Self-regulation and household routines at age three and obesity at age eleven: longitudinal analysis of the UK Millennium Cohort Study

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ABSTRACT

Objective: To examine, in a population-based cohort of three-year-old children, the association between self-regulation and exposure to the household routines of regular bedtime, regular mealtime, and limits on watching television/video; and to determine whether self-regulation and these routines predict the risk of obesity at age 11.

Methods: Analyses included 10 955 children in the nationally-representative UK Millennium Cohort Study. When children were age 3, parents reported whether children had a regular bedtime and mealtime and the amount of television/video watched. Emotional and cognitive self-regulation at age 3 were assessed by parent-report with the Child Social Behaviour Questionnaire. Children's height and weight were measured at age 11 and obesity was defined using the International Obesity Task Force (IOTF) criteria.

Results: At age 3, 41% of children always had a regular bedtime, 47% always had a regular mealtime, and 23% were limited to ≤1 hour television/video daily. At age 11, 6.2% of children were obese. All three household routines were significantly associated with better emotional self-regulation, but not better cognitive self-regulation. In a multi-variable logistic regression model including emotional and cognitive self-regulation, all routines, and controlling for sociodemographic covariates, a 1 unit difference in emotional self-regulation at age 3 was associated with an OR (95% CI) for obesity of 1.38 (1.11, 1.71) at age 11, and inconsistent bedtimes with an OR (95% CI) for obesity of 1.87 (1.39, 2.51) at age 11. There was no evidence that emotional self-regulation mediated the relationship between regular bedtimes and later obesity. Cognitive self-regulation was not associated with later obesity.

Conclusions: Three-year-old children who had regular bedtimes, mealtimes, and limits on their television/video time had better emotional self-regulation. Lack of a regular bedtime and poorer emotional self-regulation at age 3 were independent predictors of obesity at age 11.

INTRODUCTION

Young children benefit from having household routines around sleep and meals and limits on television/video time.[1-3] These routines have been linked to a reduced risk of childhood obesity[4-9] and better self-regulation.[1, 10] At the same time, poor self-regulation in early childhood has been associated with increased risk for overweight and obesity in late childhood,[11-13] and adulthood.[14] However, no prospective studies have examined how both household routines and self-regulation in early childhood predict later obesity.

Self-regulation is a complex, multi-dimensional construct, that encompasses both emotional and cognitive processes that modulate arousal and attention, thereby enabling goal-directed behavior.[15, 16] Although overlapping and interrelated in young children, emotional and cognitive self-regulation have different developmental trajectories.[16] The neurobiology of emotion and appetite are both centered in the subcortical limbic structures of the brain,[17, 18] while the more cognitive processes of self-regulation are based in the prefrontal cortex, which matures much later in development.[19, 20] Obesity researchers have recently begun differentiating between emotional and cognitive self-regulation,[21-23] and childhood obesity prevention strategies that target supporting the development of self-regulation may need to account for the relative immaturity of cognitive self-regulation processes in young children. To our knowledge the relationship of both emotional and cognitive aspects of self-regulation to the development of obesity has not been examined prospectively in a population-based cohort.

Through longitudinal analyses of the UK Millennium Cohort Study (MCS), we investigate whether emotional and cognitive self-regulation are related to household routines in early childhood and how both self-regulation and routines predict later obesity. We hypothesize that 3-year-old children with household routines will have better self-regulation at age 3 and lower risk for obesity at age 11, and that poor self-regulation will explain part of the relationship between the lack of household routines and obesity.

METHODS

The Millennium Cohort Study (MCS)

The MCS is a prospective, longitudinal study of a representative sample of children born into 19 244 families in the United Kingdom (UK) between September 2000 and January 2002. All children born during this time frame who were alive and living in the UK at 9 months of age were eligible for the study. However, the sample was selected from the Child Benefit register maintained by the Department of Social Security, and although almost all children receive the Child Benefit, a small number of children of recent immigrants and non-national temporary residents (e.g., foreign students) are ineligible.[24] A clustered, stratified design was used with oversampling to ensure representation of children living in areas of high poverty or with large ethnic minority populations in England. Details of the design and procedures have been published elsewhere.[25] The first study visit occurred when children were 9-months-old with follow-up visits at ages 3, 5, 7, and 11 years. All visits were conducted in the home by trained, computer-assisted interviewers.[25] The MCS was reviewed and approved by appropriate research ethics committees at each cycle of data collection, and parents provided written informed consent for all components of MCS. At the age 11 follow-up (MCS 5), children also provided informed consent.[25] De-identified data files were downloaded from the UK data archive in October 2015.[26, 27]

Household routines at age 3

Information about household routines at age 3 was reported by primary caregivers (>98% biological mothers) during the computer-assisted personal interview. Specifically, parents were asked, “Does [child’s name] go to bed at regular times?“ and “Does [child’s name] have meals at regular times?” with response options of “Never or almost never”, “Sometimes”, “Usually”, or “Always”.[28] Those with responses of “always” were coded as having a regular bedtime and/or mealtime routine. Responses of “sometimes” or “almost never or never” were indicative of inconsistent bedtime or mealtime routines. Children’s typical daily television/video time was assessed with the question, “Typically, how many hours a day does [child’s name] watch television or videos? Would you say Not at all, Up to 1 hour, More than 1 hour–less than 3 hours, or More than 3 hours”.

