Depressive symptoms, overweight/obesity, and ADHD from childhood to adolescence: a cross-cohort study of cultural and timing effects

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Abstract

Background: Children who are persistently overweight/obese have higher risk of ADHD symptoms. Comorbid ADHD increases psychosocial challenges that could worsen mental health problems in children with overweight/obesity. This study analyzed data from England and Hong Kong to examine whether, and why, comorbid ADHD and persistent overweight/obesity is associated with depressive symptoms during the transition into adolescence.

Methods: Body mass index and ADHD symptoms were measured in childhood (T1) and early adolescence (T2) on 4,340 participants of the Avon Longitudinal Study of Parents and Children (ALSPAC) in England and 184 individuals of the Healthy Kids cohort in Hong Kong. Depressive symptoms were also measured at T2. Moderated mediation analysis was conducted to examine whether early (T1 & T2) ADHD accounted for the association between persistent overweight/obesity (T1 & T2) and depressive symptoms at T2.

Results: In Hong Kong, risk of depression in adolescence was highest among children with early ADHD as well as persistent overweight/obesity. Also, persistent overweight/obesity was only associated with depressive symptoms in adolescence among children with early ADHD; and this was primarily explained by persistence of ADHD into adolescence ($\beta = 1.66$, 95%CI [0.44, 3.36]). These findings were not replicated in the England cohort.

Conclusions: In some cultural settings, persistent ADHD symptoms have the potential to exacerbate depressive symptoms in adolescence. Early detection and intervention of ADHD symptoms is crucial for promoting mental well-being.

Keywords: attention-deficit/hyperactivity disorder, overweight/obesity, chronic disease, depression, transition into adolescence

Introduction

Childhood obesity is a global health concern because of its increasing prevalence and association with adult diseases. The prevalence of childhood obesity has risen more than eightfold over a 40-year period (NCD Risk Factor Collaboration (NCD-RisC), 2017). In 2020, an estimated 39 million children under the age of 5, and 150 million children aged 5-19, were classified as overweight or obese, with projected increases to 40 million and 254 million, respectively, by 2030 (World Health Organization, 2021). A study of 432,302 children in the USA reported that the covid-19 pandemic had exacerbated this trend by doubling the rate of increase, with preschoolers and school-age children experiencing the largest impact (Lange et al., 2021).

Concurrently, there has been a notable increase in attention-deficit/hyperactivity disorder (ADHD) symptoms among children worldwide (Rogers and MacLean, 2023). ADHD, one of the most common neurodevelopmental disorders in childhood, affects approximately 5% of children and adolescents globally (Polanczyk et al., 2014). Although ADHD symptoms often lessen with age, some individuals continue to experience persistent symptoms into adolescence and even adulthood, with the prevalence of ADHD persisting into adulthood estimated at 2.58% (Song et al., 2021). Recently, there has been a surge of studies investigating the association between ADHD and overweight/obesity. A meta-analysis conducted in 2020 estimated that the prevalence of obesity and overweight among individuals with ADHD was 14.7% and 20.9%, respectively (Li et al., 2020). Another meta-analysis of 42 studies, involving a total of 728,136 participants, reported a significant association between ADHD and obesity in both children and adults (Cortese et al., 2015). A subsequent meta-analysis of 43 studies involving fewer (n=703,937) participants suggested that the association was significant and became stronger with increasing age (Nigg et al., 2016).

Childhood obesity can affect both physical and psychological well-being. Depression is a recognized comorbidity of obesity and vice versa (Markowitz et al., 2008). Obesity can lead to depression through functional limitations, quality of life, physical activity levels, experiences of stigma, dissatisfaction with body image, and engagement in dieting behaviors. Conversely, depression can contribute to obesity through direct physiological mechanisms and indirect psychosocial pathways, involving factors such as heightened stress responses, immune system dysfunction, the hypothalamic-pituitary-adrenal axis, negative thought patterns, disrupted eating patterns, and poor adherence to treatment (Markowitz et al., 2008).

