Research Square

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The Temporal Effects of ADHD symptoms on Physical, Psychological and Socioemotional Wellbeing and the Moderating Role of Sleep Problems in Children from an East London cohort study

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Abstract

Background

Children with ADHD often experience poorer physical, psychological, and socioemotional wellbeing, and co-occurring sleep problems may further exacerbate these difficulties; however, little is known about whether sleep problems influence the longitudinal relationship between ADHD symptoms and wellbeing.

Objectives

We aimed to investigate the temporal associations between ADHD symptoms and physical, psychological and socioemotional wellbeing and whether sleep problems amplify these temporal associations in primary school-aged children living in East London.

Methods

Data came from 879 children (7–12 years old) enrolled in the Development of Emotional Resilience study, of whom 711 were included in the present analyses. We used teacher-reported ADHD symptoms, self-reported data on physical, psychological and socioemotional wellbeing outcomes and sleep problems across two waves.

Results

Structural Equation Modelling analysis showed good stability of ADHD symptoms across waves (β = .72, p< .001). The latent factors capturing physical, psychological and socioemotional wellbeing also indicated temporal stability across waves (β = .54, p<.001). Sleep problems aggregated across waves were negatively associated with physical, psychological and socioemotional wellbeing at Wave 3 (β=−.26, p<.001). Earlier (Wave 2) ADHD symptoms were not significantly associated with later (Wave 3) physical, psychological and socioemotional wellbeing after controlling for earlier (Wave 2) physical, psychological and socioemotional wellbeing and sleep problems (β=−.043, p=.3). The interaction between earlier ADHD symptoms and sleep problems was not statistically significant (β = .02, p=.7).

Conclusion

ADHD symptoms and physical, psychological and socioemotional wellbeing outcomes showed good stability over time. Sleep problems were significantly associated with lower subsequent children's physical, psychological and socioemotional wellbeing but ADHD symptoms did not temporally predict later physical, psychological and socioemotional wellbeing after accounting for these variables at an earlier time-point. These findings highlight the important role of sleep problems in children's physical, psychological and socioemotional wellbeing outcomes.

1. Introduction

Attention-deficit/hyperactivity disorder (ADHD) affects 7.2–12% of children worldwide [1, 2], with more boys than girls diagnosed [3]. Recently, in the UK, rates of diagnosis have doubled for boys and quadrupled for girls [3]. Child-onset ADHD can persist into adulthood where it impacts wellbeing [4, 5]. However, symptoms of inattention and hyperactivity/impulsivity in childhood can negatively impact concurrent wellbeing [5–9]. Children with ADHD frequently experience other mental health challenges such as substance use, antisocial behaviour and suicidal thoughts [6, 10–12]. They also have worse health outcomes such as obesity and hypertension [12] and neurocognitive deficits, which may affect educational and occupational attainment [6, 7, 13]. There are reports of greater social difficulties including peer rejection, exclusion, and bullying, which may be underpinned by poor social cognition and emotion recognition [14]. Children with ADHD report lower self-esteem and self-worth as compared to those without an ADHD diagnosis [6, 8, 10]. Taken together, children with ADHD tend to struggle more than their peers with physical health problems and psychosocial wellbeing [15]. Interventions to help manage the impact of ADHD on some areas of functioning and wellbeing are much needed.

Within the repertoire of available interventions, sleep problems have emerged as a promising target, and there is robust evidence that addressing sleep problems can lead to improvements in ADHD symptom severity [16–18]. Recent transdiagnostic theories propose sleep and circadian problems as a feature across and risk factor for many psychiatric disorders [19–21], leading interventions for sleep and circadian dysfunction being used to address mental illnesses [22]. Consistent with this, up to 70% of those with ADHD report sleep disturbances [5, 22–24], a finding that also extends to children with ADHD [8, 26–29]. Individuals with ADHD (children and adults) experience more circadian phase delay, evening chronotype, reduced sleep quality, and hypersomnolence than their peers [22, 24]. There is also evidence that sleep problems precede and follow ADHD symptoms [30–32]. In ADHD, the presence of sleep disturbances may worsen symptoms [19]. Even in typically developing children, atypical sleep length and poor sleep quality are associated with more inattention and challenging daytime behaviours as well as neurocognitive problems [33, 34]. Co-occurring sleep disturbances in ADHD children can exacerbate hyperactivity, distractibility, and restlessness [26, 34–37].

Sleep problems may also worsen the impact of ADHD symptoms on health, educational and socioemotional wellbeing [27, 29, 38, 39], and overall wellbeing [5, 19, 40]. Sleep problems affect these children's family life such as relationships and communication, and their school life by worsening their attention control [41–43]. These impacts of sleep on symptoms and functioning may be explained through dopamine pathways. Sleep disturbances may impair dopamine signaling by reducing the availability of D2/D3 receptors in the brain's reward system, particularly in the ventral striatum, which can exacerbate

core ADHD symptoms such as inattention and impulsivity, especially when sleep deprivation is prolonged [44]. Thus, improving sleep can both reduce symptoms and mitigate their impact on daily functioning, advocating for the routine use of sleep interventions [45] such as sleep hygiene and behavioral interventions which have been adapted for use in children with ADHD [17, 46–48]. Yet within this literature, while there are some longitudinal studies exploring the long-term effects of sleep problems on ADHD symptoms [25, 49], fewer have investigated the long-term effects of sleep dysfunction on ADHD-linked functional outcomes.