Those with responses of "not at all" or "up to 1 hour" were coded as having the routine of limited television/video viewing.

Child self-regulation at age 3

During the self-completion module of the parent-interview at age 3, parents completed 10 items from the Child Social Behaviour Questionnaire,[29, 30] which was adapted from the Adaptive Social Behavior Inventory.[31] The parent was directed to think about their child's behaviour during the past 6 months and to choose whether each statement was: Not true (1), Somewhat true (2), Certainly true (3), or Can't say (4). Responses of "Can't say" were treated as missing in our analyses. The scale labeled "emotional dysregulation" contains five items related to emotional self-regulation (e.g., "is easily frustrated"). The scale labeled "independence and self-regulation" contains five items related to cognitive self-regulation (e.g., "persists in the face of difficult tasks"). Emotional self-regulation and cognitive self-regulation scores were calculated as the average response to the items completed within each scale; a score was not calculated if more than 2 items were missing. Cronbach's coefficient alpha was used to assess internal consistency reliability.[32] All items of the cognitive self-regulation scale were worded such that a higher score indicates that the child had better self-regulation. Cronbach's alpha was 0.57 for this scale. Four of the 5 items of the emotional self-regulation scale are worded such that a higher score indicates that the child has more challenges regulating emotion; a fifth item was reverse coded. Cronbach's coefficient alpha for the 5 items in the scale was 0.63, but the reverse coded item was only weakly correlated with the others (Cronbach's alpha was 0.70 for the 4-items) and thus we elected to use the average score across these 4 items as our measure of emotional self-regulation. However, our findings were not meaningfully different using the 5-item score (results not shown), and the correlation of scores using 4 items or 5 items was very high (r=0.96). Wording and response distributions for the Child Social Behaviour Questionnaire are provided in the **Appendix.**

Obesity at age 11

Children's height and weight, without shoes and wearing light clothing, were measured by trained interviewers using standardized protocols. Standing height was measured with heels together and head in the Frankfurt plane using a Leicester stadiometer and recorded to the nearest millimeter. Weight was measured using a Tanita BF-522W scale.[33] Body mass index (BMI) was calculated as kg/m^2. The revised IOTF age- and sex-specific LMS values were used to determine BMI z-scores;[34] LMS values are provided at 6 month intervals and we used linear interpolation to estimate LMS values to whole months for each sex.[34] The distribution of BMI z-scores was examined and children with BMI z-scores below -5 (n=4) or above 5 (n=0) were set to missing. Obesity at age 11 (MCS 5) was defined as a BMI z-score at or above the centile passing through BMI=30 at age 18 years.[34]

Covariates

Covariates were used in regression models to control for potential confounding and in stratified analyses to describe differences in prevalence of obesity and household routines by population sociodemographic characteristics. Children's age at each sweep was calculated based on their birth month and year, the date of the main parent-interview at MCS 2 and the date of child measurement at MCS 5. Birth weight in grams was reported by the main parent respondent at enrollment. Household income and household size (including the number of siblings the child had) were reported by parents at MCS 2; MCS used interval regression to impute missing income data and calculated quintiles of OECD equivalized household income which are included in the deposited data.[25] Parental age at the time of the child's birth was determined for the 'main' parent respondent; this was the child's natural mother for >98% of children, the natural father for approximately 1% of children, and another primary caregiver (e.g., adoptive mother) in fewer than 50 cases. The child's parent-reported main ethnicity was classified as 'White', 'Mixed', 'Indian', 'Pakistani and Bangladeshi', 'Black or Black British', or 'Other ethnic group' using the 6-category census classification.[29] The highest academic and vocational qualifications achieved by either parent at MCS 2 was used to define parental education; classifications were made according to the National Vocational Qualifications (NVQ) framework.[29] The country (England, Wales, Scotland, Northern Ireland) in which the child resided at 9 months was also used as a covariate.

Statistical Analyses

The MCS is designed to allow inference to the population of children born September 2001-January 2002 and living in the UK when 9 months old. All analyses utilize survey weights that adjust for unequal probabilities of selection and survey non-response; variance estimates are adjusted for stratification and clustering of the sample design.[25] Analyses were conducted using SAS version 9.4 (SAS Institute Inc, Cary, NC). Statistical tests are 2-sided and the alpha level was 0.05.

