analysis and effect size in mixed effects models: a tutorial. J Cogn. 1(1):9. 10.5334/joc.l0 [PubMed: 31517183]
45. Owens EB, Hinshaw SP, Lee SS, Lahey BB (2009) Few girls with childhood attention-deficit/hyperactivity disorder show positive adjustment during adolescence. J Clin Child Adolesc Psychol 38(1):132–143. 10.1080/15374410802575313 [PubMed: 19130363]
46. Hinshaw SP, Owens EB, Zalecki C (2012) Prospective follow-up of girls with attention-deficit/hyperactivity disorder into early adulthood: continuing impairment includes elevated risk for suicide attempts and self-injury. J Consult Clin Psychol 80(6):1041–1051. 10.1037/a0029451 [PubMed: 22889337]
47. Dirlikov B, Rosch KS, Crocetti D, Denckla MB, Mahone EM, Mostofsky SH (2015) Distinct frontal lobe morphology in girls and boys with ADHD. Neuroimage Clin 7:222–229 [PubMed: 25610784]
48. Etkin A, Egner T, Kalisch R (2011) Emotional processing in anterior cingulate and medial prefrontal cortex. Trends Cogn Sci 15(2):85–93 [PubMed: 21167765]
49. Jacobson LA, Peterson DJ, Rosch KS, Crocetti D, Mori S, Mostofsky SH (2015) Sex-based dissociation of white matter microstructure in children with attention-deficit/hyperactivity disorder. J Am Acad Child Adolesc Psychiatry 54(11):938–946 [PubMed: 26506584]
50. Hong S-B et al. (2014) Subthreshold attention-deficit/hyperactivity disorder is associated with functional impairments across domains: a comprehensive analysis in a large-scale community study. Eur Child Adolesc Psychiatry 23(8):627–636. 10.1007/s00787-013-0501-z [PubMed: 24318039]
51. Ohan JL, Johnston C (2005) Gender appropriateness of symptom criteria for attention-deficit/hyperactivity disorder, oppositional-defiant disorder, and conduct disorder. Child Psychiatry Hum Dev 35(4):359–381. 10.1007/sl0578-005-2694-y [PubMed: 15886870]
52. Quinn PO (2008) Attention-deficit/hyperactivity disorder and its comorbidities in women and girls: an evolving picture. Curr Psychiatry Rep 10(5):419–423. 10.1007/si1920-008-0067-5 [PubMed: 18803916]
53. Chung W et al. (2019) Trends in the prevalence and incidence of attention-deficit/hyperactivity disorder among adults and children of different racial and ethnic groups. JAMA Netw Open 2(11):e1914344–e1914344. 10.1001/jamanetworkopen.2019.14344 [PubMed: 31675080]
54. Bölte S, Neufeld J, Marschik PB, Williams ZJ, Gallagher L, Lai M-C (2023) Sex and gender in neurodevelopmental conditions. Nat Rev Neurol, 10.1038/s41582-023-00774-6
55. Assari S (2021) Emotional, behavioral, and cognitive correlates of attention deficit and hyperactive disorder (ADHD) screening and diagnosis history: sex/gender differences. J Neurol Neuromed 6(1):1–12. 10.29245/2572.942X/2021/L1278
56. Gordon CT, Hinshaw SP (2019) "Executive functions in girls with and without childhood ADHD followed through emerging adulthood: developmental trajectories. J Clin Child Adolesc Psychol. 10.1080/15374416.2019.1602840
57. Zelazo PD and Cunningham WA (2007) "Executive function: mechanisms underlying emotion regulation," Publ. Online
58. Barkley RA, Fischer M (2010) The unique contribution of emotional impulsiveness to impairment in major life activities in hyperactive children as adults. J Am Acad Child Adolesc Psychiatry 49(5):503–513. 10.1097/00004583-201005000-00011 [PubMed: 20431470]