To address this gap, here, we aimed to examine the temporal links between ADHD symptoms and physical, psychological and socioemotional wellbeing and whether sleep problems amplified these relationships over time. We focused on primary school children growing up in east London, a geographic area that spans neighbourhoods with high levels of child poverty, and where children and families face additional stressors likely to impact both sleep and ADHD outcomes [50]. Targeting this population is important as sleep deprivation, ADHD diagnoses, and related prescriptions have been shown to increase in socioeconomically deprived areas [3, 51–53] and their impact on wellbeing across a number of domains can add to continued health and social inequalities. We hypothesised that ADHD symptoms would be associated with later physical, psychological and socioemotional wellbeing, and that sleep problems would moderate these associations. Specifically, we expected sleep problems to worsen their impact on physical, psychological and socioemotional wellbeing.

2. Methods

2.1. Sample

Participants were from the Development of Emotional Resilience (DEER) observational cohort [54]. This a longitudinal study investigating the nature, development and measurement of resilience in primary school-aged children in East London schools. Ethical approval for the study was obtained from the Queen Mary Research Ethics Committee (ref: QMERC22.251). Children from ten primary schools across East London were recruited using a combination of opt-in and opt-out consent procedures. Where parental consent and child assent were required before participation, only 6.9% of eligible children returned consent forms. To increase representativeness, the ethics committee approved an opt-out process: in these schools, parents were asked to return a form or contact the school/research team if they did not want their child to participate, and no data were collected from opted-out children. Of the approximately 1,200 children targeted for recruitment, 876 children participated in the study. Children with a diagnosis of Intellectual Disability Disorder or those perceived not to understand the assessments were excluded.

The DEER study comprised three waves of data collection. Wave 1 (W1) data collection occurred between Nov 2022 and Nov 2023; Wave 2 (W2) between Feb 2024 to Oct 2024; Wave 3 (W3) in July 2025. This study uses W2, and W3 data. At each Wave children completed an assessment battery comprising questionnaires and experimental tasks, all of which were administered on survey platforms such as Qualtrics [55] and REDCap [56, 57] using Android tablets in group testing conditions. Research assistants were present to guide children through the data collection. Teachers also completed questionnaires on behavioural and emotional symptoms for each participating child in their class. Of the 879 children who participated across waves, 711 were included in the present analyses. Missing data were handled using full information maximum likelihood (FIML), allowing inclusion of participants with partial data across waves. The analytic sample was similar to the full baseline sample in age, ethnicity, eligibility for free school meals, teacher-reported ADHD symptoms, sleep problems, and physical, psychological and socioemotional wellbeing measures.

At baseline (W1), 879 primary school children participated in the DEER study. Of these, 425 (48.4%) were coded as male and 425 (48.4%) as female. The age range at W1 was 7–11 years (M = 8.76, S = 0.94). Age data were available for 837 participants (95.2% of the sample). In terms of ethnicity, the majority of participants identified as Asian/Asian British (61.6%), followed by White (18.0%), Black/African/Caribbean/Black British (8.9%), Mixed/Multiple ethnic groups (6.7%), and Other ethnic group (4.8%). Socioeconomic status was indexed using the Index of Multiple Deprivation (IMD) score. The mean of IMD score was 28.38 (SD = 8.39), with scores ranging from 2.06 to 49. 67. Approximately one year later, at Wave 2 (W2), 712 children (81.0% of the baseline sample) participated. The age range at W2 was 8–12 years (M = 9.91, SD = 0.89). After a further year, at Wave 3 (W3), 445 children (50.6% of the baseline sample) participated. The age range at W3 was 9–11 years (M = 10.18, SD = 0.71). Children who participated at W1 but not at subsequent waves had either withdrawn from the study or transitioned to secondary school, after which it was no longer possible to conduct follow-up assessments. The age difference between waves was significant $F(2, 737) = 201.70$, $p < .001$, $\eta^2 = .35$, indicating that children retained to later waves were significantly younger at baseline as expected. There were also significant differences in the proportions of males to females and in ethnic groups across waves but these effects were small: $\chi^2(2) = 8.80$, $p = .012$, Cramér's V = .11 and $\chi^2(8) = 16.14$, $p = .040$, Cramér's V = .10 respectively. Socioeconomic status, indexed here by IMD scores, did not change across waves: $F(2, 742) = 2.54$, $p = .080$, $\eta^2 = .007$.

2.2. Measures

2.2.1. Demographics characteristics (collected at W1): Children reported on sex and age, while ethnicity and free school meal eligibility (an index of socioeconomic status) were provided through school records.