Childhood overweight/obesity may lead to obesity in adulthood (Serdula et al., 1993). An Australian cohort study found that 91% of individuals who were obese at 18 years old had previously been overweight or obese at age 12, and 90% had been overweight or obese at age 9 (Bjerregaard et al., 2018). In Hong Kong, a study conducted on 18,863 students revealed that 35.3% of students who were obese initially remained obese after 4 years (Tung et al., 2021). Since obesity is not necessarily stable among many children, it may be more useful to examine the impact of persistent childhood obesity. Research has demonstrated a higher risk of type 2 diabetes, and early-onset type 2 diabetes, among individuals with obesity that persists beyond childhood (Bjerregaard Lise et al., 2018; Forsén et al., 2000).

As they transition into adolescence, obese children face more challenges than peers including body dissatisfaction, low self-esteem, social isolation, discrimination, depression, and diminished quality of life (Gibson et al., 2017). Similarly, children with ADHD experience more psychosocial difficulties, such as academic underperformance, peer conflicts, feelings of anxiety, low self-esteem, and poor quality of life (Peasgood et al., 2016).

Therefore, children with both ADHD and adiposity face a wide range of physical, psychological, and social stressors. Unsurprisingly, comorbid ADHD and adiposity is associated with a nearly twofold increase in healthcare costs (Libutzki et al., 2019).

Understanding the role of ADHD symptoms in the association between overweight/obesity and depression could be beneficial for guiding risk prediction and informing early-stage interventions. Given the substantial effect of parenting on the development and manifestation of ADHD behavioral symptoms (Claussen et al., 2024), and the differences in ADHD symptom endorsement thresholds between parents in Hong Kong (HK) and those in United Kingdom (UK) (Chan et al., 2022b), this study aimed to examine potential cultural differences between these two regions in the chronicity of comorbid ADHD and overweight/obesity and its association with depressive symptoms during the transition into adolescence. We hypothesized that early ADHD could account for the association between persistent overweight/obesity and depressive symptoms among adolescents as illustrated in Figure 1.

Method

Data sources

The Healthy Kids study in HK is a longitudinal cohort study. In 2011-12, 567 families with children aged 5-6 years were recruited from 20 kindergartens selected from both affluent and less wealthy districts (Ip et al., 2016). Each family contributed one child to the cohort. The cohort was followed-up at ages 8-9 (T1) and at ages 12-13 (T2) (Wong et al., 2022). Ethical approval was obtained from the Institutional Review Board of the University of Hong Kong/Hospital Authority Hong Kong West Cluster, and all participants provided written

informed consent. Our analysis included 184 children with data on height, weight, depressive symptoms, and ADHD symptoms at both T1 and T2.

The Avon Longitudinal Study of Parents and Children (ALSPAC) is a longitudinal birth cohort study that recruited 14,541 mothers from Avon, England, who were expected to deliver between April 1991 and December 1992 inclusive. Ethical approval for the study was granted by the ALSPAC Ethics and Law Committee and the Local Research Ethics Committees. All participants gave written informed consent. The study website contains full details of the study, measures, sample, and data, which is available through a fully searchable data dictionary (http://www.bris.ac.uk/alspac/researchers/data-access/data-dictionary). In cases of multiple births within a family, the oldest sibling was included in the analysis. Our analysis included the 4,340 children for whom data on height, weight, depressive symptoms, and ADHD symptoms were available at ages 7 (T1) and 11 years (T2).

Persistent overweight/obesity

In the Healthy Kids cohort, height and weight were reported by parents at T1. At T2, they were measured by a trained research assistant. Weight was measured to the nearest 0.1 kg using a digital scale (Model BF-522; Tanita Corporation of America, Inc.), while the child was dressed in light clothing and without shoes. Standing height was measured to the nearest 0.1 cm using a portable stadiometer (Model no. 213; SECA Gmbh & Co. KG). Body mass index (BMI) was determined by dividing weight by height squared (kg/m2), and categorized using age and sex-specific BMI references from the International Obesity Task Force (IOTF) Standards (Cole et al., 2000; LEUNG et al., 1996). Children who were classified as either overweight or obese at both T1 and T2 were defined as persistent overweight/obese.