Our analysis included all singleton births (n=18 982) whose parent was interviewed at MCS 2 (n=15 382), and who had BMI at age 11 (n=11 592). A further 597 children (5%) were excluded for having missing information on self-regulation. The final analytic sample included data from 10 995 children and their families. We used design-corrected median tests[35] and Rao-Scott design-corrected chi-square tests to compare sociodemographic characteristics of children in the analytic sample to those who participated in MCS 2 but were excluded from our analyses due to missing information (n=4 387). Rao-Scott design-corrected chi-square tests were used to compare the prevalence of the three household routines (regular bedtime, regular mealtime, and <1 hour per day television/video viewing) and obesity across levels of each sociodemographic characteristic.

To examine the relationship between routines and self-regulation at age 3 years, we determined the unadjusted mean (95% CI) emotional and cognitive self-regulation score at each level of a given routine. Using linear regression models to adjust for country, child age, sex, birth weight, ethnicity, parent age, education, and household income, we then estimated the adjusted mean difference in self-regulation score comparing the lowest to the highest level of each routine. We also determined the percentage (95% CI) of children who were in the lowest quartile of each self-regulation score across levels of routines and used covariate adjusted logistic regression analyses to estimate the odds ratio of being in the lowest self-regulation quartile among those in the lowest level of each routine compared to those in the highest.

Logistic regression models were used to examine the relationship of routines and self-regulation at age 3 to obesity at age 11. Unadjusted (univariate) models were conducted first. Each routine was modeled separately as a categorical variable with the reference category as “always” for regular bedtime and regular mealtime, and “up to 1 hour/per day” for TV/video viewing. Next, a

model with all three routines was used to determine the independent association of each with obesity. Then, to determine if self-regulation explained the association between routines and obesity, emotional and cognitive self-regulation scores were added to the model as continuous variables. Finally, this model was adjusted for covariates.

RESULTS

Sociodemographic characteristics of the analytic sample are presented in **Table 1**. Children who participated in MCS 2 but were excluded from the analytic sample were more likely to be from ethnic-minority and households with less socioeconomic advantage (Table 1). More than 2 out of 5 children (41.4%) always had a regular bedtime at age 3, almost half (46.6%) always had regular mealtimes, and fewer than 1 in 4 children (23.1%, 95% CI: 21.7-24.5) had daily television/video viewing of 1 hour or less (**Table 2**).

At age 11 years, 6.2% of children were obese (**Table 3**). Differences in obesity prevalence by country and ethnicity were apparent, and obesity was more common at lower levels of parental education and household income. Children who at age 3 had one sibling were less likely to be obese compared to children with none or many siblings. However, similar percentages of boys and girls were obese and obesity was not related to parental age (Table 3). Distribution of household routines by sociodemographic characteristics are shown in Table 3. Boys and girls did not differ in their exposure to any of the routines. Always having regular mealtimes was more common in Northern Ireland, but regular bedtimes and limited television/video viewing did not differ by country. With the exception that limited television/video viewing was unrelated to ethnicity, all other sociodemographic characteristics were related to the prevalence of always having a regular bedtime, always having a regular mealtime, and limited TV/video. A social gradient was evident for regular bedtime and limited TV/video viewing with these routines more common in families with higher income and more education (Table 3).

The mean (standard error of measurement, SEM) of the emotional self-regulation score was 2.0 (0.009) and the median (inter-quartile range, IQR) was 1.9 (1.5 – 2.3); the mean (SEM) and median (IQR) for the cognitive self-regulation score was, respectively, 2.5 (0.005) and 2.4 (2.1 – 2.8). The correlation between self-regulation scores was r= -0.05. All 3 routines were associated with significantly better emotional self-regulation, but only regular mealtimes were associated with significantly better cognitive self-regulation (**Table 4**).

To understand the combined influence of routines and self-regulation on risk for obesity we conducted a series of logistic regression analyses (**Table 5**). In unadjusted (univariate) models, children

with inconsistent bedtimes at age 3 were more likely [OR (95% CI) = 2.18 (1.70-2.79)] than children who always had a regular bedtime to be obese at age 11, and compared to children limited to an hour per day of TV/video viewing, those with the highest viewing times (>3 hours/day) had an OR (95% CI) for obesity of 1.39 (1.03, 1.88). Regular mealtimes were not associated with obesity at age 11 in univariate analyses. Poorer emotional self-regulation predicted obesity at age 11 (OR for 1 unit difference was 1.50, P<.001 in univariate analyses), but cognitive self-regulation was not related to obesity at age 11 (OR = 0.87, P=.30). To investigate the extent to which any association between household routines at age 3 and obesity at age 11 was mediated by self-regulation, we compared a model containing all three routines (Table 5, model B) to one that also included emotional and cognitive self-regulation scores (model C). In the presence of a strong mediator the association between routines and obesity would be attenuated, but we found that the parameter estimates were not greatly changed. Poorer emotional self-regulation and inconsistent bedtimes were independently associated with higher odds for obesity. This remained true with further adjustment for covariates; in the fully-adjusted analysis (model D), inconsistent bedtimes and poorer emotional self-regulation (1-unit difference) were, respectively, associated with an OR (95% CI) for obesity of 1.87 (1.39, 2.51) and 1.38 (1.11, 1.71). There was no evidence that television/video viewing or cognitive self-regulation predicted obesity. However, in contrast to our hypotheses, not always having a regular mealtime at age 3 was associated with lower odds for obesity at age 11 (Table 5, model D).