2.2.2. ADHD symptoms (collected at W2, W3): Teachers completed the 25-item Strengths and Difficulties Questionnaire (SDQ) [58] to measure behavioural, emotional and social difficulties. Each item is rated as "not true", "somewhat true" or "certainly true" and scored as 0, 1 or 2 respectively [58]. While these 25 items fall into 5 sub-scales, only the hyperactivity/inattention subscale which includes five items was reported here. Cronbach's alpha of the hyperactivity/inattention subscale at W2 was $\alpha = 0.869$ and at W3, $\alpha = 0.874$. SDQ has been used to screen ADHD symptoms in daily life in 5–15-year-olds [59]. In a large British validation study (on children 5–15 years old) hyperactivity/inattention SDQ scores correlated with clinical diagnoses of ADHD suggesting good validity [60]. The instrument (both parent and teacher reports) showed good sensitivity and specificity (both over 75%) with some studies reporting greater sensitivity for teacher-reported than parent reported data [59].

2.2.3. Sleep problems (collected at W2, W3): Children completed The Sleep Self-report (SSR) [61], which assesses different types of common sleep and circadian problems experienced by children across 23 items with an additional 3 questions, related to bedtime behaviour, parental rule-setting, or attitudes toward sleep routines. The scale measures bedtime routines, sleep behaviour, and daytime sleepiness on a 3-point Likert scale: 'rarely' (0–1)/week or never), 'sometimes' (2–4 times/week) or 'usually' (5–7 times)/week). Example questions include: 'Is it hard for you to go to bed?', 'Do you have nightmares?', 'Do you feel sleepy during the day?'. Higher scores indicate more sleep disturbances. The Cronbach's alpha for the SSR in the present sample at W2 was α = .798 and at W3 was α = .82. SSR has been shown to correlate with the Children's Sleep problems Questionnaire (CSHQ), a parent-report sleep measure widely used in research [62, 63]. SSR is considered to also have good discriminant validity, effectively differentiating between a control group and children with a clinical diagnosis (e.g., sleep disorders) and other psychopathological symptoms [61, 62, 64, 65]. We used a composite score summed across endorsement of a range of sleep and circadian difficulties to more comprehensively capture the diverse spectrum of sleep difficulties which can emerge in this age range [66]. For our longitudinal analyses, a mean sleep problems score was calculated by averaging standardized sleep scores across W2 and W3 to capture persistent sleep problems over time. Of note, we also conducted analysis including W2 and W3 sleep separately. However, due to the high correlation between sleep at W2 and W3 (r = 0.90), including both separately produced unstable estimates on the Structural Equation Models, with coefficients in opposite directions.

2.2.4 Physical, psychological and socioemotional wellbeing (collected at W2, W3): Physical, psychological, and socioemotional areas of wellbeing were assessed using the KIDSCREEN-52 [67], a self-reported questionnaire containing items that pertain to ten dimensions. KIDSCREEN-52 is derived from the Health-related quality of life (HRQOL) measure, a health outcome measure used in paediatric research. In our study, we focussed on 9 out of the 10 dimensions: physical wellbeing (levels of physical activity, energy and fitness), psychological wellbeing (positive emotions and satisfaction with life), moods and emotions (low/depressive moods, emotional and stressful feelings), self-perception (perceived bodily appearance and body image), autonomy (opportunities to create social and leisure time), parent relations and home life (relationships with parents and home atmosphere), social support and peers (relationships with other children), school environment (perceptions of cognitive capacities, learning and concentration, and feelings about school), and bullying (feeling rejected by peers in school). The financial resources subscale was less relevant for our study, and therefore not included in the analysis. KIDSCREEN-52 showed moderate (r = 0.31–0.5) to high (r > 0.5) correlations with similar instruments, suggesting good convergent validity for assessing broad adjustment outcomes in children [68]. For our 9 subscales internal consistency, as indicated by Cronbach's alpha were α = .79 at W2 and α = .79 at W3 for physical wellbeing, α = .88 at W2 and α = .90 at W3 for psychological wellbeing, α = .87 at W2 and α = .835 at W3 for moods and emotions, α = .76 at W2 and α = .77 at W3 for self-perception, α = .81 at W2 and α = .835 at W3 for autonomy, α = .89 at W2 and α = .90 at W3 for parent relations and home life, α = .88at W2 and α = .87 at W3 for social support and peers, α = .89 at W2 and α = .89 at W3 for school environment and α = .79 at W2 and α = .83 at W3 for bullying. At each wave, a latent variable capturing common variance across subscales was used in our longitudinal analyses.

2.3. Data Analysis

The analysis was preregistered (https://osf.io/m9eaq). First, we explored sex, age, IMD score representing socioeconomic status, and ethnicity differences on ADHD symptoms, sleep difficulties and KIDSCREEN subscales to determine if these variables should be added as covariates in longitudinal analysis. Only covariates consistently associated with children's physical, psychological, and socioemotional wellbeing outcomes at W3 were included in the longitudinal SEM models. Next, correlations were calculated between key variables: ADHD symptoms at W2 and W3, sleep problems at W2 and W3, and physical, psychological and socioemotional wellbeing variables at W2 and W3 (Table 2).

