Public Health Nutrition: 12(2), 249–258 doi:10.1017/S1368980008003935

A good-quality breakfast is associated with better mental health in adolescence

Therese A O'Sullivan[1], Monique Robinson[1,2], Garth E Kendall[3], Margaret Miller[4], Peter Jacoby[1], Sven R Silburn[5] and Wendy H Oddy[1,*]

[1]Telethon Institute for Child Health Research, Centre for Child Health Research, The University of Western Australia, PO Box 855 West Perth, Western Australia 6872, Australia: [2]School of Psychology, The University of Western Australia, Perth, Australia: [3]School of Nursing & Midwifery, Curtin University of Technology, Perth, Australia: [4]Child Health Promotion Research Centre, Edith Cowan University, Perth, Australia: [5]Centre for Developmental Health, Curtin University of Technology, Perth, Australia

Submitted 1 July 2008: Accepted 6 September 2008: First published online 25 November 2008

Abstract

Objective: Breakfast consumption has been associated with better mental health in adulthood, but the relationship between breakfast and mental health in adolescence is less well known. The aims of the present study were to evaluate breakfast quality in a cohort of adolescents and to investigate associations with mental health.

Design: Cross-sectional population-based study. Breakfast quality was assessed by intake of core food groups at breakfast, as determined from 3 d food diaries. Mental health was assessed using the Child Behaviour Checklist (CBCL), with higher scores representing poorer behaviour.

Setting: The Western Australian Pregnancy Cohort (Raine) Study, Perth, Western Australia.

Subjects: Eight hundred and thirty-six males and females aged between 13 and 15 years.

Results: Mean mental health score as assessed by the CBCL was 45·24 (SD 11·29). A high-quality breakfast consisting of at least three food groups was consumed by 11 % of adolescents, while 7 % of adolescents did not consume any items from core food groups on average over the 3 d period. The two most common core food groups consumed at breakfast in this population were dairy products followed by breads and cereals. For every additional food group eaten at breakfast, the associated total mental health score decreased by 1·66 (95 % CI −2·74, −0·59) after adjustment for potential confounding factors, representing an improvement in mental health score.

Conclusion: These findings support the concept that breakfast quality is an important component in the complex interaction between lifestyle factors and mental health in early adolescence.

Keywords
Adolescent/adolescence
Breakfast
Mental health
Child Behaviour Checklist

The positive association between breakfast consumption and improved mental health status has been observed in adults[1] and young adults[2]. However, breakfast may be especially important for children and adolescents who are not fully grown, as they have a larger brain to liver ratio than adults and therefore do not have the same ability to store required nutrients for periods of fasting[3]. Previous research reported by Lien[4] from the Oslo Health Study found that adolescents who ate breakfast daily were significantly less likely to be mentally distressed and more likely to have better school grades. However, the effect of breakfast quality on mental health in adolescence is yet to be reported. A review of breakfast quality and academic performance in children suggests that a good-quality breakfast with a variety of foods from different food groups can positively impact cognitive function[5]. Despite this potential benefit, prospective data suggest that the quality of breakfast declines as children move into adolescent years, where quality is defined by a lower consumption of core food groups at breakfast time[6]. Breakfast studies in children and adults indicate that not eating any breakfast, or consuming a poor-quality breakfast without items from core food groups, may contribute to dietary inadequacies that are not compensated for at other meals[7,8] and may lead to higher consumption of energy-dense snacks later in the day[9].

Suboptimal nutrient intake or meal skipping has been associated with adverse effects on brain function in different population groups for areas such as attention and memory[10], mood[11] and behaviour[12], suggesting a possible link with overall mental health. Investigating links between mental health and nutrition in young people is especially important as adolescence is a crucial period for

*Corresponding author: Email wendyo@ichr.uwa.edu.au

the development of behavioural patterns and social skills that will influence the individual's later adult functioning[13]. Half of all lifetime cases of psychological disorders emerge by age 14 years[14], making early adolescence an appropriate stage to examine factors associated with mental health.

The aims of the present study were to evaluate breakfast consumption patterns in early adolescence and to investigate the cross-sectional association between breakfast quality and mental health scores, using data from the Western Australian Pregnancy Cohort (Raine) Study. The Raine Study provides an ideal opportunity to investigate this relationship as it is a large, population-based cohort with data available on physical, socio-economic and lifestyle factors. We hypothesize that the consumption of a higher-quality breakfast is associated with better mental health status in adolescence.

Methods

Subjects

The Raine Study recruited 2900 pregnant women between 16 and 20 weeks' gestation from May 1989 to November 1991 through the public antenatal clinic at King Edward Memorial Hospital and private clinics in Perth, Western Australia. Of the initial cohort, 2868 live births were available for follow-up. Study enrolment methods have been reported elsewhere[15]. In the current paper we report cross-sectional results collected from the 14-year follow-up (mean age 14·0 (SD 0·2) years, range 13·0–15·0 years), as this follow-up was the first to comprehensively assess dietary intake and allow assessment of breakfast-eating habits. Derivation of the study sample from the overall Raine Study cohort is depicted in Fig. 1. Parents or primary caregivers completed the assessment of mental health using the Child Behaviour Checklist tool for 1784 adolescents. Of these, 1286 attended the assessment at the research centre and received a 3 d food record to assess breakfast intake. A total of 836 adolescents returned completed food records for a response rate of 65 % (836/1286). The ethics committees of King Edward Memorial Hospital and Princess Margaret Hospital approved the protocol for the Raine Study. Each adolescent plus their parent or guardian provided written consent for participation in the study.

Assessment of breakfast

The 3 d estimated food record in household measures was chosen to assess breakfast intake as the 3 d record has shown good validity in a child population[16]. A standard 3 d food record booklet with instructions was provided to participants who attended the 14-year follow-up assessment at the Telethon Institute for Child Health Research in Perth, Western Australia. A set of metric cups and spoons was provided to each study adolescent. Food records were completed by the adolescents themselves, with parental support if requested. The completed food records were individually checked by the study dietitian as they were returned, with clarification of data over the telephone where required[17].