DISCUSSION

In this large nationally representative study of children born in the UK, we found that the household routines of having regular bedtimes and mealtimes and limits on television/video viewing were associated with better emotional self-regulation in 3-year-old children. Poorer emotional self-regulation predicted an increased risk for obesity at age 11, but this was not the case for cognitive self-regulation. The lack of a regular bedtime and poorer emotional self-regulation at age 3 were independent predictors of obesity at age 11, and self-regulation did not appear to account for the association between the bedtime routine and obesity. Also in contrast to our hypotheses, children with inconsistent mealtimes at age 3 were less likely to be obese at age 11, and television/video viewing was not related to obesity after accounting for other routines.

This is the first prospective analysis of the relationship between household routines and self-regulation in young children and how these factors work together to predict obesity. The large, representative sample of UK children born close to the new millennium increases the generalizability of our findings. Our objective in this analysis was to understand how three household routines that are frequently recommended for families with young children,[2] and which much prior research has suggested are associated with lower prevalence of obesity,[4-8] are themselves related to young children's self-regulation. This analysis adds to the literature by demonstrating a prospective association between emotional self-regulation in early childhood and obesity in later childhood in a large recent population-based sample.

A number of studies of self-regulation and risk for weight gain or obesity in children have been conducted.[11-14, 36, 37] In the US Study of Early Child Care and Youth Development (SECCYD) in which ~1200 children born in 1991 were studied through adolescence, preschool-aged children with poorer self-regulation in the domains of observed inhibitory control and delay of gratification had greater weight gain and risk for overweight.[11, 12] Graziano and colleagues[13, 36] studied emotion regulation, inhibitory control, and sustained attention in two-year-old children in relation to weight status later in childhood; poorer emotion regulation was associated with greater weight gain between age 2 and 5.5 years and predicted overweight at 5.5 years.[36] Further, overweight 10-year-old children had lower

levels of overall self-regulation at age 2 than their healthy weight peers.[13] Greater ability to delay gratification in early childhood has also been linked to lower BMI in adulthood.[14]

The contribution of self-regulation to many positive outcomes other than healthy weight has been well-established by early childhood educators and developmental scientists,[38, 39] but there is not consensus about how to label or characterize aspects of self-regulation.[40] It is also uncertain whether self-regulation in eating differs from self-regulation in non-eating behaviors. Miller and colleagues[22] investigated behavioral and emotional self-regulation in food and non-food related contexts among 133 toddlers from low-income families and examined cross-sectional associations with children's weight. They found that toddlers who displayed better emotional regulation in both food and non-food tasks had lower risks for overweight/obesity, but better behavioral regulation was associated with lower risk of obesity for only the food task.[22] In early childhood, it is difficult to disentangle the relative contributions of emotional and cognitive self-regulation and their joint contribution to observed behavioral self-regulation. Interventions in young children designed to improve self-regulation by focusing on cognitive strategies may be limited by the relative neurobiological immaturity of cognitive versus emotional systems. This may also explain why we found stronger associations between emotional self-regulation at age 3 and later obesity.

Of the three household routines we examined, having a regular bedtime was most strongly associated with risk for obesity. This finding adds to a large literature on the importance of adequate sleep for childhood obesity prevention.[41-43] Children who have a regular bedtime routine also have earlier bedtimes, sleep more, fall asleep faster, have fewer nighttime awakenings, and are less likely to have behavior problems.[44] We found a stepwise relationship between regularity of bedtime and risk for obesity; compared to 'always' having a regular bedtime, even children who 'usually' had a regular bedtime had a statistically significantly elevated risk for obesity and the risk for obesity was even higher in children with inconsistent bedtimes.

Limiting young children's television and video viewing is recommended for numerous reasons that include and go beyond obesity prevention.[8, 45] Our results are consistent with high levels (3 or more hours daily compared to 1 or fewer hours) of television/video viewing in young children predicting higher odds of obesity, but this finding did not persist after controlling for the other

routines. Nevertheless, measurement of television and video viewing was imprecise and did not include time spent using computers. Children in MCS were not exposed to smart phones or tablet computers in early childhood.

Our result of lower risk for obesity associated with *not* 'always' having regular mealtimes at age 3 was unexpected. In fully adjusted models, obesity risk was lower for children who usually had regular mealtimes as well as for children with inconsistent mealtimes. It is important to note that almost half (47%) of children always had regular mealtimes, slightly fewer (44%) usually had regular mealtimes, and fewer than 1 in 10 had inconsistent mealtimes. In post-hoc analyses we explored how mealtime regularity was related to bedtime regularity and whether this could explain our results. For example, if the percentage of children who 'always' had regular bedtimes was lower among children who had inconsistent mealtimes compared to children who always had regular mealtimes then adjusting for bedtime might explain why inconsistent mealtimes reduced risk for obesity. However, this was not what we observed in the data; children who always had regular mealtimes were more likely to always have regular bedtimes.