Table 2
Correlations between key variables

1 Hyperactivity/Inattention (W2)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
2 Hyperactivity/Inattention (W3)	.71***												
3 Sleep Problems (W2)	.14***	.15**											
4 Sleep Problems (W3)	.17***	.14**	.63***										
5 Physical (W2)	− .15***	− .12*	− .35***	− .34***									
6 Physical (W3)	− .14**	− .08	− .35***	− .46***	.49***								
7 Psychological (W2)	− .11**	-12*	− .37***	− .29***	.63***	.40***							
8 Psychological (W3)	− .12**	− .07	− .27***	− .43***	.38***	.69***	.43***						
9 Mood & emotions (W2)	− .11**	− .11*	− .43***	− .34***	.37***	.36***	.58***	.38***					
10 Mood & emotions (W3)	− .13**	− .14**	− .29***	− .45***	.33***	.46***	.32***	.52***	.38***				
11 Self-perception (W2)	− .13***	− .14**	− .39***	− .33***	.50***	.37***	.58***	36***	.55***	.33***			
12 Self-perception (W3)	− .06	− .04	− .28***	− .47***	.34***	.53***	.33***	.61***	.40***	.57***	.45***		
13 Autonomy (W2)	− .10**	− .13**	− .30***	− .31***	.51***	.41***	.62***	35***	43***	31***	.47***	.30***	
14 Autonomy (W3)	− .13**	− .05	− .31***	− .46***	.36***	57***	.36***	.61***	.34***	.53***	.32***	.49***	.41***
15 Parent relationship (W2)	− .17***	− .21***	− .35***	− .39***	.52***	.45***	.65***	.45***	.48***	.44***	.58***	.44***	.66***
16 Parent relationship (W3)	− .22***	− .11*	− .27***	− .48***	.39***	.52***	.41***	.65***	.35***	.52***	.32***	.60***	.42***
17 Social support (W2)	− .14***	− .16**	− .28***	− .28***	.50***	.37***	.58***	.37***	.38***	.30***	.47***	.27***	.60***
18 Social support (W3)	− .12**	− .08	− .21***	− .36***	.36***	.48***	.29***	.52***	.26***	.38***	24***	.42***	.32***
19 School environment (W2)	− .28***	− .28***	− .37***	− .37***	.50***	.36***	.59***	.39***	.40***	.32***	.48***	.39***	.53***
20 School environment (W3)	− .25**	− .21**	− .35***	− .49***	.26***	.56***	.37***	.60***	.28***	.46***	.34***	.51***	.37***
21 Bullying (W2)	− .09*	− .08	− .29***	− .23***	.23***	.19***	.27***	.20***	.47***	.21***	.46***	.23***	.26***
22 Bullying (W3)	− .17***	− .15**	− .22***	− .36***	.25***	.30***	.24***	.38***	.31***	.47***	.25***	.43***	.19***

Note: *p<.05, **p<.01, ***p<.001

Our hypotheses were explored using Structural Equation Modelling (SEM) [69] and included data from 711 participants across two waves. The model was estimated using robust maximum likelihood (MLR), with missing data handled using full information maximum likelihood (FIML). A latent variable capturing common variance across the 9 KIDSCREEN subscales was specified at both W2 and W3 to represent a physical, psychological and socioemotional wellbeing factor. We included autoregressive paths to model temporal stability in ADHD symptoms and children's wellbeing over time. ADHD symptoms at W2 were included as a predictor of children's wellbeing at W3. as well as mean sleep problems across waves. An interaction term between ADHD symptoms at W2 and mean sleep problems was created to test whether average sleep problems across time amplified the relationship between ADHD symptoms and subsequent children's physical, psychological and socioemotional wellbeing. Predictors were mean-centered prior to computing the interaction term.

Overall model fits were evaluated by considering the extent to which the model matches the observed data. We considered the Comparative Fit Index (CFI) which ranges from 0 to 1, with higher values considered a good fit [70], the Standardized Root Mean Square Residual (SRMR) which from a rule of thumb should be less than .05; and the Root Mean Square Error of Approximation (RMSEA) with values larger than .10 considered unacceptable [71].

3. Results

3.1. Sample characteristics and descriptive analysis

Descriptive statistics for all variables are presented in Table 1 along with sex and age differences across variables. Teachers reported boys as having higher hyperactivity/inattention symptoms than girls across all three waves (W2: d = 0.60; W3: d = 0.66, all p < .001). Regarding sleep problems, girls reported slightly higher levels than boys at Wave 2 (d = − 0.20, p = .006), whereas the sex difference at Wave 3 was not statistically significant (d = − 0.17, p = .058). At

Wave 3, boys reported higher physical wellbeing than girls (d = 0.27, p = .004). No significant sex differences were observed for other variables: psychological wellbeing, moods and emotions, social support, autonomy, parent relations, social acceptance, school environment, or bullying (all d ≤ 0.17, all p > .05).

