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The association of diet and depression: an analysis of dietary measures in depressed, non-depressed, and healthy youth

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ABSTRACT

Background: The association of diet quality with depression among the pediatric age group has been inconsistent. This may be due, in part, to varying dietary assessment methods. The current study sought to examine this association, and its reliability, using four dietary measures previously studied in children and adolescents.

Methods: Dietary habits among 139 children and adolescents (10–18 years, 66% female) with major depressive disorder [MDD ($n = 77$)], non-MDD psychiatric conditions (PSYCH; $n = 31$), or without psychiatric illness (healthy controls [HC]; $n = 31$) were examined. Using self-reported dietary intake, diet quality was characterized using the Youth Healthy Eating Index (YHEI), Dietary Questionnaire (DQ), Health Behaviour of Teenagers (HBT), and the Healthy Eating Habits Scale (HEHS). Multivariate Analysis of Covariances examined the association between depression status and dietary habits across measures controlling for participant age.

Results: The multivariate effect was significant by diet measures, $F(16, 256) = 1.9, p = .02$, partial $\eta^2 = 0.12$, with significant differences across groups on consumption of healthy dietary practices and minimal variability across measures. In subgroup analyses, MDD children had decreased consumption of healthy foods compared with PSYCH and HC children on three out of four measures. There was no difference in consumption of unhealthy foods across diagnostic groups.

Limitations: Cross-sectional design.

Conclusions: Children with MDD consume fewer healthy foods than non-MDD children, with little variation by dietary measure. Research examining the directionality of this association and specific dietary deficits among MDD youth is needed to elucidate potential preventative targets for intervention.



KEYWORDS

Diet; depression; children and adolescents; mental health; clinical research; obesity risk; mood disorders; dietary patterns

Introduction

Major Depressive Disorder (MDD) confers increased risk for future cardiovascular disease (CVD) among affected individuals¹ Youth with MDD have an increased risk of CVD (relative risk = 2.19) and premature CVD death (standardized mortality ratio = 1.5–1.9), compared with their non-depressed peers.^{2,3} The American Heart Association confirmed in a scientific statement that youth-onset of MDD confers an increased risk of CVD that cannot be explained by anti-depressant treatment or shared comorbidities (e.g. smoking, physical inactivity),^{4,5} and recommends

wider recognition of youth-onset MDD as an independent risk condition for CVD.⁵ While this is true, the mechanism for this association is currently unknown. One putative pathway may be, in part, via increased risk of obesity among individuals with MDD.^{6,7} Thus, the role of dietary patterns in the development and course of MDD is an area of increasing scientific interest and research. Data from adult populations has confirmed an inverse relationship between healthy dietary behaviours (e.g intake of fruit, vegetables and whole grain foods) and depressive symptoms in observational studies and meta-analyses,^{8,9} with randomized

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controlled trials suggesting a causal association in some,^{10,11} but not all,¹² studies. Further, although depressed mood may contribute to unhealthy eating patterns, research suggests that unhealthy eating (e.g. intake of high-sugar, high-sodium, highly processed foods) is more likely to precede depressive symptoms.¹³

Few studies have examined the association between dietary patterns and depression among children and adolescents.¹⁴ However, greater understanding of this potential relationship in childhood is important as eating behaviours are established early in life,¹⁵ and since the majority of individuals with MDD experience illness onset as youth.¹⁶ Determining the association of dietary patterns and depression in childhood also enables examination of the relationship at its most nascent stages, prior to the emergence of the confounding effects of comorbid conditions, such as obesity. This is important because dietary patterns are more likely to be amenable targets for preventive intervention than are future weight reduction interventions, once obesity is present. To date, findings regarding the association of dietary quality and patterns with depression in the pediatric age group have been inconsistent,¹⁴ which may be partly attributable to varying methods of dietary assessment and data collection instruments.¹⁷ To address this concern, the primary objective of the current study was to examine the association between dietary patterns and depression. The secondary objective was to compare these results across four dietary quality measures that have been previously studied in children and adolescents.

Methods

Participants

Children and adolescents with major depressive disorder [MDD] and non-mood psychiatric conditions [PSYCH] were recruited from a child and adolescent psychiatry clinic at The Hospital for Sick Children (SickKids), a tertiary care children's hospital in Toronto, Canada. Participants were under the age of 18 years with current or recent MDD [MDD group], non-MDD psychiatric illness [PSYCH], or no active psychiatric disorder (> 6 months) or lifetime mood or anxiety disorder (healthy controls; HCs) as defined by the Diagnostic and Statistical Manual for Mental Disorders 5th edition (DSM-5)¹⁸ with at least one parent available to participate. Exclusion criteria included inability to provide informed consent/assent (e.g. psychotic disorder, developmental delay), history of hypomania/mania, significant chronic medical illness (e.g. rheumatologic disease, cancer), or first degree relative with MDD (HCs only).

