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Emotion regulation trajectories in childhood, anorexia nervosa and atypical anorexia nervosa in early adolescence: a UK general population cohort study.

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Abstract

Importance: People with anorexia nervosa often experience difficulties regulating emotions. There is no longitudinal evidence as to whether these differences are already present in childhood and when they begin to emerge.

Objective: To investigate the association between emotion regulation trajectories between three and seven years and symptoms of anorexia nervosa and atypical anorexia nervosa in adolescence.

Design: General population cohort study.

Setting: The Millennium Cohort Study, a UK general population birth cohort.

Participants: All children with complete exposure data.

Exposure: Mothers reported on their child's emotion regulation skills at three, five, and seven years using the Child Social Behaviour Questionnaire. We used multilevel models to derive early childhood emotion regulation scores (i.e. predicted intercept) and within-child changes in emotion regulation scores between age three and seven years (i.e. predicted slope).

Main outcome and measures: Symptoms consistent with a DSM-5 diagnosis of anorexia nervosa or atypical anorexia nervosa at age 14 years, defined using a range of questions relative to body image, weight perception and dieting behaviours (hereafter referred to as 'broad anorexia nervosa'). We used univariable and multivariable logistic regression models to test the association between exposures and outcome. We adjusted regression models for child and family's socio-demographic/-economic characteristics and mental health difficulties, pre-natal and perinatal factors, child's cognitive development, and maternal attachment.

Results: Of the 15,896 participants (85.7% of sample, [49.0% girls, 84.5% white]) included in the analyses, 97 (0.98%,[88.7% girls, 86.6% white]) had symptoms consistent with a broad diagnosis of anorexia nervosa at 14 years. We did not find strong evidence that children with lower emotion regulation ability at three years had greater odds of later reporting symptoms of broad anorexia nervosa (odds ratio[OR]:1.21, 95% confidence

intervals[CI]:0.91-1.63). However, children whose emotion regulation skills did not improve over childhood and had greater problems regulating emotions at 7 years, had higher odds of having broad anorexia nervosa at 14 years (OR:1.45, 95%CI:1.16-1.83).

Conclusions: Difficulties in developing age-appropriate emotion regulation skills in childhood are associated with experiencing broad anorexia nervosa in adolescence. Interventions to support the development of emotion regulation skills across childhood may help reduce the incidence of anorexia nervosa.

Keywords: anorexia nervosa; emotion dysregulation; cohort study; MCS.

Key points

Question: Is emotion dysregulation in childhood associated with increased risk of adolescent anorexia nervosa?

Findings: Children with poorer emotion regulation skills at age three years were not at increased risk of anorexia nervosa. However, those whose emotion regulation skills did not improve across childhood were at increased risk.

Meaning: Failure to meet key emotional developmental milestones between the ages of three and seven years could confer an increased risk for anorexia nervosa. Support with developing emotion regulation skills across childhood could be beneficial in preventing anorexia nervosa.

Introduction

Anorexia nervosa is a psychiatric disorder typically beginning in adolescence and characterised by restriction of food intake and severe anxiety regarding eating, body shape and gaining weight.[1] Anorexia nervosa, including its sub-threshold presentations, affects around 1% of young people and is associated with mental and physical health comorbidities and high mortality.[2] Childhood interventions could help to prevent a number of anorexia nervosa cases, yet longitudinal aetiological research remains scant, and targets for such interventions elusive.

Emotion regulation, defined as the ability to both intrinsically and extrinsically monitor, appraise and modify one's emotional state[3], has been increasingly proposed as such a potential target.[4] In clinical samples, people with anorexia nervosa often show suboptimal emotion regulation and awareness compared to healthy controls, as well as greater difficulties tolerating distress, and other maladaptive emotion regulation strategies such as rumination and suppression.[5–7] Poor emotion regulation can lead to emotional overcontrol, which is associated with cognitive rigidity, reward insensitivity and perfectionism, all commonly observed in patients with anorexia nervosa.[8,9] It has been hypothesised that emotional avoidance might increase negative affect and the use of maladaptive coping strategies, such as disordered eating behaviours.[10–12] Whilst such maladaptive behaviours typically begin during adolescence, emotion regulation difficulties emerge throughout childhood[13] and are associated with later psychopathology, including obsessive-compulsive disorder, depression, and anxiety[14,15], common comorbidities[16,17] of and proposed risk factors for anorexia nervosa.[18,19]