This research should be interpreted in the context of the following limitations: first, as with any observational study, causality cannot be inferred. Second, the MCS is a large, population-based study designed to be representative of children born early in the new millennium and living in the UK as infants, and findings may not be generalizable to earlier or later born cohorts or children in other countries. Third, household routines and child self-regulation at age 3 were measured imprecisely and by parent-report; thus our analyses are impacted by measurement error and may be biased by social desirability.[46] Fourth, the measure of children's self-regulation, the Child Social Behaviour Questionnaire, had only modest internal reliability in this sample. This was particularly true for the cognitive self-regulation scale and that could explain the lack of association with obesity. In addition, there are only three response options on the Child Social Behaviour Questionnaire and the distribution of responses, particularly to the cognitive self-regulation items was highly skewed. The items on cognitive self-regulation focus on independence, persistence, and task changing; whether these items assess a unitary construct in 3-year-old children is uncertain. Fifth, children's height and weight were measured and obesity categorized based on the IOTF sex-specific BMI centile associated

with an adult BMI of 30. The sensitivity and specificity of the IOTF obesity definition for identifying high levels of adiposity in children has been evaluated,[47] and although the specificity is high, the sensitivity is moderate.[47] Thus, most children classified as obese by the IOTF definition have high levels of adiposity, but other children with high levels of body fat may not be defined as obese. Sixth, although we controlled for potentially confounding child and family characteristics, these were measured imprecisely, and other confounding factors could be important; thus bias due to confounding cannot be eliminated.

Our finding that emotional self-regulation and household routines at age 3 are associated and that these are independent predictors of obesity at age 11 is consistent with a conceptual framework in which children's emotion regulation develops within a family context that includes routines. Another important aspect of this family context includes socioeconomic circumstances. We found, as have others,[4, 48] that parental education and household income were strong predictors of whether preschool-aged children had routines around bedtime, mealtime, and limits on screen time. Parenting is more challenging when resources are limited; in addition to fewer routines and less structure, children living in poverty are more likely to experience the types of parental interactions that can undermine attachment security (i.e., harsh, inconsistent, mistimed, frightening).[49] The capacity of a child to regulate his/her emotions and behavior, particularly in the context of stress, is supported by having a secure pattern of attachment with a parent or caregiver.[50, 51] Both insecure attachment and poor-quality parent-child interactions have been linked to obesity risk in prospective studies of US children.[52-54] How all these, and other, aspects of the early childhood family environment come together to influence children's weight status is an area of active inquiry.[5, 7, 21-23] Consistent with other research,[41, 44] our study provides additional evidence of the benefit of supporting parents in establishing and maintaining a regular bedtime routine for their young children. More research is needed on how and whether the timing and regularity of children's mealtimes impacts obesity risk. Inconsistent mealtimes could, for example, be associated with a confounding factor such as greater family participation in physical activity, or always having regular mealtimes could be associated with eating meals later in the evening.[55] Alternatively, genetic effects on appetite and enjoyment of food could be correlated with weight status and influence the relative importance families place on

mealtime routines. Much is not understood about how the development of emotional and cognitive self-regulation intersects with metabolic, behavioral, and social pathways to obesity among children. Such research is needed to inform development of any public health strategies targeting early childhood obesity prevention.

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Table 1: Sociodemographic characteristics of analytic sample compared to participants who were not included in analytic sample

Characteristic		Analytic sample (n=10995)	Not in analytic sample (n=4387)	P value[a]
Age	**N**[b]	**Median (IQR) or weighted percent**[c]		
Child (mo) at MCS 2[d]	10995	36.8 (36.3, 37.7)	37.0 (36.3, 38.3)	<.001
Child (mo) at MCS 5[d]	10995	134.0 (130.9, 137.0)	134.0 (131.0, 137.0)[e]	0.11
Main parent (yr) at child's birth[f]	10995	29.0 (24.7, 32.8)	27.7 (22.3, 31.9)	<.001
Birth weight (grams)[g]	10595	3397 (3054, 3738)	3349 (3028, 3700)	<.001
Country				
England	7016	83.0	81.9	0.03
Wales	1649	5.0	4.7	
Scotland	1259	8.4	9.9	
Northern Ireland	1071	3.6	3.5	
Child's Sex				
Male	5557	50.3	52.5	0.07
Female	5438	49.7	47.5	
Child's ethnicity[g]				
White	9484	88.9	79.9	<.001
Black	271	2.2	4.5	
Indian	245	1.6	2.6	
Pakistani/Bangladeshi	536	3.3	7.2	
Mixed	290	2.9	4.0	
Other	126	1.1	1.8	
Highest parental education[g]				
NVQ 5 (highest)	907	8.2	5.5	<.001
NVQ 4	4154	39.2	27.6	
NVQ 3	1814	16.0	14.6	
NVQ 2	2611	24.2	27.4	
NVQ 1	581	5.1	7.8	
Overseas qualifications only	196	1.5	3.2	
None of the above	721	5.9	14.0	
Household income quintile[g]				
Highest	2174	22.0	14.7	<.001
4	2208	21.1	16.8	
3	2230	20.6	18.5	
2	2251	18.6	23.5	
Lowest	2107	17.7	26.5	