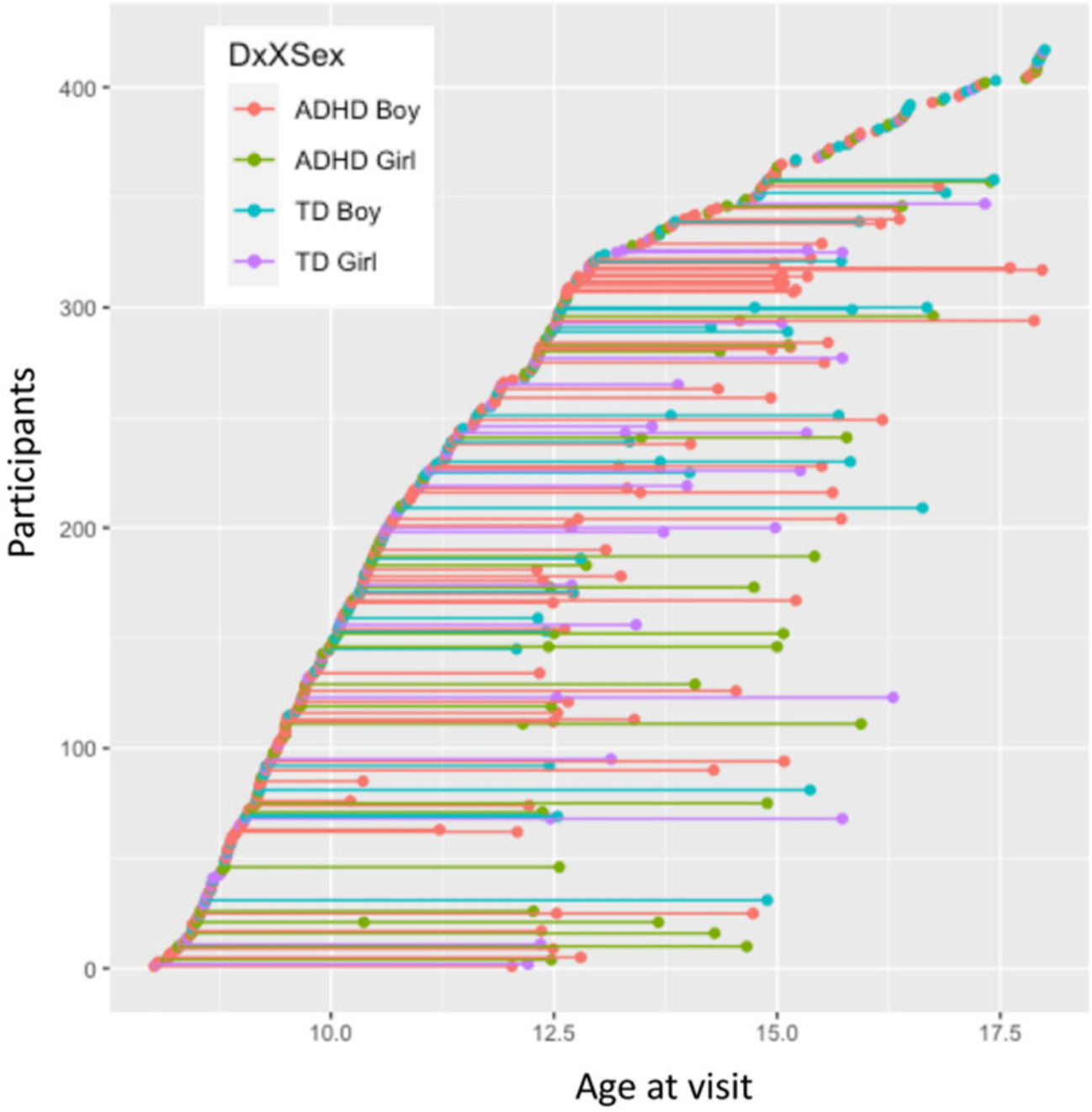

Fig. 1.
Sample distribution for age at visit for ADHD and TD girls and boys. Individual dots indicate a single visit with multiple visits within a participant connected by a line