Table 1
Descriptive Statistics of the sample

Variable*	N	Mean (SD)	Range	Male Mean (SD)	Female Mean (SD)	T(df)	Cohen's d	Correlation with age (p value, 95%CI)
ADHD symptoms W2	712	2.64 (2.73)	0–10	3.48 (3.00)	1.89 (2.31)	-7.84(625)***	0.60	-0.11*
ADHD symptoms W3	435	2.64 (2.73)	0–10	3.53 (2.94)	1.82 (2.24)	-6.76(384)***	0.66	-0.14 **
Sleep Problems W2	747	36.54 (6.94)	23–57	35.82 (6.73)	37.21 (7.11)	2.75 (745)**	-0.20	-0.22 ***
Sleep Problems W3	475	35.00 (7.00)	23–57	34–37 (6.90)	35.59 (7.05)	1.90 (473)	-0.17	-0.13 **
Physical wellbeing W2	715	19.19 (3.95)	6–25	19.57 (4.01)	18.83 (3.86)	-2.51 (707)*	0.19	0.08
Physical wellbeing W3	460	19.81 (3.86)	6–25	20.34 (3.79)	19.31 (3.87)	-2.90 (4.57)**	0.27	0.01
Psychological wellbeing W2	715	24.49 (4.79)	5–30	25.09 (4.40)	23.92 (5.08)	-3.30(707)**	0.25	0.18***
Psychological wellbeing W3	459	24.85 (5.05)	6–30	25.11 (4.80)	24.60 (5.27)	-1.09 (457)	0.10	0.02
Moods and emotions, positive W2	713	16.63 (3.23)	4–20	16.94 (3.11)	16.33 (3.31)	-2.53(711)*	0.19	0.10*
Moods and emotions, positive W3	458	16.75 (3.23)	4–20	16.91 (3.02)	16.59 (3.40)	-1.07 (4.55)	0.10	0.01
Self-perception W2	713	21.06 (4.04)	1–25	21.68 (3.57)	20.48 (4.34)	-4.01(695)***	0.30	0.06
Self-perception W3	458	21.19 (3.96)	3–25	21.54 (3.72)	20.87 (4.15)	-1.82 (4.55)	0.17	-0.04
Autonomy W2	711	18.75 (4.64)	3–25	18.97 (4.65)	18.54 (4.62)	-1.25 (707)	0.09	0.14**
Autonomy W3		19.28 (4.72)	5–25	19.30 (4.77)	19.26 (4.68)	-0.08 (451)	0.01	0.13**
Parent relations and home life W2	709	25.43 (5.00)	5–30	25.60 (4.74)	25.28 (5.24)	-0.86(705)	0.06	0.08
Parent relations and home life W3	457	25.91 (5.01)	6–30	25.92 (5.02)	25.90 (5.01)	-0.03 (452)	0.00	0.02
Social support and peers W2	708	23.79 (5.46)	6–30	23.82 (5.48)	23.75 (5.45)	-0.17(704)	0.01	0.09
Social support and peers W3	456	23.92 (5.37)	4–30	23.93 (5.59)	23.92 (5.18)	-0.01 (443)	0.00	0.00
School environment W2	709	23.12 (5.56)	3–30	22.93 (5.62)	23.30 (5.50)	0.88(704)	-0.07	0.14**
School environment W3	456	23.73 (5.38)	6–30	23.47 (5.39)	23.96 (5.37)	0.97 (451)	-0.09	0.05
Bullying W2	708	13.15 (2.57)	3–15	13.28 (2.49)	13.03 (2.65)	-1.33(706)	0.1	0.1*
Bullying W3	455	13.46 (2.41)	3–15	13.44 (2.54)	13.48 (2.28)	0.18 (439)	-0.02	0.03

Note: Some items were reverse coded (items 4 and 5 of Hyperactivity/Inattention subscale; 3 items of Psychological Wellbeing dimension, 2 items of Mood and Emotions dimension, 2 items of Self-Perception dimension, 3 items of School Environment dimension, and all 3 items of Bullying dimension, KIDSCREEN-52). Higher scores on the Hyperactivity/Inattention subscale indicate more ADHD symptoms. Higher scores at SSR (Sleep Self Report) indicate Sleep Problems. And higher scores on the KIDSCREEN-52 indicate better wellbeing and greater adjustment capacity. *Statistically significant (*p<.05, **p<.01, ***p<.001)

Age was negatively correlated with hyperactivity/inattention symptoms at all waves (W2: r = −.11, p = .023; W3: r = −.14, p = .005) and with sleep problems at both Wave 2 (r = −.22, p < .001) and Wave 3 (r = −.13, p = .004). Age was positively associated with autonomy at Wave 3 (r = .13, p = .007). Socioeconomic status, here indexed by IMD score was not significantly associated with hyperactivity/inattention symptoms, sleep problems or with any of the physical, psychological and socioemotional wellbeing outcomes at any wave (all r ≤ .05, all p > .21).