[a] P values from Rao-Scott design-corrected chi-square and design-corrected median tests.[32]
[b] Unweighted N in analytic sample.
[c] Estimates are weighted. Percentages may not sum to 100 due to rounding.
[d] Age (y) at MCS 2 in analytic sample: mean (SD)=3.1 (0.2); range=2.7 - 4.5; 77% assessed at 36m ±1m. MCS 5: mean (SD) age=11.2 (0.4) y; range= 10.2 - 12.3; 25% assessed at 132 months ±1m.
[e] Information available at MCS5 for 962 of 4387 (22%) children not in analytic sample.
[f] Parent age (y) at child's birth in analytic sample: mean (SD)=28.4 (6.7); range=14 - 58; <25 y=27.1%, 25-<30y=28.2%, 30-<35y=28.5%, ≥35 y=16.2%.
[g] Information missing in analytic sample for the following covariates: birth weight (n=400), child's ethnicity (n=43), parental education (n=11), household income quintile (n=25).

Table 2: Bedtime and mealtime regularity and typical daily television/video viewing for 3 year-olds in the UK Millennium Cohort Study

	N[a]	Percentage[b]	95% CI[c]
Regular bedtime			
Always[d]	4558	41.4	40.1, 42.8
Usually	4196	37.4	36.0, 38.8
Sometimes	1442	13.6	12.7, 14.5
Never or almost never	799	7.6	6.8, 8.3
Regular mealtimes			
Always[d]	5216	46.6	45.0, 48.3
Usually	4812	44.3	42.7, 45.9
Sometimes	760	7.0	6.4, 7.6
Never or almost never	207	2.1	1.7, 2.5
Typical television/video time			
None[d]	136	1.1	0.9, 1.4
Up to an hour[d]	2479	22.0	20.6, 23.3
>1 to <3 hours	6470	58.6	57.3, 59.9
3 or more hours	1910	18.3	17.1, 19.5

[a] Unweighted N.
[b] Percentages are weighted and may not sum to 100 due to rounding.
[c] 95% confidence intervals account for complex sample design.
[d] Defines positive household routine.

Table 3: Distribution of household routines at age 3 and prevalence of obesity at age 11 by sociodemographic characteristics in the UK Millennium Cohort Study

Characteristic	Household Routine at Age 3[a]			Obesity[b] prevalence at Age 11
	Always regular bedtime	Always regular mealtime	TV/video limited to max of 1 hour/day	
Total	41.4	46.6	23.1	6.2
Parent age at child's birth				
≥35 years	34.7	40.9	29.7	6.1
30 - <35 years	43.7	48.2	27.8	6.0
25 - <30 years	43.7	49.1	21.2	5.8
<25 years	40.7	45.8	16.3	6.7
P value[c]	<.001	<.001	<.001	.70
Country				
England	41.5	46.1	23.0	6.1
Wales	45.2	50.8	21.1	8.2
Scotland	39.9	45.6	23.8	4.9
Northern Ireland	38.9	54.2	26.3	7.9
P value[c]	.14	.002	.33	.02
Child's Sex				
Male	41.2	46.9	22.5	6.0
Female	41.7	46.4	23.8	6.4
P value[c]	.68	.68	.14	.39
Child's ethnicity				
White	42.6	47.5	22.9	5.8
Black	22.3	36.3	24.1	13.6
Indian	40.0	47.8	23.2	4.1
Pakistani/Bangladeshi	36.1	39.2	28.0	10.1
Mixed	36.4	44.2	26.0	8.5
Other	26.9	30.4	19.9	3.4
P value[c]	<.001	<.001	.49	<.001
Number of siblings				
None	36.5	43.8	21.4	6.8
One	46.4	48.1	23.0	5.3
Two or more	37.5	46.7	24.9	7.0
P value[c]	<.001	.007	.04	.02
Highest parental education				
NVQ 5 (highest)	50.4	50.5	44.0	1.8
NVQ 4	45.6	47.2	26.7	4.5
NVQ 3	41.5	48.7	19.2	6.4
NVQ 2	37.3	45.3	18.1	7.4
NVQ 1	37.1	46.6	17.9	7.7
Overseas qualifications only	34.1	37.5	21.1	14.2
None of the above	34.0	43.0	19.0	9.6
P value[c]	<.001	.04	<.001	<.001
Household income quintile				
Highest	47.1	45.7	35.4	3.1
4	44.9	49.8	23.2	5.0
3	40.6	47.6	18.8	5.9
2	36.4	44.5	19.9	7.5
Lowest	39.1	45.8	19.6	8.8
P value[c]	<.001	.05	<.001	<.001

[a] Always has regular bedtime; always has regular mealtimes; TV and video ≤1 hour/day.
[b] Body-mass-index from measured height and weight; obesity defined based on IOTF guidelines.
[c] P values from Rao-Scott design-corrected chi-square.