Existing studies of emotion regulation and anorexia nervosa have predominantly used case-control designs within clinical populations.[7] These have a number of limitations. They are prone to reverse causality and cannot exclude the possibility that emotion regulation difficulties are a consequence rather than a cause of anorexia nervosa. For instance, some

studies of people with anorexia nervosa have found that body mass index(BMI) or weight restoration did not affect emotion regulation skills,[20,21] whilst others have found that the latter improved with weight restoration.[22] Clinical studies are also susceptible to selection bias, as cases are commonly drawn from secondary care, and controls from the general population samples. They can also be an unrepresentative selection of all people with eating disorders as often the latter do not seek help.[23] Residual confounding and small sample sizes are also a concern of the existing literature.

Longitudinal general population studies can address many of these limitations. They can also detail how emotion regulation difficulties develop across childhood and how these changes might be implicated in the aetiology of anorexia nervosa. This allows to identify key developmental stages when preventative interventions could be more effective. To this end, we used data from the Millennium Cohort Study, a large United Kingdom(UK) longitudinal general population birth cohort, to investigate the association between trajectories of emotion dysregulation across childhood and broadly-defined anorexia nervosa at 14 years.

Methods

Sample

The Millennium Cohort Study(MCS) is a longitudinal population-based birth cohort study of children born between September 2000 and January 2002 who were living in the UK at nine months of age, and their families(**e-methods 1**).[24] The Multi-Centre Research Ethics Committee gave ethics approval for MCS. Participants gave written consent to take part.
In this study, we included children with complete data on exposure, imputing missing confounder and outcome data. In cases of twins/triplets, we selected one child at random to avoid over/underestimation of effects resulting from shared genetic/environmental factors.

Outcome

We used a set of questions broadly covering Diagnostic and Statistical Manual of mental disorders 5th edition(DSM-5) criteria for anorexia nervosa or atypical anorexia nervosa to identify participants who at age 14 years had behaviours and cognitions consistent with these two diagnoses (hereafter referred to as broad anorexia nervosa, Tables 1 & 2) These DSM-5 criteria include: deliberate restriction of energy intake, fear of gaining weight, behaviours preventing weight gain or maintaining low weight, and disturbed body weight perception.[1] Low weight is a diagnostic criterion for anorexia nervosa, but not atypical anorexia nervosa. We defined adolescents as having broad anorexia nervosa if they met all of the following criteria: they reported lifetime dieting and exercising for weight loss, were currently trying to lose weight, skipped breakfast every day, described themselves as overweight despite a BMI in the underweight or normal weight range, and scored below the median sample score on a question on body image. We calculated BMI from objective measures of height and weight taken by trained researchers when participants were 14 years old. We used the Stata *egen* function '*zbmicat()'* [25] to generate age- and sex-appropriate BMI categories, based on International Obesity Task Force growth charts.[26,27]

We used a broad anorexia nervosa definition for two reasons. First, people who do not meet the low BMI criterion are less likely to be referred to specialist services and are thus often excluded from clinical studies. Including adolescents with symptoms typical of clinical diagnoses can help elucidate risk factors that operate across the spectrum of disorder severity. Second, low BMI results from protracted restrictive eating behaviours and weight and shape concerns. Some people, despite experiencing all other behavioural and cognitive symptoms of the disorder might never reach an underweight BMI. Furthermore, at the early stages of anorexia nervosa (which we are likely to observe at this age) people with the condition may still be in the normal BMI range. For descriptive purposes, we also restricted our definition to underweight participants.

Exposure

At the age three, five, and seven years sweeps of data collection, mothers reported on their child's emotion regulation abilities over the previous six months using five questions from the Child Social Behaviour Questionnaire(a modified version of the Adaptive Social Behaviour Inventory).[28,29] These questions are scored on a three-point Likert scale(see **e-Table 1**) giving a total score ranging from 0 to 10, with higher scores indicating greater difficulties regulating emotions. Published studies using MCS and other datasets have previously used this measure.[30,31] Our main exposures were children's predicted emotion regulation scores at age three(i.e. *intercept*) and their within-person linear change in score between ages three and seven years(i.e. *slope*), derived using multilevel models. More details on how this variable was created in the *data analysis* section.