Breakfast was defined as the food and/or beverage items documented in the food record booklet under the breakfast heading, listed as the first meal of the day. The breakfast score described by Radcliffe *et al.*[18] was used as the basis of our breakfast quality variable. This score is based on the five core food groups as defined by the *Australian Guide to Healthy Eating*[19]: (i) breads and cereals (including breakfast cereals, bread and rice); (ii) vegetables; (iii) fruit; (iv) dairy products (including soya milk products); and (v) meat and meat alternatives (including eggs, vegetarian meat alternatives and nuts). These food groups supply different nutrients essential to health and development, and adequate intake from all groups on a daily basis is recommended. Food or drink items which are not categorized into one of the core food groups are classified as 'extras', as they provide some nutrients but are not considered to be good sources of essential nutrients; this category includes items high in sugar and/or saturated fat such as soft drinks, biscuits, cake, pancakes and chocolate bars, as well as high-fat savoury goods such as pastries and sausage rolls[19]. Each breakfast listed in the food record was evaluated according to the number of core food groups consumed at that meal to create a breakfast quality score. The breakfast quality

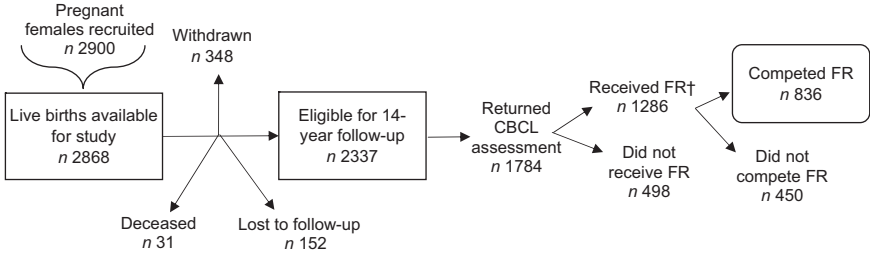

Fig. 1 Derivation of the study sample from the overall Raine Study cohort; 14-year follow-up of the Western Australian Pregnancy Cohort (Raine) Study, Perth, Western Australia (CBCL, Child Behaviour Checklist; FR, food record). †Food records and the accompanying measuring utensils and instructions were handed out only to subjects who attended the in-person follow-up session at the Telethon Institute for Child Health Research in Perth, Western Australia. Some follow-up items including the CBCL were completed through the mail; for these items subjects were not required to attend the follow-up session at the Institute

Table 1 Scoring system used to assess breakfast quality as determined by core food groups consumed[18]; 14-year follow-up of the Western Australian Pregnancy Cohort (Raine) Study, Perth, Western Australia

Score	Definition	Examples
1	No food or beverage, or water only	water 'nothing' diet cordial/soft drinks
2	Food and/or beverage from 'extra' foods only	biscuits, chocolate bars non-diet cordial/soft drinks pastries, croissants, pancakes
3	Food and/or beverage from one AGHE food group	banana orange juice toast
4	Food and/or beverage from two AGHE food groups	cereal and milk bacon, eggs and toast
5	Food and/or beverage from three or more AGHE food groups	cereal and milk and orange juice toast and banana and a glass of milk

AGHE, *The Australian Guide to Healthy Eating*[19].

score ranged from 1 point, representing no food or drink, to 5 points, representing foods from three or more different food groups (Table 1). A breakfast of 'extras' was ranked above no food or drink, but less than a core food group. In instances where subjects consumed 'extras' in addition to core food groups, the 'extras' did not contribute to the score. This was because the breakfast quality score was intended to represent the intake of required nutrients as provided by the core food groups, rather than representing excess intakes of fat, sugar and salt. For example, if a subject ate foods from two food groups plus 'extras' foods, the score of 4 reflected intake of the two food groups only. Scores over the three days were averaged to create an overall breakfast quality score for each participant.

Assessment of mental health

Mental health was assessed using the 118-item Child Behaviour Checklist (CBCL/4-18) for Ages 4–18 years, a validated measure of behaviour by parent or primary caregiver report[20]. The CBCL provides a dimensional measure of child and adolescent behaviour and is used to assess mental health over the preceding six months. The CBCL produces a raw score which can be converted into three summary T-scores, referred to as 'scores' in the current paper: total behaviour, internalizing behaviour and externalizing behaviour. The internalizing behaviour score incorporates syndromes of withdrawal, somatic complaints and anxious/depressed; the externalizing behaviour score incorporates syndromes of delinquency and aggression[20]. Three remaining syndromes of social, thought and attention problems contribute to the total behaviour score but not to the internalizing or externalizing scores. Higher scores are associated with more disturbed emotions and behaviours, with a total T-score of 60 or above classified as the clinical range for mental health morbidity[21]. Use of the CBCL as a mental health assessment tool in both clinical and community settings has been supported in a recent meta-analysis[22] and the CBCL has been shown to have good test–retest reliability in a Western Australian child population[23]. The internal consistency for the CBCL is $r = 0{\cdot}94$ (Cronbach's $\alpha = 0{\cdot}97$) for the total score, $r = 0{\cdot}91$ (Cronbach's $\alpha = 0{\cdot}90$) for the internalizing score and $r = 0{\cdot}92$ (Cronbach's $\alpha = 0{\cdot}94$) for the externalizing score[21].