Significant group differences in ethnicity were found for ADHD symptoms at W2 ($F(4, 879) = 4.71$, p = .001, $\eta^2 = 0.03$), W3 ($F(4, 879) = 3.29$, p = .011, $\eta^2 = 0.03$), and sleep problems at W3 ($F(4, 879) = 3.24$, p = .012, $\eta^2 = 0.03$). Post-hoc pairwise comparisons indicated small differences between ethnic groups: for ADHD symptoms at W2 and W3, similar small effect sizes were observed (d = 0.20–0.40 for significant comparisons). Sleep problems at W3 also showed small pairwise differences across groups (d = 0.20–0.30). No significant ethnicity differences were observed for physical, psychological and socioemotional wellbeing outcomes (all p> .05, $\eta^2 \leq 0.01$).

3.2. SEM analysis

Correlations between ADHD symptoms, sleep problems and KIDSCREEN subscales are presented in Table 2.

Our temporal SEM (W2-W3) yielded acceptable model fit: $\chi^2(224) = 1034.64$, p < .001, CFI = 0.876 and TLI = 0.860, RMSEA = 0.061 (90% CI: 0.057–0.065), SRMR = 0.059. All nine Kidscreen indicators loaded significantly on the latent psychological and socioemotional factor at W2. Standardized factor loadings ranged from 0.384 for bullying to 0.826 for parent relations, with most loadings falling between 0.60 and 0.83 (all p < .001), indicating generally strong measurement properties. The proportion of explained variance (R^2) for the W2 indicators ranged from 0.146–0.680. Similarly, at W3 all nine Kidscreen indicators loaded significantly on a latent psychological and socioemotional factor. Standardized loadings ranged from 0.485 for bullying to 0.815 for psychological wellbeing (all p < .001), again demonstrating good factor structure overall. The explained variance (R^2) for W3 indicators ranged from 0.231–0.660.

Regarding ADHD stability, ADHD symptoms at W2 significantly predicted ADHD symptoms at W3 (β = 0.721, p < .001), explaining 52.0% of the variance in ADHD at W3; findings which indicate strong temporal stability of ADHD symptoms.

The model explained 50% of the variance in the physical, psychological and socioemotional wellbeing factor at W3. The physical, psychological and socioemotional wellbeing factor at W2 was a significant predictor of this same factor at W3 (β = 0.536, p < .001), indicating temporal stability in these functional domains over time.

ADHD symptoms at W2 were not significantly associated with physical, psychological and socioemotional wellbeing at W3 after controlling for prior physical, psychological and socioemotional wellbeing at W2 and mean sleep problems (β = -0.043, p = .3). Greater (mean) sleep problems across W2 and W3 significantly associated with lower physical, psychological and socioemotional wellbeing at W3 (β = -0.26, p < .001). However, the interaction between ADHD symptoms at W2 and mean sleep problems was not statistically significant on the W3 physical, psychological and socioemotional wellbeing factor (β = 0.019, p = .7; Table 3). Sex was also not significantly associated with physical, psychological and socioemotional wellbeing at W3 (β = -0.013, p = .7).

Table 3
Path coefficients for the temporal SEM model

Outcome	Predictor	Unstandardised β(S.E.)	95%CI	P value	Standardised β all
ADHD symptoms at W3	ADHD symptoms at W2	0.714 (0.039)	0.638–0.791	< .001	0.721
Wellbeing at W3	Wellbeing at W2	0.563 (0.071)	0.425–0.6702	< .001	0.536
Wellbeing at W3	ADHD symptoms at W2	-0.04 (0.053)	-0.147-0.059	.39	-0.043
Wellbeing at W3	Mean Sleep Problems (W2-W3)	-0.113 (0.025)	-0.163 --0.064	< .001	-0.256
Wellbeing at W3	Interaction	0.003 (0.009)	-0.015, 0.021	.7	0.019
Wellbeing at W3	Sex	-0.072 (0.21)	-0.494, 0.350	.7	-0.013

Note: Mean Sleep Problems represents the average of sleep problems assessed at W2 and W3. The interaction term represents the interaction between ADHD symptoms at W2 and mean sleep problems (W2–W3). Wellbeing at W2 and W3 was modelled as a latent construct indicated by KIDSCREEN subscales at each Wave point.

Covariances included to account for interrelations among variable showed that ADHD symptoms at W2 were positively associated with mean sleep problems (β = 0.184, p < .001). Mean sleep problems were significantly associated with sex (β = 0.09, p = .01). ADHD symptoms at W2 were negatively associated with concurrent physical, psychological and socioemotional wellbeing (β = -0.19, p < .001), and mean sleep problems were negatively associated with physical, psychological and socioemotional wellbeing at W2 (β = -0.475, p < .001). At W3, the residual association between ADHD symptoms and concurrent physical, psychological and socioemotional wellbeing was not statistically significant (β = 0.057, p = .3).

As noted, sensitivity analysis conducted with sleep at W2 and W3 separately were conducted and are presented in Supplementary Materials, Supplementary Fig. 1.