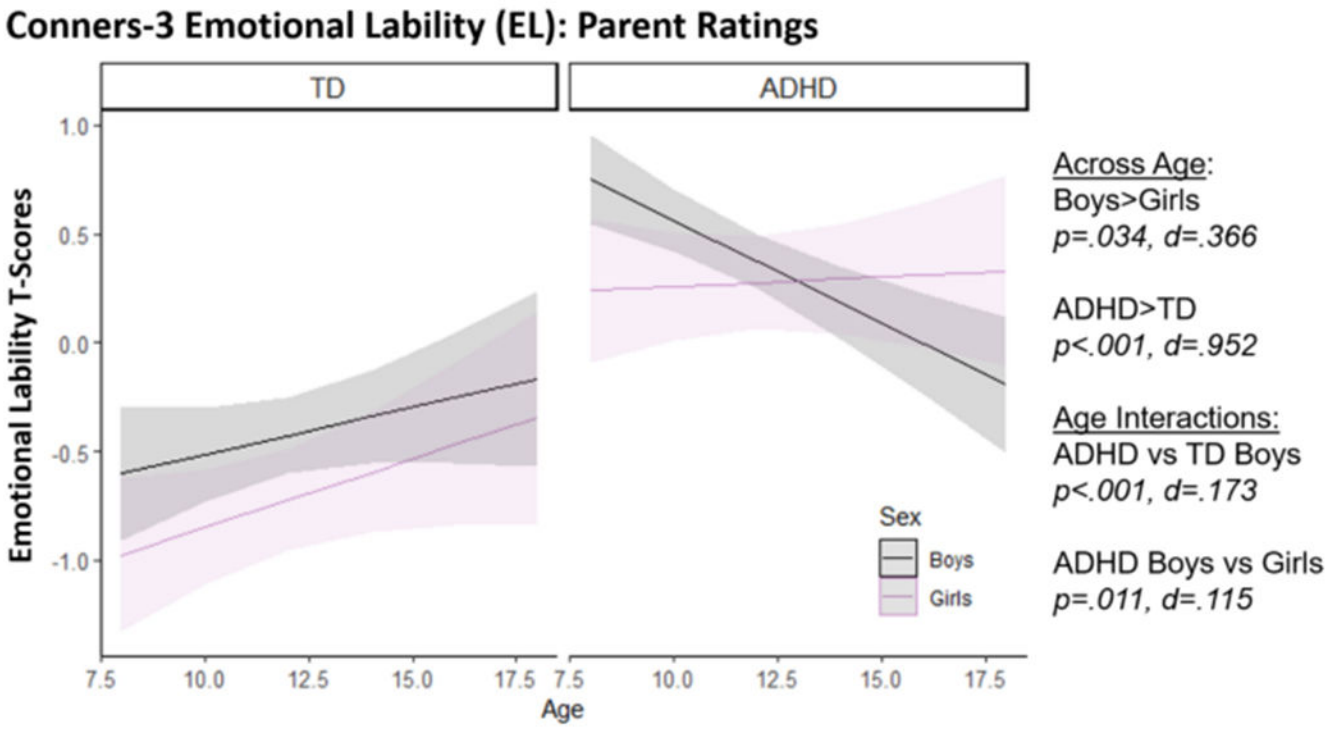

Fig. 2.

Conners-3 Emotional Lability Parent Rating T-Scores. Estimated marginal means from linear mixed effects models