In ALSPAC, height and weight were objectively measured at T1 and T2 during research clinic visits. Height was recorded to the nearest 0.1cm using a Harpenden stadiometer, while weight was measured to the nearest 0.1 kg using a Tanita scale (Bell et al., 2018). BMI z-scores at T1 and T2 were computed using the UK90 reference data (Cole et al., 1995) and categorized as healthy weight (z-score < 1) and overweight/obese (z-score ≥ 1). Participants who were classified as obese/overweight at both T1 and T2 were labeled as persistent overweight/obese.

ADHD symptoms

In the Healthy Kids cohort, ADHD symptoms at T1 and T2 were measured using the parent-completed Chinese Strengths and Weaknesses of Attention-Deficit/Hyperactivity-symptoms and Normal-behaviours Questionnaire (SWAN) (Lai et al., 2013). This scale consists of 18 items rated on a 7-point scale ranging from -3 (far better than normal) to +3 (far worse than normal), with the average score representing the ADHD-combined (ADHD-C) score. ADHD was defined by Chinese SWAN cut-offs values (0.33 for boys and 0.39 for girls) (Lai et al., 2013).

In ALSPAC, ADHD symptoms at T1 and T2 were reported by parents using the hyperactivity subscale of the Strengths and Difficulties Questionnaire (SDQ) (Goodman, 1997). This scale asked about five symptoms of ADHD over the past 6 months, with each scored 0 (not true), 1 (somewhat true) or 2 (certainly true). Scores were added to produce an overall score ranging from 0 to 10. ADHD was defined as an overall score of 7-10 at T1 (Green et al., 2005).

Depressive symptoms

In the Healthy Kids cohort, depressive symptoms were self-reported at T2 using the depression subscale of the 21-item Depression anxiety stress scale (DASS-D) (Taouk et al., 2001). The DASS-D measures an individual's feelings of hopelessness, positive affect, and self-esteem over the previous week using seven items rated from 0 (did not apply to me at all) to 3 (applied to me very much, or most of the time) that are added to produce an overall DASS-D score ranging from 0 to 21.

In the ALSPAC cohort, depressive symptoms were self-reported at T2 using the 13-item short Mood and Feelings Questionnaire (SMFQ) (Messer et al., 1995) which measures the frequency of depressive symptoms, such as feelings of loneliness, over the preceding two weeks. Responses to 13 items were recorded on a 3-point scale ranging from 0 ("not true") to 2 ("true"), producing an overall score ranging from 0 to 26.

Analysis

All analyses were conducted using R. Study variables were inspected for impossible values and extreme outliers. Multiple imputations with five iterations were used to input missing responses. Spearman correlations were calculated to characterize relationships between study variables. Moderated mediation analyses employed a 95% bias-corrected bootstrap confidence interval (CI) with 5,000 bootstrapped samples to test whether the association between persistent obesity/overweight status at T1 and T2 and depressive symptoms at T2 could be explained by ADHD symptoms at T2, and whether such relationships were dependent on ADHD status at T1. To further assess the impact of high ADHD symptoms at T2, we compared depressive symptoms in participants who had ADHD at T2 and/or persistent (T1&T2) overweight/obesity with those who did not have either

condition. Demographic variables (i.e., sex, age, parental education level) were adjusted during the analyses. Percentile bootstrap confidence intervals for the indirect effect of ADHD symptoms were obtained from the manymome package (S. Cheung and Cheung, 2022). An effect was considered statistically significant if the 95% confidence interval did not include 0.