Confounding variables included in the model

Physical measurements

Weight status may influence aspects of mental health such as depression in adolescents[24]. Height and weight measurements were taken by a trained research assistant using standard calibrated equipment to calculate BMI as [weight (kg)]/[height $(m)^2$]. BMI categories of underweight, normal weight overweight and obese were defined using standard criteria for this age group[25,26]: (i) underweight, BMI $\leq$ $16{\cdot}41\,kg/m^2$ in males and $\leq 16{\cdot}88\,kg/m^2$ in females; (ii) normal weight, BMI = $16{\cdot}42$–$22{\cdot}61\,kg/m^2$ in males and $16{\cdot}89$–$23{\cdot}33\,kg/m^2$ in females; (iii) overweight, BMI = $22{\cdot}62$–$27{\cdot}62\,kg/m^2$ in males and $23{\cdot}34$–$28{\cdot}56\,kg/m^2$ in females; and (iv) obese, BMI $\geq 27{\cdot}63\,kg/m^2$ in males and $\geq 28{\cdot}57\,kg/m^2$ in females.

Sociodemographic and family characteristics

Socio-economic factors such as family income have been associated with both child behaviour problems[27] and breakfast frequency[28]. Evidence suggests that family characteristics may also affect the behaviour of children in the family[29]. Information regarding maternal age at conception, maternal education, current family income, family structure and family functioning were obtained by parent report. Maternal age at conception was classified as: (i) <20 years; (ii) 20–29 years; or (iii) ≥30 years. Maternal education was assessed by the highest school year completed, with responses grouped as: (i) grade 10 or less; (ii) grade 11; or (iii) grade 12. Current family income was defined as the annual income for the household before tax at the time of the survey and was

assessed categorically in three groups as follows: (i) <$AU 35 000; (ii) $AU 35 000–70 000; and (iii) >$AU 70 000 per annum. Family structure was assessed as either yes or no for living in a single-parent family. The General Functioning Scale from the McMaster Family Assessment Device was used to assess family functioning[30]. This short-form scale consists of twelve statements that were derived from an item analysis of the complete sixty-item scale, and includes questions on family communication, affective responsiveness and behaviour control. Lower scores on the General Functioning Scale represent poorer family functioning and higher scores represent better family functioning. This scale has been shown to be reliable ($r = 0{\cdot}83$) and internally consistent ($r = 0{\cdot}86$)[31].

Lifestyle factors

In addition to increasing dietary energy requirements, increased regular physical activity may assist in the management of mild-to-moderate mental health problems[32]. Likewise, sedentary behaviour may have the opposite effect. The lifestyle factors included in analysis for the present study were physical activity in leisure time and computer or television screen usage. In addition, an estimate of overall diet quality was also chosen as a confounding variable to adjust for usual nutrient intake over the whole day. Education level was not included as a confounding variable as school education in Western Australia is mandatory until age 15 and all adolescents in this study were aged 13·0 to 15·0 years.

To determine physical activity level, adolescents were asked how often they exercised outside of school hours per week, where exercise was defined as activity causing breathlessness or sweating. These data were converted into an ordinal variable with three levels: (i) exercise <1 time/week; (ii) exercise 1–3 times/week; and (iii) exercise ≥4 times/week. As a proxy measure of sedentary behaviour, adolescents were asked about their television or video viewing and computer use, measured as hours per day of combined screen use. This data was categorized into three levels: (i) <2 h/d; (ii) 2–4 h/d; and (iii) >4 h/d.

We collected information on overall diet using a 221-item FFQ provided by the Commonwealth Scientific and Industrial Research Organisation that has been validated in adults and previously applied in children[33,34]. To represent the overall nutritional value of individual diets, a diet quality score was developed based on similar scores published in the international literature[35]. The diet quality score consisted of thirteen dietary components, including both nutrients and food groups, with each component given a score out of 10 based on degree of compliance with Australian dietary recommendations[19], for a total possible score of 130.

Statistical analyses

Breakfast quality was analysed as both a continuous and categorical variable. For the categorical variable, no breakfast and 'extras' only were combined due to low subject numbers in these groups. The χ^2 test was used to investigate associations between potential risk factors and breakfast quality. Pearson's correlation was used to determine the association between breakfast quality and overall diet quality. ANOVA was applied to assess differences in mean mental health score between breakfasts of differing core food groups, with Tukey's Honestly Significant Difference test used for *post hoc* analysis. A general linear model was applied to examine the relationship between breakfast quality and mental health adjusted for confounding variables; variables were entered simultaneously. Independent *t* tests and χ^2 tests were used to examine differences between adolescents who completed the food record and those who did not. Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) statistical software package version 15·0 (SPSS Inc., Chicago, IL, USA).

Results

The mean total mental health score as assessed by the CBCL was 45·24 (SD 11·29), with mean internalizing behaviour score of 45·87 (SD 10·53) and mean externalizing behaviour score of 46·58 (SD 10·52). Within the study group, 11·0 % of adolescents were categorized in the clinical range for mental health morbidity.

For breakfast quality, the mean score was 3·70 (SD 0·75). Skipping breakfast on at least one of the three days was reported by 14·6 % (*n* 122) of adolescents; overall, 1·1 % (*n* 9) reported skipping breakfast each day over the 3 d period. An average breakfast of 'extras' food alone over the 3 d period was reported by 5·6 % (*n* 47) and food from one food group was reported by 27·9 % (*n* 233). The majority of adolescents (54·0 %, *n* 452) consumed a breakfast consisting of food from two different food groups over the three days, while a high-quality breakfast consisting of three or more food groups was consumed by 11·4 % (*n* 95). Milk, followed by fortified breakfast cereals and bread, were the food and beverage types most commonly consumed by the adolescents for breakfast.

Breakfast quality was positively associated with overall diet quality ($r = 0{\cdot}28$, $P < 0{\cdot}001$). Adolescents who reported lower breakfast quality scores were significantly more likely to be female, have mothers with a younger maternal age and a lower level of maternal education, come from lower-income families, have higher screen use and be less physically active than adolescents who reported higher breakfast quality scores (Table 2).