Confounders

We used Direct Acyclic Graphs(**e-figures 1, 2**) to guide our choice of confounders, based on assumptions informed by previous literature and clinical observations. According to these assumptions, in order to estimate the total effect of both exposures on broad anorexia nervosa at 14 years, it was necessary to adjust analyses for child's: birthweight, gestational age, sex, ethnicity, breastfeeding status, cognitive self-regulation and cognitive development (indexed in our sample by language development and school readiness) at age three, and underlying genetic risk. It was also necessary to adjust for family socio-economic status, maternal and paternal depression, maternal and paternal emotion regulation, pre-pregnancy BMI, smoking habits in pregnancy, and maternal attachment to the child. We had data on all these hypothesised confounders with the exception of genetic risk and parental emotion regulation. More details in **e-methods 2**.

We also adjusted analyses of the association between emotion regulation slope and broad anorexia nervosa for child BMI and mental health difficulties at age three years. We did not include these two measures in the intercept analyses because we hypothesised they could

be mediators of its association with the outcome. There is longitudinal evidence that more emotionally dysregulated children have higher BMI[30] and greater internalising and externalising symptoms.[32,33] As measures of emotion regulation, mental health difficulties, and BMI were collected at the same time, it was difficult to disentangle temporality. Emotion regulation difficulties can however also occur as a result of neurodevelopmental disorders[34] and there is some evidence that emotion regulation improves with weight restoration.[22] Hence, in a sensitivity analyses, we also included mental health difficulties and BMI as potential confounders.

Data Analysis

To create the exposure variables, we used multilevel models to model within-child repeated emotion regulation scores between ages three and seven. We used linear and quadratic indicators of child's age at assessment(three, five, and seven years), and included a random intercept for child and a random slope for linear time. For each child, we predicted an intercept and a linear slope value for each child representing, respectively, their predicted emotion regulation scores at age three and the within-child score changes between three and seven years. To derive the child's intercept, we centred the age variable at three years. To derive the slope, we centred age at five years. In regression models, we standardised these values to have a mean of zero and a standard deviation of one.

To investigate the association between emotion regulation exposures and broad anorexia nervosa, we used univariable and multivariable logistic regression models. First, we ran univariable models for each exposure. Subsequently, we ran a series of multivariable models progressively adjusting each exposure for child- and family-level confounders. Models testing the association between emotion regulation slope and broad anorexia nervosa were also further adjusted for emotion regulation intercept, to test whether changes in emotion regulation are associated with broad anorexia nervosa regardless of baseline levels. We imputed missing confounder and outcome data using multiple imputation with

chained equations (**e-methods 3**)[35]**.** In all analyses, we used survey and non-response weights and accounted for sampling strata.

As sensitivity analyses, we re-ran all models restricting the sample to participants with: complete exposure and outcome data and imputed confounders, and complete data on all variables. Second, we ran univariable and multivariable models using emotion regulation scales age three, five, and seven separately as exposures. These analyses were based on participants with complete exposure and imputed confounders and outcome at each time point. Finally, we used linear mixed models to model trajectories of emotion regulation scores for adolescents with and without broad anorexia nervosa. Our models included a random intercept for child and a random slope for linear time. We ran univariable and multivariable models, adjusting for all previously identified confounders, and included interactions with age and age squared to test for differences in trajectories' slopes centering age at 5 years. Analyses were run in Stata16.

Results

Sample and missing data

Of the 18,552 children included in the first wave of MCS, 15,896(85.7%) provided data for at least one emotion regulation assessment and were included in the analyses. Of these, 9,255(58.2%) had data on all three assessments, 4,103(25.8%) on two, and 2,538(16.0%) on one. Among children with complete exposure data, 5,981(37.6%) did not have outcome data. In **e-table 2** we present factors associated with missing outcome data.

The majority of participants were male, of white ethnicity, had at least one parent in a non-manual occupation, and a mother who only completed compulsory education. A complete overview of sample characteristics is provided in **Table 3**.

Emotion Regulation

Mean emotion regulation scores were: 4.39(standard deviation[SD]:2.25) at age three, 3.61(SD: 2.30) at age five, and 3.59(SD:2.37) at age seven. Multilevel models also showed a decrease in scores between age three and five and a subsequent stabilization(**e-table3, e-figure3**). Overall, boys, children from more deprived backgrounds and those whose parents had greater depressive symptoms had more difficulties regulating emotions. Children with mental health difficulties, lower cognitive development, and those with greater pre- and perinatal adversities (e.g. those born prematurely or at lower weight, exposed to maternal smoking in utero) also were more emotionally dysregulated(**Table 3**).