4. Discussion

This project examined the temporal associations between ADHD symptoms and sleep problems on physical, psychological and socioemotional wellbeing outcomes across three waves in primary school children, and the interaction between ADHD symptoms and sleep. We explored these questions in children living in East London, which spans some socioeconomically deprived areas and ethnically diverse communities. Structural equation modelling showed strong temporal stability in ADHD symptoms and in wellbeing indices over time. Sleep problems were significantly associated with poorer physical, psychological and socioemotional wellbeing. In contrast, ADHD symptoms did not predict children's physical, psychological and socioemotional wellbeing at Wave 3 after accounting for prior wellbeing and sleep problems. The interaction term (ADHD symptoms × sleep problems) was not statistically significant.

The absence of a significant longitudinal effect of ADHD symptoms on physical, psychological and socioemotional wellbeing should not be interpreted as evidence that ADHD symptoms are unrelated to children's functioning. In the present study, ADHD symptoms were significantly associated with wellbeing concurrently at Wave 2, indicating that children with higher ADHD symptoms experienced poorer functioning at the same time point. However, once baseline wellbeing and sleep problems were accounted for, ADHD symptoms did not explain additional variance in wellbeing approximately one year later. These findings suggest that, within this developmental period and sample, the longitudinal predictive effect of ADHD symptoms may be largely captured by existing levels of functioning and co-occurring sleep difficulties. Thus, ADHD-related impairments may be expressed more strongly as contemporaneous or short-term associations rather than as cumulative effects over the follow-up period examined here. It is also possible that ADHD symptoms and related longer-term impairments in wellbeing and functioning are present at other development phases, such as in earlier childhood or later in adolescence [72–74]. Instead, sleep problems did temporally associate with these functional outcomes, consistent with prior literature in age-typical children and those with neurodevelopmental challenges [64, 75, 76]. However, its effects on outcomes did not emerge through exacerbation of ADHD symptoms. Prior data has shown that when sleep is experimentally manipulated through interventions, it can worsen ADHD symptoms and their impact on health and wellbeing [17, 34, 77, 78].

The absence of ADHD main effects and the interaction with sleep problems may reflect the characteristics of our non-clinical, unselected school-based sample, with relatively low ADHD symptoms and relatively high physical, psychological and socioemotional wellbeing scores. Consequently, our findings may primarily reflect the developmental consequences of subclinical ADHD traits rather than clinically significant ADHD. It is important to note that previous studies that have found an interaction between ADHD and sleep problems on functional outcomes used diagnostic measures of ADHD within clinical samples. Future research should directly compare children with subclinical ADHD symptoms and those with clinical diagnoses to determine whether symptom severity, comorbidity burden, and neurodevelopmental complexity influence the long-term relationship between ADHD and wellbeing. Another difference is that our sample represented children from particular minoritised ethnic groups and who were living in and likely to have grown up in socially and economically deprived areas. This is a sub-group (or sub-groups) who tend to report more sleep problems [79] and who may not have 'sleep privilege' [80]. It is unknown whether this difference in sample composition may explain some unexpected findings.

This project provides novel insights by extending correlational, one-wave cross-sectional evidence of links between ADHD symptoms and sleep [43] by using a two-wave prospective design. As there is still a main effect of average sleep problems on physical, psychological and socioemotional wellbeing outcomes, consistent with previous studies [76, 81, 82], and a correlation between ADHD symptoms and sleep problems, it is still nonetheless important for practitioners to identify and address sleep problems in children experiencing ADHD symptoms [24]. Thus, these data still highlight the potential value of interventions targeting sleep to support children's psychosocial wellbeing [17, 77].

Several limitations of our study should be considered. First, we used a self-reported measure of sleep which although validated in research, should be considered alongside more objective sleep measures [83]. However, a recent review investigating the relationship between self-reported sleep quality and polysomnography highlighted that the sleep self-report remains the most consistent way of screening sleep quality. Markers of objective sleep quality such as total sleep time, waking after sleep onset, sleep efficiency, sleep onset latency, REM latency, EEG arousal can depend on the sample influencing the generalizability of these latter findings [83]. Relatedly, we only had ADHD symptoms as reported by teachers rather than additional parent reports, which would have provided a more complete picture of symptoms. Future iterations of this research should incorporate, alongside teacher reports, parent- or self-reported ADHD symptoms and include repeated measures of both ADHD symptoms and sleep problems across waves. This would help to enhance the validity and interpretability of the findings. Moreover, our results should be interpreted with caution especially when generalizing to other sub-populations living in low-resource settings and/or with sociocultural diversity in the UK or globally. Future work should examine whether similar temporal associations are observed across other underserved contexts.

In conclusion, this study provides novel and valuable insights into the temporal interplay between ADHD symptoms, sleep problems, and physical, psychological and socioemotional wellbeing outcomes of primary school children, particularly those lower resource, culturally diverse settings. ADHD symptoms and wellbeing showed strong temporal stability across time. However, after accounting for baseline wellbeing and sleep problems, ADHD symptoms did not independently predict later wellbeing in this non-clinical sample, whereas sleep problems remained significantly associated with poorer subsequent wellbeing. These findings highlight the important role of sleep problems in children's physical, psychological and socioemotional wellbeing outcomes.