Results

Descriptive statistics and correlation

Table 1 shows the mean plus standard deviation for continuous variables and frequency plus percentage for categorical variables, and intercorrelation for all measures in the respective cohort study. Of the 184 Healthy Kids, 43 (23.4%) screened positive for ADHD at T1 and 38 (20.7%) were persistent overweight/obese. Of the 4,340 ALSPAC participants, 412 (9.5%) screened positive for ADHD at T1 and 584 (13.0%) were persistent overweight/obese. In both cohorts, boys had a higher prevalence of ADHD than girls. Children whose parents had higher levels of education had a lower prevalence of ADHD and persistent overweight/obesity. In both cohorts, ADHD at both T1 and T2 were positively correlated with depressive symptoms at T2. In the Healthy Kids cohort only, there was a positive correlation between persistent overweight/obesity and ADHD symptoms at T2. The correlation between persistent overweight/obesity and depressive symptoms at T2 was not significant before adjusting for early ADHD in either cohort.

Moderated mediation analysis

Table 2 shows the effect estimates of the hypothesized pathways in each study cohort. After adjusting for sex and age and parental education level, the association between persistent overweight/obesity and ADHD symptoms at T2 was not significant in either cohort. However, in the Healthy Kids cohort, there was a significant interaction with ADHD

at T1 whereby persistent overweight/obesity was associated with ADHD at T2 only among children who already had evidence of ADHD at T1. Further conditional effects modeling indicated that while persistent overweight/obesity was not directly associated with depressive symptoms at T2 (β = .26, p = .813), it was indirectly related to increased depressive symptoms through ongoing ADHD symptoms in those who had ADHD at T1 (β = 1.66, 95% CI [0.44, 3.66]). Specifically, children who had ADHD at T1 as well as persistent overweight/obese exhibited increased ADHD symptoms at T2 (β = .70, p = .007), which, in turn, was related to more severe depressive symptoms (β = 2.37, p < .001), as seen in Figure 2. Nonetheless, in ALSPAC, despite a significant and positive association between ADHD symptoms and depressive symptoms at T2 (β = .61, p < .001), the relationship between persistent overweight/obesity and ADHD symptoms at T2 was not significant regardless of ADHD status at T1. Overweight/obesity at T2 was associated with overweight/obesity (OR = 3.5, p < .001) but not with ADHD status (OR = -.09, p = .60) at T1. There was also no evidence of interaction between overweight/obesity and ADHD status at T1 (p = .40).

Persistent overweight/obesity and comorbid ADHD at T2 with depressive symptoms

Table 3 shows the results of linear regression on depressive symptoms in children with persistent overweight/obesity and/or ADHD at T2 compared with those who had none. In both cohorts, children with persistent overweight/obesity and comorbid ADHD at T2 had the most severe depressive symptoms (Healthy Kids: β = 6.87, p < .001; ALSPAC: β = 2.70, p < .001), followed by those with only ADHD (Healthy Kids: β = 3.38, p < .043; ALSPAC: β = 2.40, p < .001). Children with only persistent overweight/obesity were similar to those with neither condition.

Discussion

This study sought to examine the chronicity of comorbid ADHD and overweight/obesity and its association with depressive symptoms during the transition into adolescence in HK and England. The study found that, in the HK Healthy Kids study, persistent overweight/obesity was associated with depressive symptoms in adolescence only among those with comorbid early ADHD, and such relationship could be explained by elevated ADHD symptoms in adolescence. However, the England ALSPAC study found little evidence that early comorbidity increased the risk of developing depression in adolescence. On the other hand, persistent comorbidity or late onset of comorbidity was associated with elevated depressive symptoms in both samples.

In addition, our findings indicated that persistent overweight/obesity was prevalent in both samples (20.7% for HK Healthy Kids and 13.0% for England ALSPAC), even though the England data was collected almost 10 years earlier than the HK one. This suggests that some children with overweight/obesity could remain obese in adolescence regardless of the study years. Nonetheless, our cohorts differed in terms of the extent to which ADHD symptoms persisted from childhood to adolescence. In the England sample, the differences in ADHD symptoms between children who initially had ADHD and those without at a young age were observed to diminish as they grew older, but such differences remained in the HK sample. The chronicity of ADHD symptoms could have implications for mental health. Specifically, in both samples, when not stratified by early-age ADHD screening status, we found no link between persistent overweight/obesity and depressive symptoms. However, after stratification by their early-age ADHD screening status, children who had persistent overweight/obese and ADHD in the HK sample had an increased susceptibility to depression during the transition into adolescence. These findings underscore the significance of early interventions for preventing and managing these conditions.