Broad Anorexia Nervosa

Among participants with complete exposure data, 97(0.98%) adolescents had symptoms consistent with a broad diagnosis of anorexia nervosa. Prevalence was lower in boys(n=11, 0.22%) than in girls(n=86, 1.74%), and similar in white(n=85, 1.00%) and ethnic minority(n=14, 0.80%) participants(**eTable4)**. Seven participants (0.07%) met strict criteria for anorexia nervosa.

Emotion Regulation and anorexia nervosa

There was no evidence that children with higher intercept scores had increased odds of broad anorexia nervosa at age 14 years in the univariable model. The association remained largely unchanged when including all hypothesised confounders(**Table 4**). Further including child BMI and mental health difficulties in sensitivity analyses did not alter these findings (odds ratio: 1.15,95% confidence intervals[CI]: 0.82,1.62, not reported in table).

There was evidence that increases in emotion regulation slope were associated with greater odds of broad anorexia nervosa at 14 years in the univariable model. This association persisted in models adjusted for all hypothesised confounders(**Table 3**).

Sensitivity Analyses

When running models on participants with complete exposure and outcome variables and imputed confounders(n=9,912, **e-table5**) and those based on complete cases (n=4,004 for intercept, n=3,768 for slope, **e-table6**) results showed a reduced strength of association, although 95% CIs overlapped with those of the main analyses. When we used individual measurements of emotion regulation we found no evidence of an association at age three (fully adjusted OR: 0.99, 95%CI: 0.89,1.11). However, we found weak and strong evidence of an association between greater emotion dysregulation at age five (OR: 1.11, 95%CI:0.95,1.31) and seven (OR:1.19, 95%CI:1.05,1.36), respectively, and greater odds of broad anorexia nervosa at 14(**e-table7**). These findings were also mirrored by mixed model analyses. Here, we found no evidence of differences in score at age 5 years between those with and without anorexia nervosa (mean difference: 0.25, 95%CI:-0.09,0.60). However, there was an interaction with time(p=0.001) indicating that, whilst emotion regulation scores were similar between groups at age 3 years, trajectories began to diverge at age 5 resulting in differences in scores by age 7(**etable8, Figure1**).

Discussion

In this study, we found that children whose emotion regulation skills improved less over the course of childhood and who had greater problems regulating emotions by age 7 years had increased odds of broadly-defined anorexia nervosa at 14 years. This association was independent of baseline levels of internalising and externalising symptoms, emotion and cognitive self-regulation skills, cognitive development, maternal attachment, BMI, and family characteristics, and was consistent across main and sensitivity analyses. We did not find consistent evidence of an association across main and sensitivity analyses when investigating emotion regulation difficulties at age three years as the exposure.

Interpretation of findings

Clinical case-control studies have found that people with anorexia nervosa have emotion regulation difficulties.[7] A previous longitudinal study had also found that adolescents with emotion regulation difficulties had greater disordered eating behaviours at a seven-month follow-up.[36] Our study improves on these previous investigations, by showing that emotion regulation difficulties not only precede the onset of anorexia nervosa, but that they also likely emerge over the course of early to mid-childhood. We observed that whilst for most children, their ability to regulate their emotions improved over time between the ages of three and seven years, this was not the case for those who later developed symptoms consistent with a diagnosis of anorexia nervosa or atypical anorexia nervosa(**Figure 1**). This suggests that failure to meet key emotional developmental milestones, as opposed to having greater emotion dysregulation since early childhood, could confer an increased risk for anorexia nervosa. Emotion regulation difficulties might also be independent from BMI and increase the risk of restrictive eating behaviours across a range of eating disorders. This hypothesis needs to be further investigated.

Several mechanisms could explain the association we observed. Emotion dysregulation might represent an early manifestation of genetic and neurobiological risk. Cognitive rigidity, reward

insensitivity, and perfectionism typical of anorexia nervosa[8,9] could emerge in response to difficulties regulating negative emotions. Emotion dysregulation could also trigger environmental risk factors. For instance, children learn from a young age to avoid peers who display extreme emotions and consequently children who are unable to regulate emotions often struggle to develop peer relations.[37] Poor social competence and emotional control can lead to being bullied,[38] a risk factor for eating disorders in young people.[39] The ability to regulate emotions also helps individuals cope with negative experiences and fosters resilience in stressful situations.[40–42] In adolescence, when peer relationships begin to play a key role in an individual's life, the lack of such skills could lead to feelings of anxiety and consequently to developing coping strategies such as emotional avoidance, which are common clinical observations in this population.[43]

Limitations

The MCS did not collect information on binge-eating and purging behaviours. Hence, we cannot exclude that some participants whom we classified as having symptoms of broad anorexia nervosa could have had bulimia nervosa or binge eating disorder, although at this age, this is likely to be a minority of adolescents.[44] It is also possible that some adolescents with broad anorexia nervosa at 14 years could have later transitioned to a different eating disorder as this is often observed in clinical samples. Future studies should aim at capturing whether emotion dysregulation is a shared or specific risk factor across diagnoses.