There was a stepwise decrease in total mental health score for each increase in breakfast quality ranking ($P = 0{\cdot}009$, Fig. 2), representing improved mental health. A multivariable general linear model incorporating potential confounding factors showed that a higher breakfast quality score was significantly associated with a

Table 2 Characteristics of study adolescents for each breakfast quality level; 14-year follow-up of the Western Australian Pregnancy Cohort (Raine) Study, Perth, Western Australia

	No breakfast or 'extras' only		One food group		Two groups		Three or more food groups		
	n	valid %	*n*	%	*n*	%	*n*	%	*P* for trend
Gender									
Male	24	5·6	109	25·7	237	55·9	54	12·7	0·029
Female	32	7·7	124	30·1	215	52·2	41	10·0	
BMI category†									
Underweight	3	5·7	16	30·2	29	54·7	5	9·4	0·057
Normal weight	34	5·8	155	26·5	324	55·5	71	12·2	
Overweight	14	9·3	47	31·1	76	50·3	14	9·3	
Obese	4	9·1	14	31·8	23	52·3	3	6·8	
Maternal characteristics									
Age at conception									
<20 years	8	13·3	15	25·0	36	60·0	1	1·7	0·029
20–29 years	26	6·4	113	28·0	226	55·9	39	9·7	
≥30 years	22	5·9	105	28·2	190	51·1	55	14·8	
Highest school year									
Grade 10 or less	31	10·7	88	30·3	149	51·4	22	7·6	<0·001
Grade 11	5	3·6	41	29·5	73	52·5	20	14·4	
Grade 12	20	4·9	104	25·6	230	56·7	52	12·8	
Sociodemographic factors									
Annual family income									
<$AU 35 000	15	8·7	45	26·0	104	60·1	9	5·2	0·001
$AU 35 000–70 000	23	7·8	96	32·7	143	48·6	32	10·9	
>$AU 70 000	15	4·2	91	25·3	199	55·4	54	15·0	
Single-parent family									
Yes	12	8·3	41	28·3	78	53·8	14	9·6	0·356
No	44	6·4	192	27·8	374	54·1	81	11·7	
Family functioning									
Poor functioning, score ≤24	8	8·1	20	20·2	60	60·6	11	11·1	0·541
Well functioning, score ≥25	47	6·5	206	28·7	382	53·2	83	11·6	
Lifestyle factors									
Physical activity									
<1 time/week	10	13·3	25	33·3	39	52·0	1	1·3	0·002
1–3 times/week	33	7·1	129	27·6	249	53·2	57	12·2	
≥4 times/week	12	4·2	78	27·0	163	56·4	36	12·5	
Screen use									
<2 h/d	11	4·7	54	23·2	140	60·1	28	12·0	0·034
2–4 h/d	20	6·1	102	30·9	174	52·7	34	10·3	
>4 h/d	24	9·2	75	28·7	131	50·2	31	11·9	

†Defined according to BMI classification groups[25, 26].

lower total CBCL score ($b = -1{\cdot}66$; 95% CI $-2{\cdot}74$, $-0{\cdot}59$; $P = 0{\cdot}002$; Table 3), equating to a decrease in the total CBCL score of 4·8 from no food groups eaten at breakfast to three or more food groups eaten at breakfast. A higher breakfast quality score was also significantly associated with lower internalizing behaviour scores ($b = -1{\cdot}13$; 95% CI $-2{\cdot}15$, $-0{\cdot}10$; $P = 0{\cdot}031$) and lower externalizing behaviour scores ($b = -1{\cdot}57$; 95% CI $-2{\cdot}59$, $-0{\cdot}56$, $P = 0{\cdot}002$).

The characteristics of the study sample were compared with the other adolescents in the 14-year Raine Study follow-up who did not complete a food record (Table 4).

Discussion

Our results support the hypothesis that higher breakfast quality is associated with better mental health in adolescence. Compared with skipping breakfast, eating a breakfast with foods from three or more core food groups was associated with a decrease in total CBCL total score of 4·8 points, approximately 10% of the mean CBCL score. The difference in score was independent of confounding factors and is potentially clinically meaningful. Of particular interest in our results was the stepwise decrease in total mental health score with increasing breakfast quality, suggesting a possible dose–response relationship.

Previous studies have found a similar relationship between mental health and breakfast cereal consumption in populations of adults[1] and young adults[2], and with breakfast regularity in adolescents[4]. The present research takes the relationship one step further by showing an association between the quality of breakfast and mental health. The breakfast quality of boys in our study was significantly better than for girls, a trend that has also been found in terms of breakfast consumption or

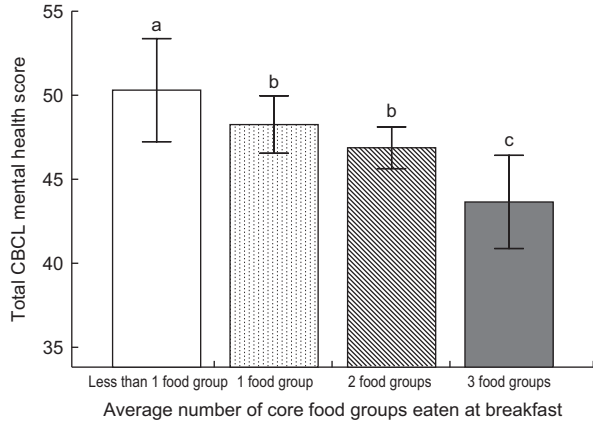

Fig. 2 Total mental health scores, as assessed by the Child Behaviour Checklist (CBCL), for the varying breakfast categories based on core food groups (ANOVA test for trend $P = 0{\cdot}009$); 14-year follow-up of the Western Australian Pregnancy Cohort (Raine) Study, Perth, Western Australia. Values are means with their 95 % confidence intervals represented by vertical bars. [a,b]Mean values with unlike superscript letters were significantly different ($P < 0{\cdot}05$, *post hoc* analysis using Tukey's Honestly Significant Difference test)

quality in other adolescent population groups in Spain[36], Belgium[37] and Norway[4].