Research indicates that children with overweight/obesity face various psychosocial challenges that can negatively impact their mental well-being (Markowitz et al., 2008). These challenges may increase with pubertal changes and adjustment to new school settings during the transition into adolescence (Gibson et al., 2017). Given that the association was not significant before stratification by ADHD status, elevated depressive symptoms in children with persistent overweight/obesity may be attributed not directly to the persistent overweight/obesity itself, but rather to the functional limitations that are commonly, though not always, associated with this condition. For example, emotional regulation is known to be an important skill for preserving mental well-being. Studies have demonstrated that ADHD is strongly and in part independently, linked to emotional dysregulation (Astenvald et al., 2022), which involves challenges in handling or controlling strong emotions, particularly those classified as negative, such as anger, frustration, and sadness. Therefore, individuals with chronic ADHD who are also overweight/obese could be more susceptible to depression, as they can be stressed by both weight-related stigma (Westbury et al., 2023) and difficulties in emotional regulation associated with ADHD (Khalid et al., 2025).

Our findings emphasize the importance of early ADHD screening in facilitating timely interventions, such as adjusting ineffective parenting strategies (Claussen et al., 2024), to address early ADHD symptoms in children. This is especially crucial for at-risk groups, such as children with overweight/obesity who often experience difficulties with impulse control, which is also a known sign of ADHD. Another notable finding is the cultural differences in the persistence of ADHD symptoms. The England sample showed no link between persistent overweight/obesity and chronic ADHD, while the HK sample indicated that the comorbid condition of overweight/obesity and ADHD could persist and be linked to a

subsequent increase in depressive symptoms. Although further research is needed to confirm the underlying mechanism, there are several possible explanations. Firstly, as both samples in this study had ADHD symptoms assessed by parents, if parents perceive behaviors that are seen as typical childhood conduct in a different region as problematic and impairing, these differences in perception may lead to a higher prevalence of children being identified and diagnosed with ADHD in one region compared to others (Garcia-Argibay et al., 2024). Secondly, the HK education system places a greater focus on traditional classroom-based learning rather than outdoor active learning, limiting the opportunity for improvement in ADHD symptoms. Additionally, the densely populated environment in HK, as opposed to the less crowded setting in UK, could exacerbate or perpetuate ADHD symptoms by overloading the brain's processing capacity (Fabio et al., 2024). Thirdly, HK parents tend to exhibit a heightened level of vigilance towards academic-related behaviors, such as hyperactivity and inattention, throughout their children's schooling years, whereas UK parents embrace a more lenient parenting style (Chan et al., 2022a). It is possible that parents' increased tolerance for misbehavior as their children transition into adolescence could alleviate the stress and concerns that had previously prompted them to perceive their children as having significant symptoms of ADHD.

This study has several limitations. The ADHD and depression symptoms were measured using different questionnaires at different times. These measurement differences make it challenging to thoroughly investigate cultural differences between the two groups. Other factors such as parenting approaches may also affect the results. Future research should explore how parenting differences between the two regions could impact the persistence of ADHD symptoms in children and their later risk of depression. Additionally, this study only considered parents' views on their children's ADHD symptoms, which does not necessarily

correspond to the DSM criteria where multiple assessment settings are required. While self- or parent-reported measures can be used to explore how perceptions influence results, reporting bias could lead to a distorted understanding of the actual link between different disease conditions.

Conclusions

Despite limitations, this study offers a new direction for research and services to address ongoing issues related to overweight/obesity and comorbid mental health problems. Children who are persistently overweight/obese and show early signs of ADHD are more likely to experience depression during adolescence. Early screening and intervention for ADHD symptoms can help prevent at-risk children from developing chronic health issues and mental health problems, such as depression, in the future.