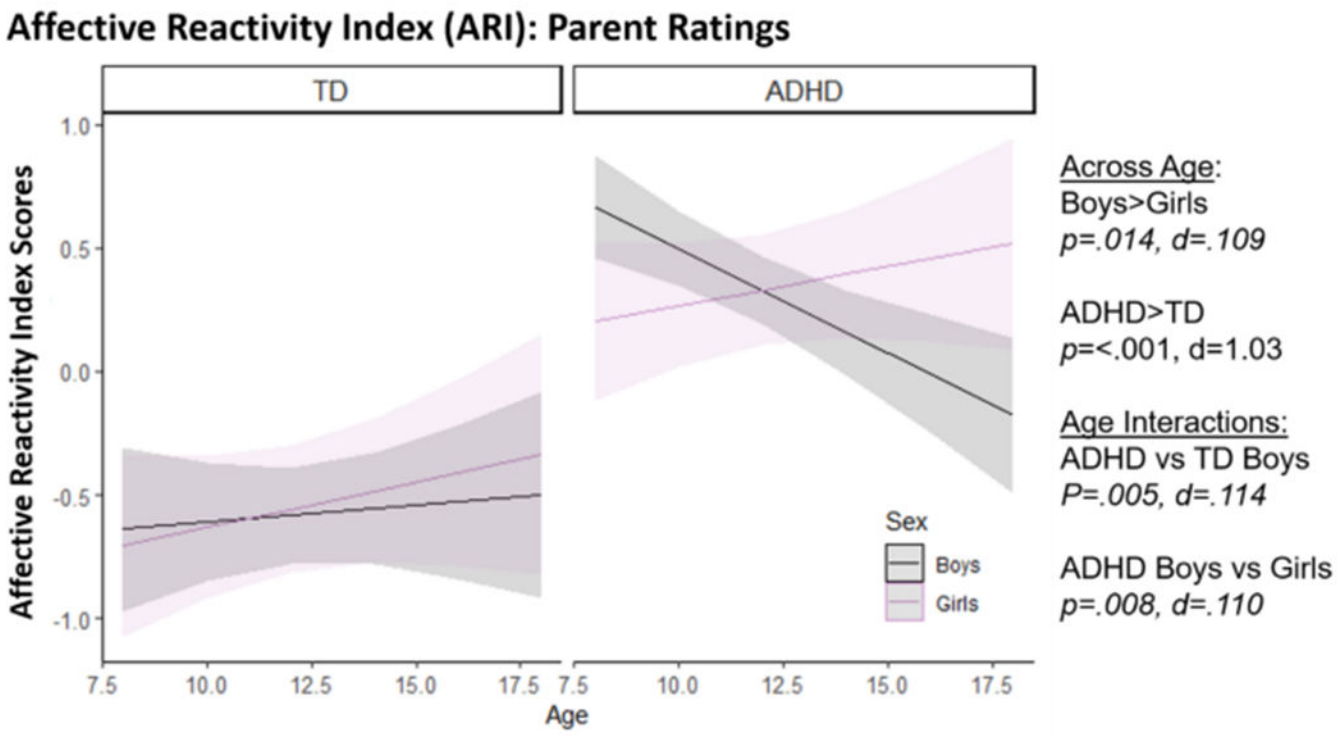

Fig. 3.

Affective Reactivity Index Parent Ratings. Estimated marginal means from linear mixed effects models