Breakfast can potentially influence mental health in a number of ways. In terms of nutrient intake, milk, fortified breakfast cereals and bread, the most common foods consumed for breakfast by the Raine Study adolescents, are good sources of nutrients that affect brain function, including carbohydrate, Ca, B vitamins, Fe and folate. As the association with breakfast and mental health was independent of our indicator of overall diet quality, the consumption of these breakfast foods at the start of the day may be particularly beneficial.

All core food groups except meat and meat alternatives supply carbohydrate which is converted to glucose, the metabolic fuel required for brain function. Blood glucose concentrations are closely regulated by the body; however, short-term variation of glucose availability can affect the brain even when adequate nutritional status exists[13]. For example, a double-blind trial by Benton *et al.*[38] found that ingestion of a glucose drink two hours after lunch improved attention and reaction to frustration in children. When blood glucose concentrations fall below normal, hormones such as adrenalin and cortisol are released which are associated with feelings of agitation and irritability; symptoms such as difficulty concentrating and destructive outbursts can also occur[39]. The breads and cereals food group is the most carbohydrate-dense of the food groups and incorporation of these foods into breakfast, in suitable portion sizes, may help to avoid low blood glucose concentrations. These behaviours of aggression and delinquency were encompassed into the externalizing mental health score, which showed a stronger association with breakfast quality in our study than the internalizing mental health score, which included syndromes of depressive behaviour and withdrawal.

As well as carbohydrate, intake of vitamins and minerals also affects brain function. A variety of vitamins and minerals assist with optimal functioning of neurotransmitters, chemicals used to communicate information between neurons in the nervous system. Neurotransmitters are directly responsible for aspects such as behaviour, mood and intellectual function. Although severe malnutrition would be required to cause neurotransmitter deficits serious enough to result in neurological impairment, changes in everyday diet may result in subtle changes[39]. Milk, the most popular breakfast item consumed by the Raine Study adolescents, provides Ca which is involved in the release of neurotransmitters[40]. Milk also contains tryptophan, a precursor to serotonin and a neurotransmitter involved in psychological processes. Breads and fortified breakfast cereals are good sources of the B vitamins thiamin and pyridoxine. These vitamins assist in attentional processes, synthesis of neurotransmitters and carbohydrate metabolism[41,42]. As B vitamins are water-soluble, body stores are relatively small and can decline over a period of a few weeks in the absence of sufficient dietary intake. Double-blind, placebo-controlled studies show that thiamin supplementation improves composure, mood and clarity of thought, even in subjects who are classified as having adequate thiamin status[11,43]. Fortified breakfast cereals are also good sources of folate and Fe, which are used in the synthesis of serotonin[44] and other neurotransmitters[45]; Fe is additionally used to bind neurotransmitters to receptors in the brain[46].

An increased intake of valuable vitamins and minerals at the start of the day, resulting from consumption of a breakfast with a variety of food groups, may partially explain the relationship with better mental health that was observed in our study. Other explanations may include regular eating leading to improved quality of sleep[47] or fibre from breakfast cereal assisting with bowel function and reduced fatigue[48]. A behavioural clustering effect may also be present: a positive association between breakfast quality and our indicator of overall diet quality was found in our study, and Lien[4] notes that adolescents who eat breakfast and other meals regularly are more likely to display other healthy behaviours, such as a good diet, lower alcohol consumption and abstinence from smoking.

Our study had three notable strengths. The first was the large population-based cohort and assessment of a wide array of variables, including lifestyle factors, BMI, and family and sociodemographic characteristics. Poor breakfast quality was shown to be associated with adverse mental health independently of these factors and therefore independent of the established relationship between low socio-economic status and poor nutritional intake[49] and between poor family functioning and

Table 3 Adjusted regression coefficients in the multivariate general linear model for mental health, as assessed by the Child Behaviour Checklist (CBCL); 14-year follow-up of the Western Australian Pregnancy Cohort (Raine) Study, Perth, Western Australia

	CBCL score					
	Total problems		Internalizing problems		Externalizing problems	
	b	95 % CI	*b*	95 % CI	*b*	95 % CI
Breakfast quality	−1·66**	−2·74, −0·59	−1·13*	−2·15, −0·10	−1·57**	−2·59, −0·56
Gender						
Male	0·41	−1·16, 1·98	−2·24**	−3·74, −0·75	0·03	−1·51, 1·45
BMI category†						
Underweight	−1·28	−4·32, 1·77	−0·78	−3·68, 2·12	−1·82	−4·69, 1·05
Overweight	1·08	−0·91, 3·01	0·07	−1·89, 1·90	0·61	−1·26, 2·49
Obese	5·09*	1·51, 8·66	2·84	−0·57, 6·24	3·91*	0·55, 7·28
Maternal characteristics						
Age at conception‡						
20–29 years	−5·43**	−8·62, −2·23	−5·14**	−8·18, −2·10	−5·05**	−8·06, −2·03
≥30 years	−6·00**	−9·20, −2·79	−5·40**	−8·45, −2·35	−6·01**	−9·03, −2·99
Highest school year§						
Grade 11	0·80	−1·41, 3·18	1·54	−0·65, 3·73	−0·31	−2·48, 1·85
Grade 12	−0·22	−2·05, 1·61	0·86	−0·88, 2·60	−1·21	−2·93, 0·52
Sociodemographic factors						
Annual family income‖						
$AU 35 000–70 000	−3·29*	−5·66, −0·91	−2·31*	−4·57, −0·04	−2·99**	−5·23, −0·74
>$AU 70 000	−3·89**	−6·47, −1·31	−3·27**	−5·73, −0·81	−3·17*	−5·60, −0·74
Single-parent family						
Yes	1·08	−1·36, 3·52	1·13	−1·20, 3·45	−0·10	−2·40, 2·20
Family functioning	−0·43**	−0·57, −0·29	−0·36**	−0·50, −0·23	−0·38**	−0·52, −0·25
Overall diet quality	0·05	−0·01, 0·10	0·03	−0·03, 0·08	0·04	−0·01, 0·09
Lifestyle factors						
Physical activity¶						
1–3 times/week	−0·97	−3·78, 1·83	−0·11	−2·78, 2·56	−0·15	−2·79, 2·50
≥4 times/week	−1·47	−4·42, 1·49	−1·12	−3·93, 1·69	0·50	−2·28, 3·29
Screen use††						
2–4 h/d	3·35**	1·47, 5·23	2·40*	0·61, 4·19	2·09*	0·32, 3·86
>4 h/d	3·36**	1·34, 5·37	1·90	−0·02, 3·82	2·32*	0·42, 4·23