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Table 1. Descriptive statistics and correlation between study variables.

	mean(SD)/n(%)	1	2	3	4	5	6	7	8
a. HK Healthy Kids (n=184)									
1. Age	8.04(0.19)	-	-	-	-	-	-	-	-
2. Male	102(55.4)	0.12	-	-	-	-	-	-	-
3. Maternal education	4.71(1.30)	-0.02	-0.07	-	-	-	-	-	-
4. Paternal education	4.89(1.38)	-0.01	-0.02	0.66***	-	-	-	-	-
5. ADHD scores at T2	-0.70(0.91)	0.06	0.26***	-0.16*	-0.17*	-	-	-	-
6. Persistent overweight/obesity since T1	38(20.7)	0.04	0.16*	-0.20**	-0.19*	0.18*	-	-	-
7. Depression scores at T2	5.61(6.42)	-0.01	0.14	0.03	0.12	0.38***	-0.01	-	-
8. ADHD screen positive at T1	43(23.4)	0.09	0.24**	-0.21**	-0.25**	0.52***	0.10	0.31***	-
b. ALSPAC (n=4,340)									
1. Age	7.45(0.14)	-	-	-	-	-	-	-	-
2. Male	2,178(50.0)	-0.02	-	-	-	-	-	-	-
3. Maternal education	3.42(1.16)	-0.03*	-0.01	-	-	-	-	-	-
4. Paternal education	3.42(1.36)	-0.05**	0.02	0.52***	-	-	-	-	-
5. ADHD scores at T2	2.67(2.21)	0.01	0.21***	-0.09***	-0.10***	-	-	-	-
6. Persistent overweight/obesity since T1	584(13.0)	0.01	-0.01	-0.04*	-0.05**	-0.01	-	-	-
7. Depression scores at T2	2.26(3.14)	-0.02	-0.01	-0.03	-0.03*	0.41***	0.01	-	-
8. ADHD screen positive at T1	412(9.5)	-0.02	0.11***	-0.04**	-0.05**	0.45***	0.01	0.22***	-

*p<0.05, **p<0.01, ***p<0.001.

Table 2. Testing the moderated mediation effect of persistent overweight/obesity and ADHD screen positive on future ADHD symptoms and depressive symptoms in adolescents

		HK Healthy Kids (n=184)					UK ALSPAC (n=4,340)				
Outcome	**Predictors**	**R^2**	**F**	**β**	**SE**	**t value**	**R^2**	**F**	**β**	**SE**	**t value**
T2 ADHD scores	Age	0.31	12.63	-0.11	0.29	-0.36	0.23	202.4	0.25	0.21	1.2
	Male			0.24	0.12	2.04*			0.74	0.06	13.00***
	Maternal education			-0.03	0.06	-0.45			-0.08	0.03	-2.95**
	Paternal education			-0.02	0.05	-0.34			-0.09	0.02	-3.80***
	Persistent overweight/obesity			0.03	0.17	0.18			-0.06	0.09	-0.73
	T1 ADHD screen positive			0.85	0.16	5.30***			3.26	0.11	30.68***
	Overweight/obesity x T1 ADHD			0.67	0.31	2.19*			-0.38	0.28	0.17
T2 Depression scores	Age	0.11	4.91	-2.38	2.27	-1.05	0.18	167.0	-0.45	0.3	-1.51
	Male			0.36	0.91	0.4			-0.63	0.09	-7.37***
	Maternal education			-0.29	0.44	-0.66			-0.003	0.04	-0.08
	Paternal education			0.97	0.41	2.34*			0.04	0.04	0.98
	T2 ADHD scores			2.37	0.51	4.69***			0.61	0.02	31.49***
	Persistent overweight/obesity			0.26	1.11	0.24			0.18	0.12	1.51
Conditional indirect effect analysis at the result of T1 ADHD screen:				**β**	**95% CI LL**	**95% CI UL**			**β**	**95% CI LL**	**95% CI UL**
ADHD screen positive				1.66	0..44	3.36			-0.28	-0.63	0.10
ADHD screen negative				0.07	-0.90	1.01			-0.04	-0.13	0.09

Note: Bootstrap sample size = 5000, LL = low limit, CI = confidence interval, UL = upper limit. The beta coefficient was unstandardized. *p<0.05, **p<0.01, ***p<0.001.