The question on weight perception does not include a qualitative element (i.e., whether the adolescent is happy or not with their perceived weight) and that on body image is not weight- or shape-specific. To capture adolescents who were dissatisfied with their weight we included only those who overestimated their weight and also scored higher than the median sample value on the body image question. This choice should have restricted our definition to adolescents with more severe weight and shape concerns.

We made our causal assumptions around confounder adjustment explicit by using DAGs and we were able to adjust for most variables that we had identified. However, we did not have data available on possible confounders such as parental emotion regulation and genetic factors. It is possible that residual confounding may explain our results. Although this can never be entirely excluded as a possibility, we observed very little change in the magnitude and strength of the association between the univariable and the multivariable models, thus providing some reassurance around the robustness of the results.

As it is common in longitudinal cohort studies this study was affected by some degree of attrition. Nevertheless, our main analyses – based on participants with complete exposure – included the majority of the sample(85.7%). Furthermore, when we compared the results from these models with those of complete case analyses and analyses imputing only confounders, our results remained largely consistent.

Conclusions

If the associations we observe were causal, universal interventions fostering skills for emotion regulation in this age group, such as building tolerance for uncomfortable feelings and learning how to overcome frustration, could have a preventative role in the emergence of eating disorders and, perhaps, other mental health problems with an onset in adolescence.

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Contributor's statement: MH and FS conceptualized the study with input from all co-authors. FS and MH conducted the analyses, interpreted results. MH drafted the paper with supervision and input from FS and JS. All authors helped with results' interpretation and contributed to drafting and revising the manuscript.

Data sharing: Millennium Cohort Study data are available free of cost to researchers from the UK Data Service website (https://www.ukdataservice.ac.uk/).

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TABLES and FIGURES

Table 1: Criteria used to define anorexia nervosa

No.	Millennium Cohort Study questions age 14	Answers	Answer used to define anorexia nervosa
1	*Which of the following are you trying to do about your weight?*	(1) Lose weight (2) Gain weight (3) Stay the same weight (4) I am not trying to do anything about my weight	Lose weight
2	*Have you ever exercised to lose weight or to avoid gaining weight?*	(1) Yes (2) No	Yes
3	*Have you ever eaten less food, fewer calories, or foods low in fat to lose weight or to avoid gaining weight?*	(1) Yes (2) No	Yes
4	*How often do you eat breakfast over a week?*	(1) Never (2) Some days, but not all days (3) Every day	Never
5	*Which of these do you think you are?*	(1) Underweight (2) About the right weight (3) Slightly overweight (4) Very overweight	Slightly overweight or very overweight
6	*How do you feel about the way you look?*	On a scale of 1 to 7 where '1' means completely happy and '7' means not at all happy	≥ 4[a]
	Millennium Cohort Study physical health age 14	**Categories**	***Category used to define anorexia nervosa***
7	*Age- and sex-standardised BMI at age 14*	(1) Underweight (2) Normal weight (3) Overweight (4) Obese	Underweight or Normal BMI

[a] median value

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548 **Table 2: criteria used to define anorexia nervosa in MCS against DSM-5 criteria**

DSM 5 anorexia nervosa criteria	***Questions used***
Restriction of food intake leading to weight loss or a failure to gain weight resulting in a "significantly low body weight" of what would be expected for someone's age, sex, and height.	1, 2, 3, 4, 6, 7
Fear of becoming fat or gaining weight.	1, 5
Have a distorted view of themselves and of their condition	5, 6, 7
Criteria for Atypical Anorexia nervosa	
All criteria are met, except despite significant weight loss, the individual's weight is within or above the normal range.	7