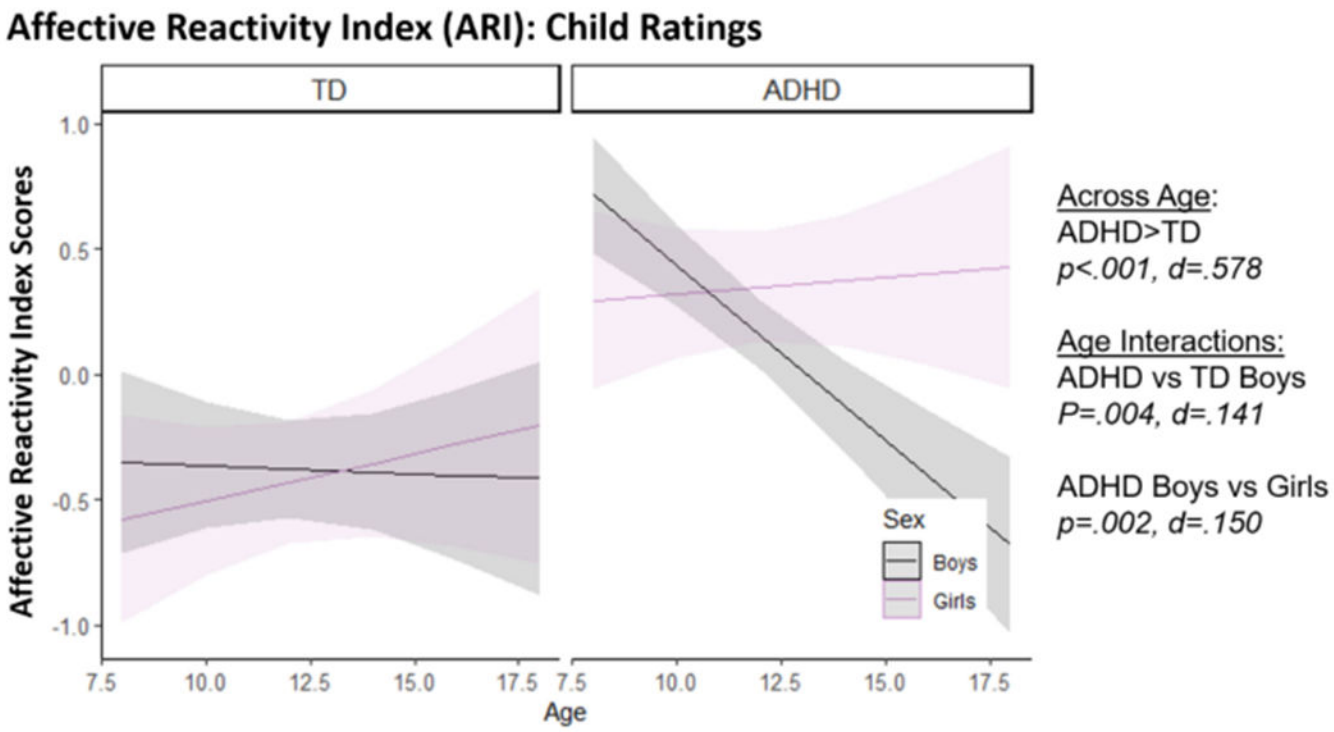

Fig. 4.

Affective Reactivity Index Child Ratings. Estimated marginal means from linear mixed effects models

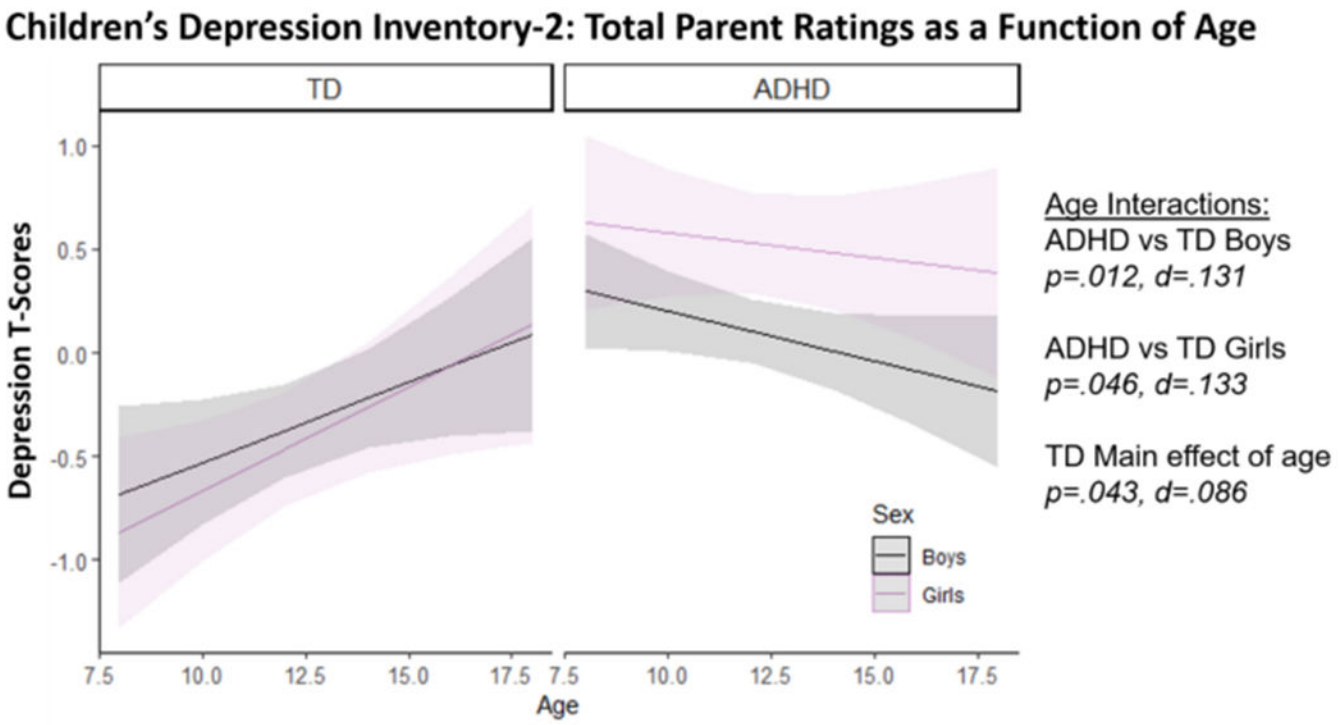

Fig. 5.