Table 3. Joint association of persistent overweight/obesity and comorbid ADHD at T2 with depressive symptoms at T2

	β	95% CI LL	95% CI UL	p-value
a. HK Healthy Kids (n=184)				
Neither	0 (Reference)			
ADHD only	3.38	0.11	6.65	0.043
Persistent overweight/obesity only	-0.63	-3.02	1.75	0.603
Both	6.87	2.86	10.88	<0.001
b. ALSPAC (n=4,340)				
Neither	0 (Reference)			
ADHD only	2.4	2.1	2.7	< 0.001
Persistent overweight/obesity only	0.09	-20	0.37	0.60
Both	2.7	2.0	3.5	< 0.001

Note: ADHD = attention deficit hyperactivity disorder, LL = low limit, CI = confidence interval, UL = upper limit.

Adjusted for age, sex, and parental education

Figure 1. Hypothesized model

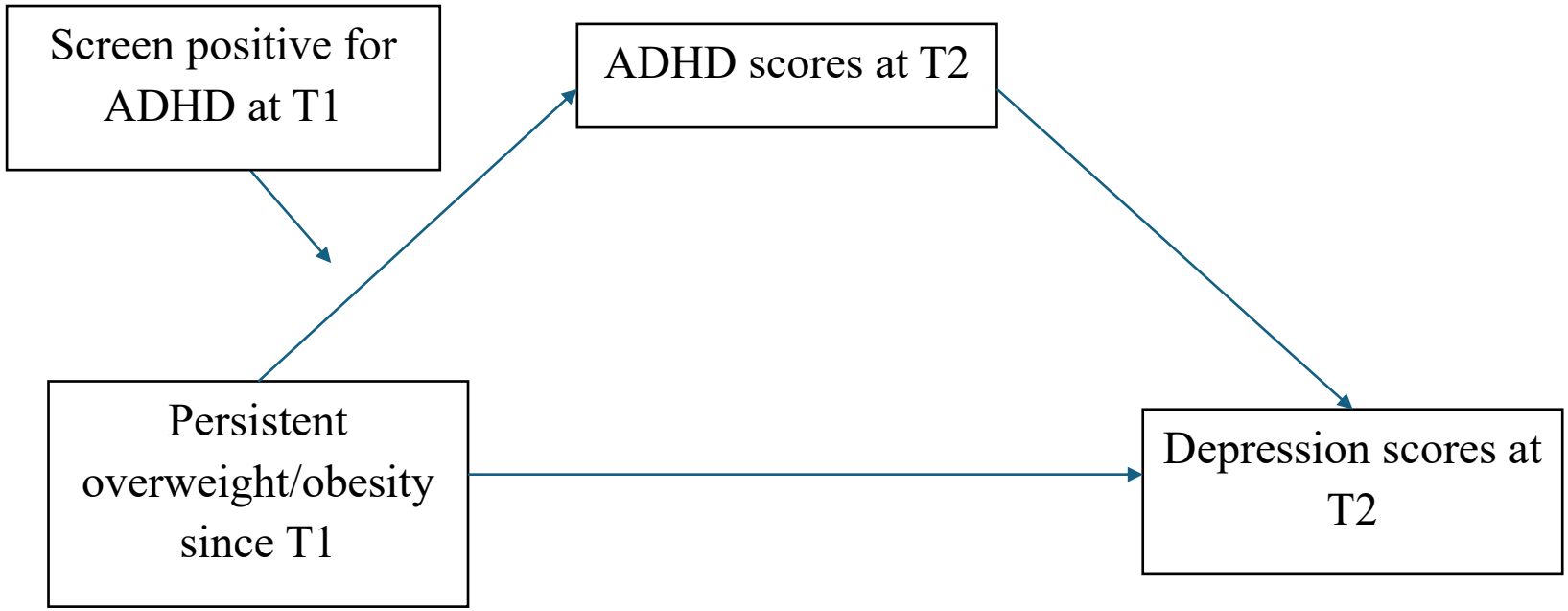
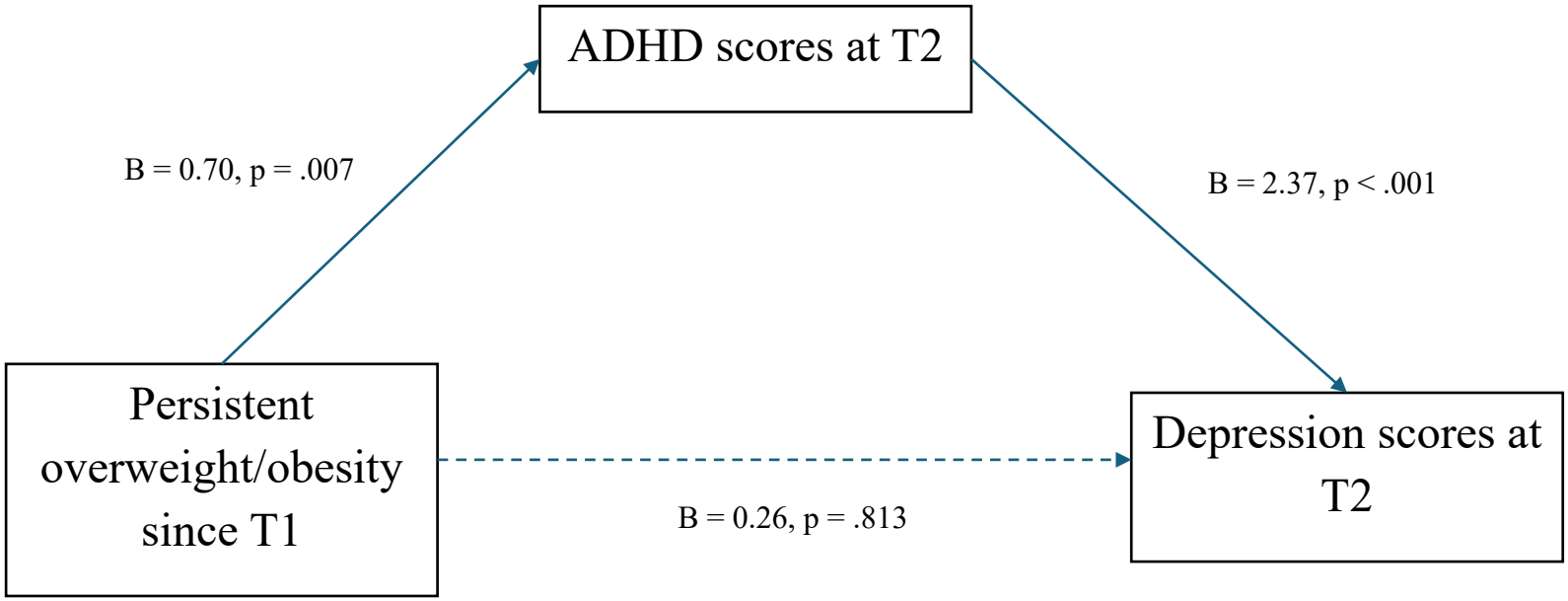


Figure 2. Association between persistent overweight/obesity since T1 and depressive symptoms at T2 through ADHD symptoms in HK individuals screened positive for ADHD at T1





Wong, Rosa S., Zhou, Ziyi, Tung, Keith T.S., Ho, Frederick K., Pell, Jill P. and Ip, Patrick (2026) Depressive symptoms, overweight/obesity, and ADHD from childhood to adolescence: a cross-cohort study of cultural and timing effects. *Journal of Affective Disorders*, 393(Part A), 120343. (doi: 10.1016/j.jad.2025.120343)

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