549 **Table 3: sample characteristics (n=15,896)**

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		Emotion regulation intercept	p-value	Emotion regulation slope	p-value
	n (%)	Mean (SD)		Mean (SD)	
Child's sex					
Male	8,110 (51.0%)	4.57 (1.52)		-0.19 (0.16)	
Female	7,786 (49.0%)	4.30 (1.47)	<0.0001	-0.21 (0.16)	<0.0001
Child's ethnicity					
White	13,432 (84.5%)	4.41 (1.52)		-0.20 (0.16)	
Black	516 (3.3%)	4.34 (1.35)		-0.19 (0.15)	
South Asian	1,303 (8.2%)	4.76 (1.30)		-0.19 (0.15)	
Mixed	460 (2.9%)	4.53 (1.50)		-0.19 (0.16)	
Other	185 (1.1%)	4.56 (1.31)	<0.0001	-0.18 (0.14)	0.018
Thirds of child's mental health difficulties scores at age 3 years					
1st (lowest symptoms)	5,358 (39.3%)	3.39 (1.17)		-0.20 (0.15)	
2nd	3,944 (28.7%)	4.45 (1.21)		-0.21 (0.17)	
3rd (highest symptoms)	4,318 (31.7%)	5.57 (1.27)	<0.0001	-0.20 (0.17)	0.047
Parents' highest social class					
Manual	5,459 (36.3%)	4.13 (1.47)		-0.21 (0.16)	
Non-manual	9,572 (63.7%)	4.89 (1.44)	<0.0001	-0.19 (0.15)	<0.0001
Fifths of family weekly income					
1st (lowest income)	3,724 (23.5%)	4.99 (1.44)		-0.18 (0.16)	
2nd	3,464 (21.8%)	4.67 (1.46)		-0.20 (0.16)	
3rd	3,053 (19.3%)	4.34 (1.45)		-0.21 (0.16)	
4th	2,925 (18.5%)	4.08 (1.43)		-0.21 (0.16)	
5th (highest income)	2,687 (16.9%)	3.88 (1.44)	<0.0001	-0.22 (0.16)	<0.0001
Child's BMI at age 3 years					
Normal weight (incl. underweight)	10.138 (76.1%)	4.38 (1.52)		-0.20 (0.16)	
Overweight	2,423 (18.2%)	4.42 (1.48)		-0.21 (0.17)	
Obese	756 (5.7%)	4.52 (1.50)	0.027	-0.19 (0.16)	0.053
Thirds of maternal Kessler-6 depression score					
1st (lowest symptoms)	5,175 (40.3%)	3.99 (1.44)		-0.21 (0.16)	
2nd	4,449 (34.6%)	4.37 (1.47)		-0.21 (0.16)	
3rd (highest symptoms)	3,229 (25.1%)	5.00 (1.50)	<0.0001	-0.20 (0.17)	0.0001
Thirds of paternal Kessler-6 depression score					
1st (lowest symptoms)	3,684 (41.4%)	4.14 (1.46)		-0.22 (0.16)	
2nd	2,537 (28.5%)	4.23 (1.50)		-0.21 (0.17)	
3rd (highest symptoms)	2,682 (30.1%)	4.48 (1.54)	<0.0001	-0.20 (0.17)	<0.0001
Child's birthweight					
Low birthweight	1,093 (6.9%)	4.43 (1.50)		-0.20 (0.16)	
Normal birthweight	14,760 (93.1%)	4.68 (1.46)	<0.0001	-0.19 (0.16)	0.005
Gestational age					
Preterm	1,161 (7.4%)	4.42 (1.50)		-0.20 (0.16)	
At term	14,547 (92.6%)	4.57 (1.49)	0.002	-0.19 (0.16)	0.044

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Table 3: Continued from previous page