Table 4: Association between household routines and emotional and cognitive self-regulation scores at age 3

	Self-regulation at age 3 [a]			
	Emotional score		Cognitive score	
Household Routine at age 3	Mean (95% CI)[b]	% (95% CI) in least self-regulated quartile[c]	Mean (95% CI)[b]	% (95% CI) in least self-regulated quartile[c]
Overall	2.01 (1.99, 2.02)	25.5 (24.2, 26.9)	2.46 (2.45, 2.47)	29.8 (28.6, 31.0)
Regular bedtime				
Always	1.97 (1.95, 1.99)	24.0 (22.3, 25.8)	2.47 (2.46, 2.49)	28.3 (26.7, 30.0)
Usually	1.98 (1.96, 2.00)	22.8 (21.0, 24.6)	2.45 (2.44, 2.47)	30.1 (28.3, 31.8)
Sometimes, almost never or never	2.13 (2.10, 2.16)	33.3 (30.6, 36.0)	2.44 (2.42, 2.46)	32.2 (29.9, 34.5)
β / OR[d]	β =0.12	OR=0.72	β =-0.02	OR=0.88
P value	P<.001	P <.001	P=.08	P=.07
Regular mealtimes				
Always	1.98 (1.95, 2.00)	24.4 (22.7, 26.1)	2.48 (2.47, 2.49)	26.9 (25.3, 28.5)
Usually	2.00 (1.98, 2.01)	23.7 (22.0, 25.3)	2.44 (2.43, 2.46)	31.8 (30.1, 33.5)
Sometimes, almost never or never	2.21 (2.17, 2.25)	40.5 (36.4, 44.5)	2.42 (2.39, 2.45)	34.8 (31.0, 38.7)
β / OR[d]	β =0.18	OR=0.55	β =-0.04	OR=0.78
P value	P<.001	P<.001	P=.02	P =.009
Typical Daily TV/video time				
Up to an hour	1.91 (1.88, 1.94)	20.8 (18.6, 22.9)	2.46 (2.44, 2.47)	30.8 (28.7, 32.9)
>1 to <3 hours	2.00 (1.98, 2.01)	24.5 (22.9, 26.0)	2.47 (2.45, 2.48)	28.6 (27.1, 30.2)
3 or more hours	2.16 (2.13, 2.19)	34.9 (32.0, 37.8)	2.44 (2.42, 2.46)	32.3 (29.6, 35.0)
β /OR[d]	β =0.12	OR = 0.73	β =-0.004	OR=1.02
P value	P<.001	P=.002	P=.79	P=.83

Millennium Cohort Study sweep 2. Analyses are weighted and variance estimates account for complex sample design.

[a] Child Social Behaviour Questionnaire. Emotional and cognitive self-regulation scores range from 1 to 3. Higher emotion self-regulation scores indicate a child who has more difficulties regulating emotion. Higher cognitive self-regulation scores indicate a child who is more persistent and shows more independence in planning and changing tasks.

[b] Mean (95% CI) self-regulation score at each level of routine, unadjusted for covariates.

[c] Percentage, unadjusted for covariates, in least self-regulated quartile: defined as scores ≥2.5 for emotional self-regulation; ≤2.2 for cognitive self-regulation.

[d] Estimates from multi-variable adjusted linear regression and logistic regression models. Covariates = country, child age, siblings, sex, ethnicity, birth weight, parent age, education, household income. Routines modeled as categorical variables. β / OR and P value for contrast of highest to lowest routine level adjusted for covariates.

Table 5: Obesity at age 11 in relation to household routines and self-regulation at age 3