Children's Depression Inventory T-Scores across Age, Sex, and Diagnosis. Estimated marginal means from linear mixed effects models

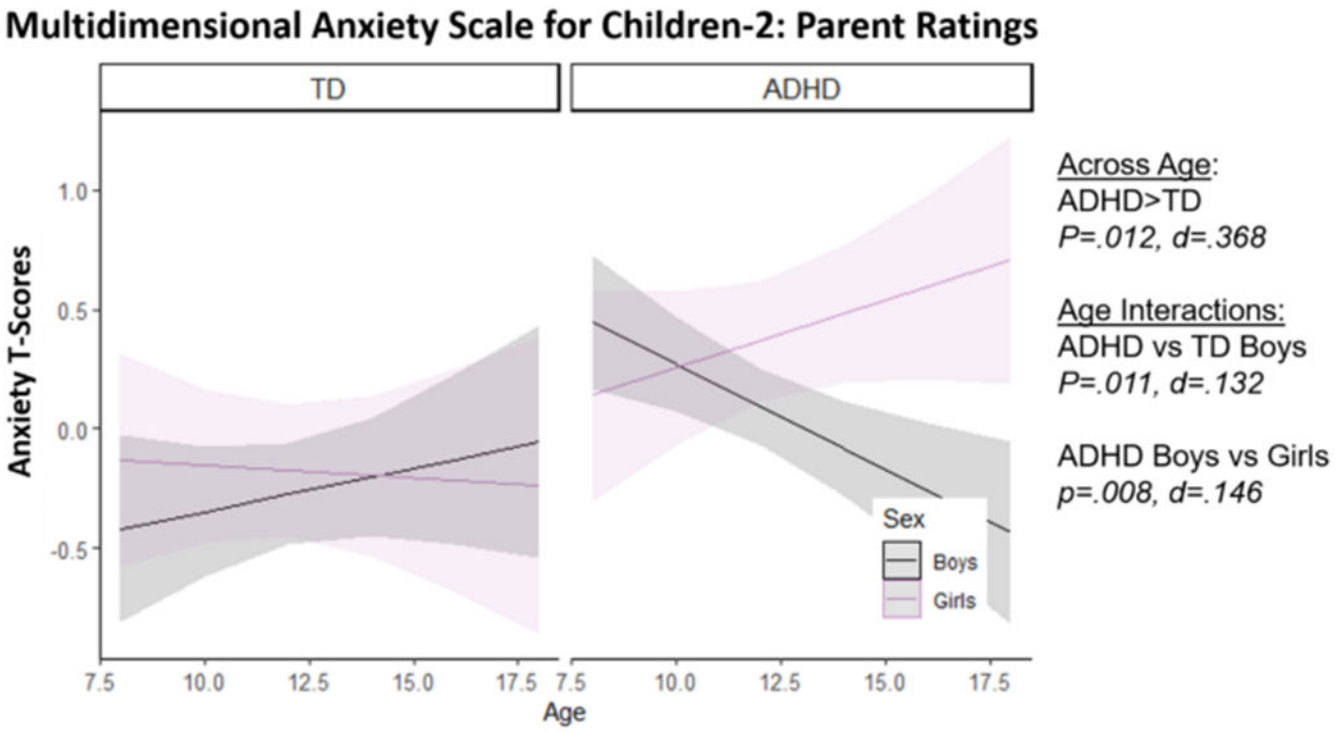

Fig. 6.

Multidimensional Anxiety Scale for Children–2 Parent Ratings T-Scores. Estimated marginal means from linear mixed effects models