Association was significant: *$P < 0·05$, **$P < 0·01$.
†Defined according to BMI classification groups[25, 26]; reference category: normal weight.
‡Reference category: mothers aged <20 years at conception.
§Reference category: grade 10 or less.
‖Reference category: annual family income <$AU 35 000.
¶Reference category: <1 time/week.
††Reference category: <2 h/d.

mental health problems[50]. The second strength of our study was the use of the CBCL, a well-researched and validated measure of mental health morbidity that has shown good sensitivity in the diagnosis of adolescent psychopathology[22]. The third strength of the study was the use of 3 d food records which were checked by a trained dietitian for precise determination of breakfast quality[17].

Interpretation of our study results are limited by the cross-sectional design. The association observed may also be due to poor mental health leading to a lower-quality breakfast. For example, some people experiencing emotional distress such as depression may lose their appetite or report a craving and preference for sweet carbohydrate- and fat-rich foods[51]. These comfort foods, such as chocolate, stimulate endorphin release in the brain to elevate mood[52]. In addition, positive mental health behaviours may be a result of overall higher self-efficacy and self-esteem rather than as a result of dietary factors. Good dietary patterns have been linked with other positive healthy lifestyle behaviours[53], a trend that was also observed in our study, with higher breakfast quality scores significantly associated with increased levels of physical activity.

The prevalence of clinical mental health morbidity in our subject group was 11·0 %, slightly lower than the national estimate of 13·1 % obtained from the national mental health survey of 13–17-year-old adolescents[54]. Generalization of the results from our study to the wider adolescent population must be done with caution, due to the differences existing between those adolescents who completed the food record compared with those who did not. Adolescents who took the time to complete the food record and return it were less likely to have mental health problems (Table 4). In addition, adolescents who completed the food record were more likely to have better

Table 4 Frequency characteristics for study participants who completed the CBCL and the food record (*n* 836) compared with the study participants who completed the CBCL but did not complete the food record (*n* 948); 14-year follow-up of the Western Australian Pregnancy Cohort (Raine) Study, Perth, Western Australia

	Subjects who completed the food record		Subjects who did not complete the food record	
	Mean	SD	Mean	SD
Diet quality score*†	77·08	15·05	75·01	15·9
CBCL mental health score				
Total*	45·24	11·29	47·67	11·89
Internalizing*	45·87	10·53	47·62	10·80
Externalizing*	46·58	0·52	49·30	11·32
	n	valid %	*n*	valid %
Gender				
Male	424	50·7	461	51·3
Female	412	49·3	487	48·7
BMI category*‡				
Underweight	53	6·4	44	6·2
Normal weight	584	70·2	468	65·7
Overweight	151	18·1	131	18·4
Obese	44	5·3	69	9·7
Missing	4		236	
Maternal characteristics				
Age at conception*				
<20 years	60	7·2	96	10·1
20–29 years	404	48·3	536	56·6
≥30 years	372	44·5	315	33·3
Missing	0		1	
Highest school year*				
Grade 10 or less	290	34·8	370	39·2
Grade 11	139	16·6	194	20·5
Grade 12	406	48·6	381	40·3
Missing	1		3	
Sociodemographic factors				
Annual family income*				
<$AU 35 000	173	21·0	256	27·7
$AU 35 000–70 000	294	35·6	319	34·5
>$AU 70 000	359	43·4	349	37·8
Missing	10		24	
Single-parent family*				
Yes	145	17·3	217	23·0
No	691	82·7	725	77·0
Missing	0		6	
Family functioning				
Poor functioning, score ≤24	99	12·1	131	14·5
Well functioning, score ≥25	718	87·9	774	85·5
Missing	19		43	
Lifestyle factors				
Physical activity				
<1 time/week	75	9·0	69	9·7
1–3 times/week	468	56·3	423	59·7
≥4 times/week	289	34·7	217	30·6
Missing	4		239	
Screen use				
<2 h/d	233	28·3	187	26·7
2–4 h/d	330	40·0	278	39·8
>4 h/d	261	31·7	234	33·5
Missing	12		249	

CBCL, Child Behaviour Checklist.
Differences between subjects who did and did not complete the food record were significant: *$P < 0·05$.
†*n* 805 for subjects who did not complete the food record.
‡Defined according to BMI classification groups[25,26].

overall diet quality, be less obese, have older and more educated mothers, a higher family income and a two-parent family. Nevertheless, the variance within the subject group was still large enough to observe a significant association between breakfast quality and mental health in the Raine Study.

In summary, our study supports the concept that breakfast quality is a significant component in the complex

interaction between lifestyle factors and mental health in adolescence. We found that a higher-quality breakfast, consisting of foods from multiple food groups, was significantly related to better mental health scores in adolescents after adjustment for a number of sociodemographic and lifestyle factors. Intervention studies will also help to further define this relationship, particularly through examination of meal patterns and nutrients that may exert an influence on externalizing behaviours. Potential public health implications of this and future research include the development of adolescent-focused education on the importance of breakfast, particularly for girls, and the incorporation of breakfast programmes into high schools.