Declarations

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Ethics Statement: Ethical approval was obtained from the Queen Mary Research Ethics Committee (ref: QMERC22.251). Participants were recruited from ten schools across East London using a combination of opt-in and opt-out consent procedures. Parental consent and child assent were obtained before participation. All planned analyses were preregistered on the Open Science Framework (https://osf.io/m9eaq).

Data Availability Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request

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Figures

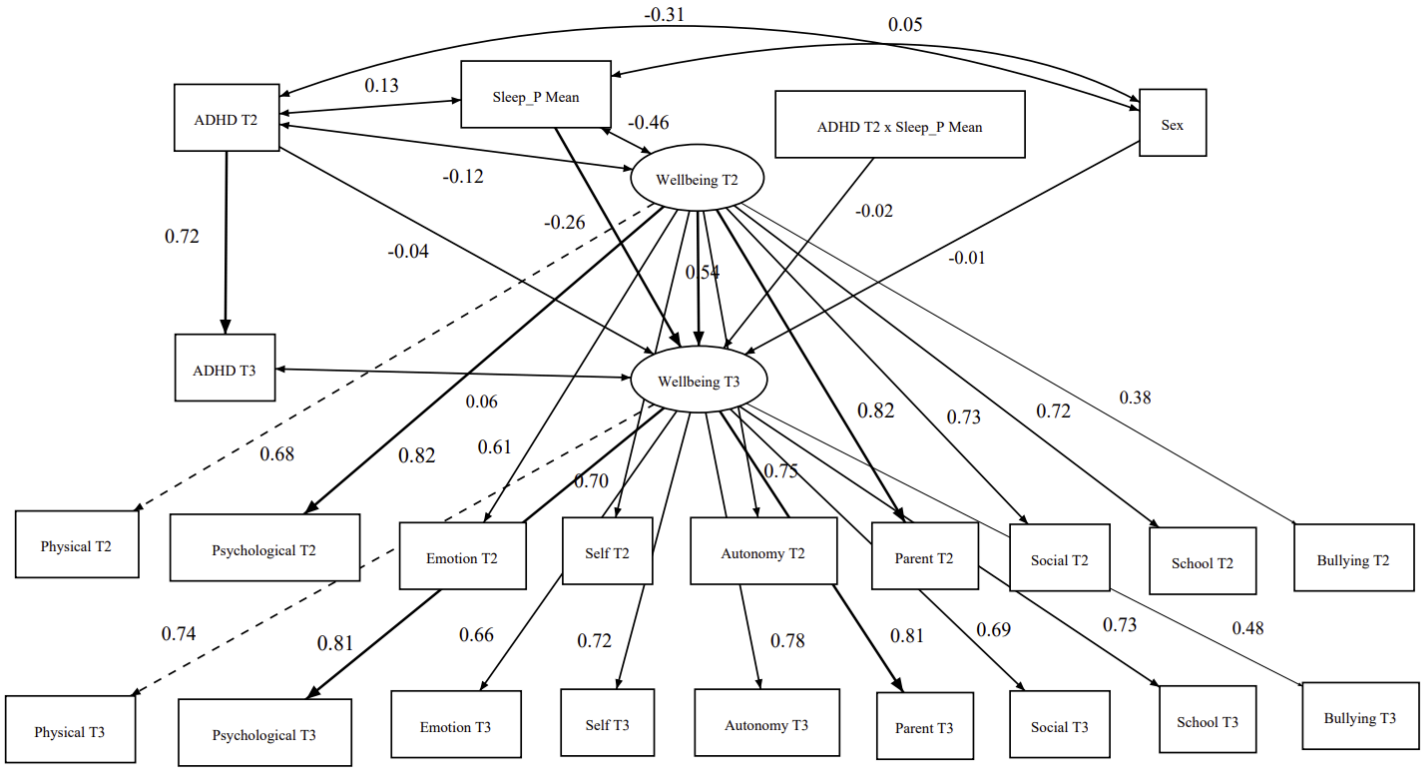


Figure 1

Structural Equation Model Illustrating the Effects of ADHD symptoms, Sleep Problems, their Interaction term including sex over time (Wave 2-Wave 3) on children's Physical,Psychological and Socioemotional wellbeing Outcomes

Note. Predictors*:* ADHD W2 =Attention-deficit/hyperactivity disorder at Wave 2; ADHD W3=Attention-deficit/hyperactivity disorder at Wave 3, Sleep_P mean =Sleep problems mean calculated by averaging standardized sleep scores across Wave 2 and Wave3;

Interaction term: ADHD symptoms (W2) * Sleep problems mean;

Latent construct(functional outcome): wellbeing at Wave 2 and wellbeing at Wave 3; *Outcomes:* Physical, physical adjustment; Psychological, psychological adjustment; Emotion, mood and emotions; Self, self-perception; Autonomy, autonomy; Parent, parental relations and home life; Social, social support and peers; School, school environment; Bullying, all at Wave 2 respectively at Wave 3. *Covariates:*Sex

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- SupplementaryMaterials3.docx