Household Routines at age 3	Obesity[a] prevalence, % (95% CI)	OR (95% CI) for Obesity[a] at age 11			
		Unadjusted (univariate)	Household routines	Routines and self-regulation[b]	Routines, self-regulation[b] and covariates[c]
Regular bedtime		**A**	**B**	**C**	**D**
Always	4.7 (4.0, 5.5)	Reference (1.0)	Reference (1.0)	Reference (1.0)	Reference (1.0)
Usually	5.7 (4.9, 6.5)	1.21 (0.96, 1.53)	1.38 (1.06, 1.80)	1.38 (1.06, 1.79)	1.31 (1.01, 1.71)
Sometimes, almost never or never	9.8 (8.1, 11.4)	2.18 (1.70, 2.79)	2.40 (1.82, 3.15)	2.30 (1.75, 3.03)	1.87 (1.39, 2.51)
Regular mealtimes					
Always	6.4 (5.6, 7.3)	Reference (1.0)	Reference (1.0)	Reference (1.0)	Reference (1.0)
Usually	5.7 (4.9, 6.4)	0.87 (0.72, 1.05)	0.73 (0.59, 0.91)	0.73 (0.59, 0.91)	0.77 (0.62, 0.97)
Sometimes, almost never or never	7.2 (4.9, 9.4)	1.12 (0.78, 1.61)	0.75 (0.51, 1.11)	0.72 (0.48, 1.06)	0.62 (0.41, 0.94)
Typical Daily TV/video time					
Up to an hour	5.5 (4.4, 6.7)	Reference (1.0)	Reference (1.0)	Reference (1.0)	Reference (1.0)
>1 to <3 hours	6.0 (5.3, 6.7)	1.09 (0.85, 1.40)	1.05 (0.81, 1.35)	1.02 (0.79, 1.32)	0.96 (0.74, 1.25)
3 or more hours	7.5 (6.1, 8.9)	1.39 (1.03, 1.88)	1.24 (0.91, 1.69)	1.16 (0.84, 1.59)	1.08 (0.78, 1.48)
Self-Regulation at age 3[b]					
Emotional self-regulation[b]	NA[e]	1.50 (1.24, 1.82)[d]	--	1.40 (1.13, 1.71)[d]	1.38 (1.11, 1.71)[d]
Cognitive self-regulation[b]	NA[e]	0.87 (0.68, 1.13)[d]	--	0.90 (0.70, 1.16)[d]	0.95 (0.73, 1.24)[d]

Millennium Cohort Study sweep 2 and sweep 5. Analyses are weighted and variance estimates account for complex sample design.

[a] BMI from measured height and weight at MCS5 – age 11; obesity defined based on IOTF guidelines.

[b] Child Social Behaviour Questionnaire. Subscale scores range from 1 to 3. Higher emotional self-regulation scores indicate a child who has more difficulties regulating emotion. Higher cognitive self-regulation scores indicate a child who is more persistent and shows more independence in planning and changing tasks. Odds ratio for a 1 unit difference in score.

[c] Covariates adjusted are country, child age, number of siblings, sex, ethnicity, birth weight, parent age, education, household income.

[d] P value for emotional self-regulation was P<.001 in univariate model, P=.002 in model adjusted for routines, and P=.003 in fully adjusted model; for cognitive self-regulation these P values were, respectively, .30, .43, and .72.

[e] Not applicable for continuous measure. The prevalence (95% CI) of obesity at age 11 by quartiles of emotional self-regulation score (most well-regulated to least well-regulated) was 4.9% (3.7, 6.0); 4.8% (3.9, 5.8); 7.1% (6.0, 8.2); and 7.8% (6.4, 9.1); by quartiles of cognitive self-regulation score (most well-regulated to least well-regulated) the prevalence (95% CI) of obesity was 6.3% (5.1, 7.4); 5.5% (4.5, 6.4); 6.1% (4.8, 7.4); and 6.6% (5.7, 7.6).

Supplementary Information: Wording and response to Child Social Behaviour Scale: Millennium Cohort Study

Subscale	Item order	Item wording	N	Mean	Standard error	Response frequency, row percent[a]			Cronbach alpha with item deleted[b]
						Not true	Somewhat true	Certainly true	
Independence self-regulation	3	Does not need much help with tasks	10856	2.2	0.007	9.7	58.2	32.1	0.52
	8	Persists in the face of difficult tasks	10541	2.2	0.008	10.2	56.7	33.2	0.50
	1	Likes to work things out for self; seeks help only when has to, or as a last resort	10913	2.5	0.007	3.9	38.7	57.4	0.52
	9	Can move to a new activity after finishing a task	10789	2.6	0.007	2.6	32.2	65.2	0.51
	5	Chooses activities on their own	10937	2.7	0.006	1.6	28.6	69.8	0.53
Emotion dysregulation	2	Shows wide mood swings	10828	1.9	0.010	31.6	43.4	25.0	0.52
	6	Is easily frustrated	10791	2.0	0.010	27.1	47.5	25.4	0.51
	10	Is impulsive, acts without thinking	10472	2.0	0.011	28.0	48.1	23.9	0.57
	4	Gets over excited	10854	2.1	0.011	19.1	47.2	33.7	0.54
	7	Gets over being upset quickly[c]	10919	2.5	0.007	7.4	35.1	57.5	0.70

Sweep 2 (children were aged 3-years) of the Millennium Cohort Study was conducted between September 2003 and January 2005. The Child Social Behaviour Questionnaire contains 10 items (statements) that the parent is asked to indicate if they are 1: Not true, 2: Somewhat true, 3: Certainly true, or 4: can't say (recoded to missing). The time period is over the past 6 months. Analytic sample = 10 995 children.

[a]May not sum to 100 due to rounding.

[b]Cronbach coefficient alpha (standardized) for subscale with item deleted. Cronbach alpha for the 2 subscales (5-items) were 0.57 and 0.63 respectively.

[c] Item is reverse coded.