Acknowledgements

We would like to acknowledge the Chief Investigators of the Raine Study, the Study Executive and Study Staff for their ongoing commitment to data collection. We would especially like to acknowledge Kathryn Webb as the Raine Study dietitian from 2004 to 2006, and Professor Nick de Klerk for statistical advice. Special thanks go to the Raine Study adolescents and their families for their participation in the research.

Sources of funding: The Western Australian Pregnancy Cohort (Raine) Study is funded by the Raine Medical Research Foundation at The University of Western Australia, the National Health and Medical Research Council of Australia, the Telstra Research Foundation, the Western Australian Health Promotion Foundation, and the Australian Rotary Health Research Fund.

Conflict of interest declaration: The authors declare no conflict of interest.

Authorship contributions: Planning research (W.H.O., G.E.K., M.M., S.R.S.); executing research (W.H.O., G.E.K., M.M., S.R.S.); analysing data (M.R., T.A.O'S., P.J., W.H.O.); interpreting data (T.A.O'S., M.R., P.J., W.H.O.); and writing (T.A.O'S., M.R., W.H.O., S.S.).

References

1. Smith AP (1998) Breakfast and mental health. *Int J Food Sci Nutr* **49**, 397–402.
2. Smith AP (2003) Breakfast cereal consumption and subjective reports of health by young adults. *Nutr Neurosci* **6**, 59–61.
3. Pollitt E, Leibel RL & Greenfield D (1981) Brief fasting, stress, and cognition in children. *Am J Clin Nutr* **34**, 1526–1533.
4. Lien L (2007) Is breakfast consumption related to mental distress and academic performance in adolescents? *Public Health Nutr* **10**, 422–428.
5. Rampersaud GC, Pereira MA, Girard BL, Adams J & Metzl JD (2005) Breakfast habits, nutritional status, body weight, and academic performance in children and adolescents. *J Am Diet Assoc* **105**, 743–760.
6. Lytle L, Seifert S, Greenstein J & McGovern P (2000) How do children's eating patterns and food choices change over time? Results from a cohort study. *Am J Health Promot* **14**, 222–228.
7. Nicklas TA, Bao W, Webber LS & Berenson GS (1993) Breakfast consumption affects adequacy of total daily intake in children. *J Am Diet Assoc* **93**, 886–891.
8. Kerver JM, Yang EJ, Obayashi S, Bianchi L & Song WO (2006) Meal and snack patterns are associated with dietary intake of energy and nutrients in US adults. *J Am Diet Assoc* **106**, 46–53.
9. Dubois L, Girard M, Potvin Kent M, Farmer A & Tatone-Tokuda F (2008) Breakfast skipping is associated with differences in meal patterns, macronutrient intakes and overweight among pre-school children. *Public Health Nutr* (E-publication ahead of print version).
10. Wesnes KA, Pincock C, Richardson D, Helm G & Hails S (2003) Breakfast reduces declines in attention and memory over the morning in schoolchildren. *Appetite* **41**, 329–331.
11. Benton D, Griffiths R & Haller J (1997) Thiamine supplementation mood and cognitive functioning. *Psychopharmacology* **129**, 66–71.
12. Simeon DT & Grantham-McGregor SM (1990) Nutritional deficiencies and children's behaviour and mental development. *Nutr Res Rev* **3**, 1–24.
13. Bellisle F (2004) Effects of diet on behaviour and cognition in children. *Br J Nutr* **92**, S227–S232.
14. Kessler RC, Berglund P, Demler O, Jin R & Walters EE (2005) Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication. *Arch Gen Psychiatry* **62**, 593–602.
15. Newnham JP, Evans SF, Michael CA, Stanley FJ & Landau LI (1993) Effects of frequent ultrasound during pregnancy: a randomised controlled trial. *Lancet* **342**, 887–891.
16. Crawford P, Obarzanek E & Morrison J (1994) Comparative advantage of 3-day food records over 24-hour recall and 5-day food frequency validated by observation of 9- and 10-year-old girls. *J Am Diet Assoc* **94**, 626–630.
17. Di Candilo KG, Oddy WH, Miller M, Sloan N, Kendall GE & de Klerk NH (2007) Follow-up phone-calls increase nutrient intake estimated by three-day food diaries in 13 year old participants of the Raine study. *Nutr Diet* **64**, 165–171.
18. Radcliffe BC, Ogden C, Coyne T & Craig P (2004) Breakfast consumption patterns of upper primary school students in 14 Queensland schools. *Nutr Diet* **61**, 151–158.
19. Smith A, Kellett E & Schmerlaib Y (1998) *The Australian Guide to Healthy Eating*. Victoria: Commonwealth of Australia.
20. Achenbach TM & McConaughy SH (1997) *Empirically Based Assessment of Child and Adolescent Psychopathology*, 2nd ed. Thousand Oaks, CA: Sage Publications.
21. Achenbach TM (1991) *Manual for the Child Behavior Checklist/4-18 and 1991 Profile*. Burlington, VT: University of Vermont, Department of Psychiatry.
22. Warnick EM, Bracken MB & Kasl S (2008) Screening efficiency of the Child Behavior Checklist and Strengths and Difficulties Questionnaire: a systematic review. *Child Adolesc Ment Health* **13**, 140–147.
23. Zubrick SR, Silburn S, Gurrin L, Teoh H, Shepherd C, Carlton J & Lawrence D (1997) *Western Australian Child Health Survey: Education, Health and Competence*. Perth: Australian Bureau of Statistics and the Telethon Institute for Child Health Research.
24. Rierdan J & Koff E (1997) Weight, weight-related aspects of body image, and depression in early adolescent girls. *Adolescence* **32**, 615–624.
25. Cole TJ, Flegal KM, Nicholls D & Jackson AA (2007) Body mass index cut offs to define thinness in children and adolescents: international survey. *BMJ* **335**, 194–201.