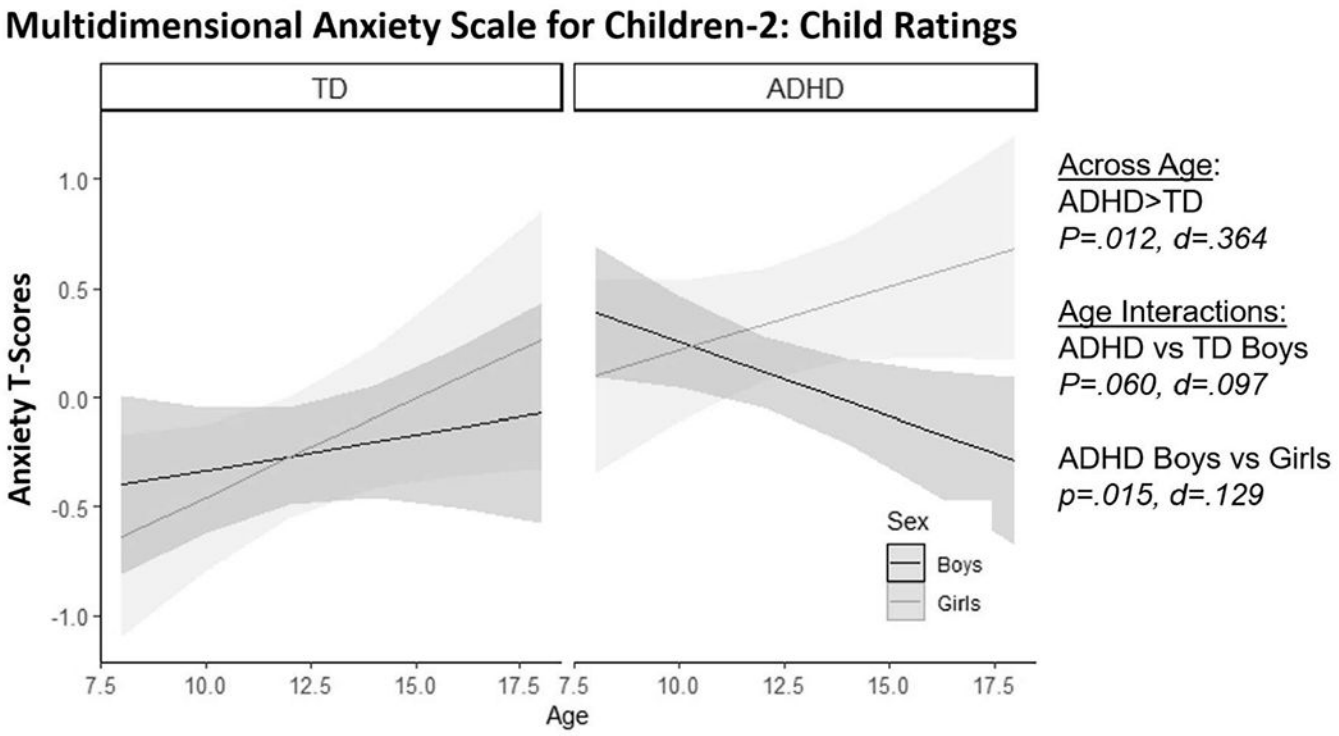

Fig. 7.

Multidimensional Anxiety Scale for Children-2 Child Ratings T-Scores. Estimated marginal means from linear mixed effects models

Table 1

Participant demographic and clinical information

	TD (n = 153)		ADHD (n = 264)		Group Comparisons (*p*-value)			
	Boys (n = 97)	Girls (n = 56)	Boys (n = 188)	Girls (n = 76)	ADHD vs. TD All	ADHD vs. TD Boys	ADHD vs. TD Girls	ADHD Boys v. Girls
Age	12.0 (2.6)	11.2 (2.8)	11.3 (2.4)	11.8 (2.9)	0.352	0.030 *	0.222	0.220
Race, n (%) White	64 (66%)	36 (64%)	127 (68%)	52 (68%)	0.674	0.880	0.618	0.891
SES	55.3 (9.6)	56.2 (9.9)	52.5 (9.8)	52.6 (8.7)	0.002 *	0.025 *	0.042 *	0.899
GAI	116 (12.5)	115 (10.8)	109 (12.5)	106 (14.6)	< 0.001 *	< 0.001 *	< 0.001 *	0.182
Conners IA T-score	46.3 (8.4)	48.0 (8.5)	74.8(10.5)	78.1 (14.6)	< 0.001 *	< 0.001 *	< 0.001 *	0.035 *
Conners HI T-score	47.2 (8.3)	46.3 (6.6)	74.4 (14.2)	73.2 (14.5)	< 0.001 *	< 0.001 *	< 0.001 *	0.537
ODD, n (%)	0	0	49	14	–	–	–	0.187
Anxiety Disorder, n (%)	0	1 (1%)	56 (30%)	34 (45%)	–	–	–	0.020 *
Depressive Disorder, n (%)	0	0	11 (6%)	7 (9%)	–	–	–	0.327
Stimulant medication, n (%)	0	0	110 (59%)	31 (41%)	–	–	–	0.009 *

Results are presented as Mean (SD) unless otherwise noted

SES Holllingshead Socioeconomic Status; *GAI* Wechsler Intelligence Scale for Children General Ability Index; *IA* Inattention; *HI* Hyperactivity/Impulsivity

* $p < .05$