		Emotion regulation intercept	p-value	Emotion regulation linear slope	p-value
	n (%)	Mean (SD)		Mean (SD)	
Maternal pre-pregnancy BMI					
Underweight	814 (5.6%)	4.76 (1.52)		-0.20 (0.15)	
Normal weight	9,539 (65.4%)	4.34 (1.51)		-0.21 (0.16)	
Overweight	2,952 (20.2%)	4.50 (1.51)		-0.20 (0.17)	
Obese	1,291 (8.8%)	4.60 (1.52)	<0.0001	-0.19 (0.17)	0.008
Maternal highest academic qualification					
Compulsory	10,218 (64.5%)	4.71 (1.47)		-0.20 (0.16)	
Non-compulsory	5,616 (53.5%)	3.95 (1.44)	<0.0001	-0.21 (0.16)	<0.0001
Maternal age at child's birth					
14 – 20 years	1,389 (8.7%)	5.13 (1.38)		-0.18 (0.15)	
21 – 30 years	7,368 (46.5%)	4.66 (1.47)		-0.20 (0.16)	
31 – 40 years	6,793 (42.8%)	4.08 (1.47)		-0.21 (0.16)	
>40 years	309 (2.0%)	3.88 (1.48)	<0.0001	-0.22 (0.17)	<0.0001
Housing tenure					
Own	9,852 (60.4%)	4.15 (1.45)		-0.21 (0.16)	
Rent	5,327 (33.6%)	4.91 (1.48)		-0.19 (0.16)	
Live rent free/other	957 (6.0%)	4.81 (1.39)	<0.0001	-0.20 (0.16)	<0.0001
Maternal smoking in pregnancy					
Never smoked	10,231 (64.5%)	4.23 (1.47)		-0.21 (0.16)	
Smoked but stopped	2,026 (12.7%)	4.60 (1.45)		-0.20 (0.16)	
Smoked throughout	3,618 (22.8%)	4.94 (1.48)	<0.0001	-0.19 (0.16)	<0.0001
Child was ever breastfed					
No	5,025 (31.7%)	4.73 (1.49)		-0.20 (0.16)	
Yes	10,838 (68.3%)	4.31 (1.48)	<0.0001	-0.20 (0.16)	0.017
Thirds of British Ability Scale language score					
1st (lowest scores)	4,769 (35.1%)	4.76 (1.50)		-0.20 (0.16)	
2nd	5,663 (41.6%)	4.31 (1.49)		-0.21 (0.16)	
3rd (highest scores)	3,165 (23.3%)	3.99 (1.46)	<0.0001	-0.21 (0.16)	<0.0001
Thirds of Bracken school readiness score					
1st (lowest scores)	4,369 (33.8%)	4.83 (1.50)		-0.20 (0.16)	
2nd	4,371 (33.8%)	4.32 (1.49)		-0.21 (0.16)	
3rd (highest scores)	4,195 (32.4%)	3.99 (1.45)	<0.0001	-0.21 (0.16)	0.0001
Thirds of maternal attachment score					
1st (lowest scores)	6,077 (45.5%)	4.53 (1.49)		-0.20 (0.16)	
2nd	4,055 (30.4%)	4.38 (1.51)		-0.21 (0.16)	
3rd (highest scores)	3,215 (24.1%)	4.30 (1.50)	<0.0001	-0.21 (0.16)	0.010

Abbreviations: BMI= body mass index, SD=standard deviation
Details on all scales used to measures these variables are provided in *e-method 2*