26. Cole TJ, Bellizzi MC, Flegal KM & Dietz WH (2000) Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ* **320**, 1240–1243.
27. Bor W, Najman JM, Andersen MJ, O'Callaghan M, Williams GM & Behrens BC (1997) The relationship between low family income and psychological disturbance in young children: an Australian longitudinal study. *Aust N Z J Psychiatry* **31**, 664–675.
28. Gleason PM (1995) Participation in the National School Lunch Program and the School Breakfast Program. *Am J Clin Nutr* **61**, 213S–220S.
29. Najman JM, Behrens BC, Andersen M, Bor W, O'Callaghan M & Williams GM (1997) Impact of family type and family quality on child behavior problems: a longitudinal study. *J Am Acad Child Adolesc Psychiatry* **36**, 1357–1365.
30. Epstein NB, Baldwin LM & Bishop DS (1983) The McMaster Family Assessment Device. *J Marital Fam Ther* **9**, 171–180.
31. Byles J, Byrne C, Boyle MH & Offord DR (1988) Ontario Child Health Study: reliability and validity of the General Functioning subscale of the McMaster Family Assessment Device. *Fam Process* **27**, 97–104.
32. Paluska SA & Schwenk TL (2000) Physical activity and mental health: current concepts. *Sports Med* **29**, 167–180.
33. Baghurst KI & Record SJ (1983) Intake and sources in selected Australian subpopulations of dietary constituents implicated in the etiology of chronic diseases. *J Food Nutr* **40**, 1–15.
34. Rohan TE, Record SJ & Cook MG (1987) Repeatability of estimates of nutrient and energy intake: the quantitative food frequency approach. *Nutr Res* **7**, 125–137.
35. Haines PS, Siega-Riz AM & Popkin BM (1999) The diet quality index revised: a measurement instrument for populations. *J Am Diet Assoc* **99**, 697–704.
36. Aranceta J, Serra-Majem L, Ribas L & Pérez-Rodrigo C (2001) Breakfast consumption in Spanish children and young people. *Public Health Nutr* **4**, 1439–1444.
37. Matthys C, De Henauw S, Bellemans M, De Maeyer M & De Backer G (2007) Breakfast habits affect overall nutrient profiles in adolescents. *Public Health Nutr* **10**, 413–421.
38. Benton D, Brett V & Brain PF (1987) Glucose improves attention and reaction to frustration in children. *Biol Psychol* **24**, 95–100.
39. Fishbein DH & Pease SE (1994) Diet, nutrition, and aggression. *J Offender Rehab* **21**, 117–144.
40. Kaplan BJ, Field CJ, Crawford SG & Simpson JSA (2007) Vitamins, minerals, and mood. *Psychol Bull* **133**, 747–760.
41. Blokland A (1995) Acetylcholine: a neurotransmitter for learning and memory? *Brain Res Rev* **21**, 285–300.
42. Hartvig P, Lindner KJ, Bjurling P, Långström B & Tedroff J (1995) Pyridoxine effect on synthesis rate of serotonin in the monkey brain measured with positron emission tomography. *J Neural Transm* **102**, 91–97.
43. Benton D, Haller J & Fordy J (1995) Vitamin supplementation for 1 year improves mood. *Neuropsychobiology* **32**, 98–105.
44. Young SN (2002) Clinical nutrition: 3. The fuzzy boundary between nutrition and psychopharmacology. *Can Med Assoc J* **166**, 205–209.
45. Hutto BR (1997) Folate and cobalamin in psychiatric illness. *Compr Psychiatry* **38**, 305–314.
46. Jimenez Del Rio MM, Velez Pardo CC, Pinxteren JJ, De Potter WW, Ebinger GG & Vauquelin GG (1993) Binding of serotonin and dopamine to 'serotonin binding proteins' in bovine frontal cortex: evidence for iron-induced oxidative mechanisms. *Eur J Pharmacol* **247**, 11–21.
47. Tanaka H, Taira K, Arakawa M, Masuda A, Yamamoto Y, Komoda Y, Kadegaru H & Shirakawa S (2002) An examination of sleep health, lifestyle and mental health in junior high school students. *Psychiatry Clin Neurosci* **56**, 235–236.
48. Smith A, Bazzoni C, Beale J, Elliott-Smith J & Tiley M (2001) High fibre breakfast cereals reduce fatigue. *Appetite* **37**, 249–250.
49. Shahar D, Shai I, Vardi H, Shahar A & Fraser D (2005) Diet and eating habits in high and low socioeconomic groups. *Nutrition* **21**, 559–566.
50. Bond L, Toumbourou JW, Thomas L, Catalano RF & Patton G (2005) Individual, family, school, and community risk and protective factors for depressive symptoms in adolescents: A comparison of risk profiles for substance use and depressive symptoms. *Prev Sci* **6**, 73–88.
51. Christensen L (2001) The effect of food intake on mood. *Clin Nutr* **20**, S161–S166.
52. Benton D & Donohoe RT (1999) The effects of nutrients on mood. *Public Health Nutr* **2**, 403–409.
53. Liebman M, Pelican S, Moore S *et al.* (2003) Dietary intake, eating behavior, and physical activity-related determinants of high body mass index in rural communities in Wyoming, Montana, and Idaho. *Int J Obes Relat Metab Disord* **27**, 684–692.
54. Sawyer MG, Miller-Lewis MR & Clark JJ (2007) The mental health of 13–17 year-olds in Australia: Findings from the national survey of mental health and well-being. *J Youth Adolesc* **36**, 185–194.