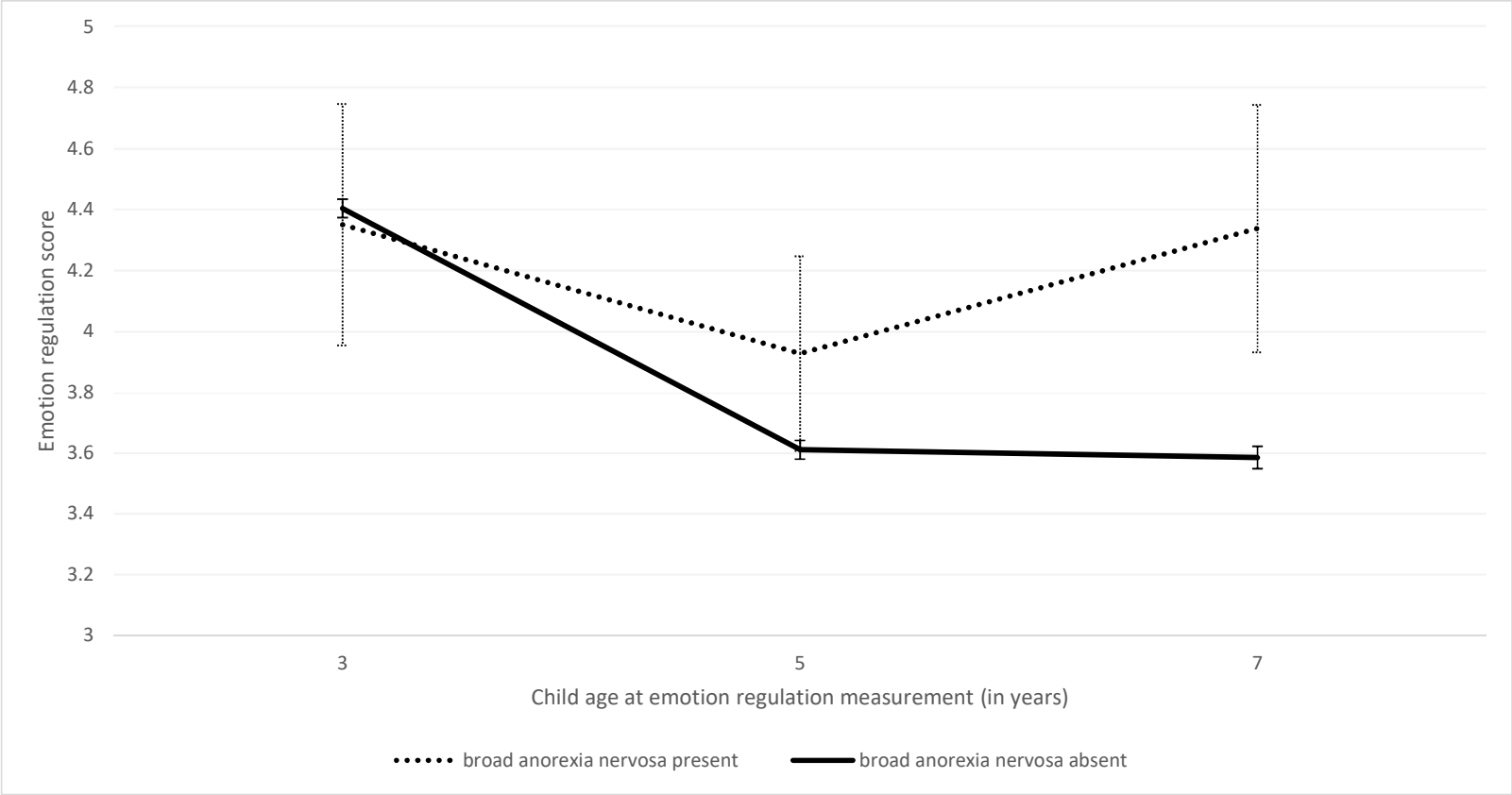
Table 4: Results of univariable and multivariable logistic regression models testing the association between increases in emotion regulation *intercept* and *slope* and anorexia nervosa at age 14 years. Based on participants with complete exposure and imputed confounder[a] and outcome data (n=15,896)

	Anorexia nervosa, 14 years Odds Ratio (95% confidence intervals), p-value
Emotion regulation intercept	
Univariable model	1.19 (0.94 to 1.48) p=0.144
Adjusted model 1: child's sex and ethnicity	1.27 (1.00 to 1.62) p=0.043
Adjusted model 2: model 1 + birth-weight, gestational age, breastfeeding status; self-regulation, language score, school readiness at age 3	1.29 (1.00 to 1.67), p=0.045
Adjusted model 3: model 2 + family socio-economic status[b]	1.23 (0.93 to 1.64), p=0.165
Adjusted model 4: model 3 + maternal pre-pregnancy BMI, smoking in pregnancy, maternal and paternal depression, maternal attachment	1.21 (0.91 to 1.63), p=0.185
Emotion regulation slope	
Univariable model	1.40 (1.13 to 1.74), p=0.002
Adjusted model 1: child's sex and ethnicity	1.48 (1.19 to 1.85), p=0.001
Adjusted model 2: model 1 + self-regulation & mental health scores, language score, school readiness, and BMI at age 3 years; gestational age, birthweight, breastfeeding status	1.48 (1.18 to 1.85), p=0.001
Adjusted model 3: model 2 + family socio-economic status[b]	1.47 (1.17 to 1.84), p=0.001
Adjusted model 4: model 3 + maternal pre-pregnancy BMI, maternal smoking in pregnancy, maternal & paternal depression, maternal attachment	1.47 (1.17 to 1.84), p=0.001
Adjusted model 5: model 4 + emotion regulation intercept	1.45 (1.16 to 1.83), p=0.001

[a] Details on all scales used to measures confounder variables are provided in *e-method 2*

[b] includes maternal education and age, highest parental social class, weekly family OECD equivalised income, and housing tenure.

Figure 1: trajectories of emotion regulation derived from multilevel growth curves models conducted as sensitivity analyses. Trajectories are estimated from Model 3 presented in e-Table 8 (n=15,896).



Error bars represent 95% confidence intervals; higher scores on the emotion regulation scale indicate greater difficulties regulating emotions.