Study procedure

MDD and PSYCH participants were referred to the study via the Children's Integrated Mood and Body (CLIMB) programme, an outpatient clinical research programme within the Department of Psychiatry. Youth with relevant reasons for referral (e.g. sadness, decreased motivation) and increased self-reported depressive symptoms (see measures below) are referred to CLIMB via the departmental centralized intake system, which receives referrals from a wide variety of clinicians and settings, including family physicians, pediatricians, nurse practitioners, emergency medicine clinicians, and psychiatrists. HCs were recruited from the community via study flyers inviting them to participate in a study on cardiovascular risk factors among healthy youth. MDD and PSYCH participants completed self-reported dietary intake measures in the week prior to psychiatric evaluation. HC participants completed all measures at a single timepoint. Participants and their parent/guardian provided written informed consent. The study was approved by the Sick-Kids' Research Ethics Board.

Measures

Exposure: Psychiatric diagnoses. Current and lifetime diagnoses were determined by standardized semi-structured psychiatric interview using the Schedule for Affective Disorders and Schizophrenia for School-Age Children, Present and Lifetime Version (KSADS-PL).¹⁹ The Depression (Current) supplement (DEP-C) was used to assess depressive symptoms in current and previous depressive episodes for confirmation of MDD diagnosis.²⁰ The youth and their parent each separately served as informants. All interviewers had completed a master's degree in a health science field, were trained in the KSADS-PL, and had experience administering standardized semi-structured psychiatric interviews. Consensus conferences were held with a child-adolescent psychiatrist (D.K.) blinded to research participation status.

Dietary Assessment. Participants in this study completed the Healthy Heart Niagara Assessment (HHNA), a self-report questionnaire developed for grade 7, 9 and 11 students in the Niagara region of Ontario, Canada.²¹ Respondents reported on their consumption of 24 defined categories of foods (e.g. fruit, chocolate, candy) over the previous 24 h period. Within each category, participants additionally reported on the frequency of consumption of foods ranging from 0 to 3+ times over the previous 24 h. HHNA responses were systematically re-coded based on pre-determined

algorithms in order to evaluate four different measures of pediatric dietary patterns (see below) for comparison across the three diagnostic groups. Measures that were selected for evaluation had been previously utilized in studies examining dietary intake among youth.^{22–31} Further details regarding HHNA coding specific to each of the dietary measures below are described in Supplemental Table 1.

Youth Healthy Eating Index (YHEI). The YHEI is a 13-item modified version of the Healthy Eating Index (HEI)²⁷ that was simplified for use in older children and adolescents and examined in 16,452 children, 9–14 years old, during the Nurses Health Study II in the United States.²³ The YHEI evaluates the consumption of various healthy and unhealthy foods in the past 24 h and the frequency of different dietary behaviours (e.g. eating a cooked dinner as a family) occurring over the past week. Points are awarded in favour of healthier dietary intake and eating behaviours to a maximum of 90 points, with higher scores indicating healthier dietary practices.

Healthy Eating Habits Scale (HEHS). This 23-item measure of dietary intake was extracted from the National Longitudinal Study of Adolescent Health (Add Health).^{22,24} Respondents indicate whether or not each healthy or unhealthy food item was consumed in the previous day. Items are summed to create 2 subscale scores: healthy and unhealthy eating (maximum scores 22 and 15, respectively) with higher scores indicative of greater healthy or unhealthy food intake.

Dietary Questionnaire (DQ).²⁵ The DQ is a 9-item self-report measure previously adapted from the Amherst Health and Activity Study Adult Survey of Child Health Habits.³² Items assess the intake of key foods that suggest healthy (4 items) or unhealthy (5 items) dietary choices and the quantity of each food category consumed (from 0 to 5+ servings per day) and yield subscale scores to a maximum of 5 (healthy) and 30 (unhealthy). Higher scores on healthy and unhealthy subscales indicate greater healthy and unhealthy diet, respectively.

Health and Behaviour of Teenagers Dietary Questionnaire (HBT). The HBT is a 9-item measure comprised of dietary intake items administered in the Health and Behaviour of Teenagers Study (HABITS),³¹ and includes items from the Dietary Instrument for Nutrition Education (DINE)²⁸ and The Foods That You Eat³⁰ measures, and also previously utilized by the Research with East London Adolescents Community Health Survey^{26,29} study of the relationship between diet quality and adolescent mental health. When completing the HBT, participants report on the number of servings of healthy (fruits and vegetables) and unhealthy

(sweets, crisps) foods consumed in a typical day. Higher subscale scores (maximum scores are 13 [healthy] and 20 [unhealthy]) indicate greater healthy and unhealthy eating habits, respectively.

Statistical analyses

Descriptive statistics (t-tests for continuous variables, chi-square tests for categorical variables) were used to compare demographic characteristics between participant groups. A one-way multivariate analysis of covariance (MANCOVA)³³ was conducted to examine mean differences between groups (MDD, PSYCH, HC) and dietary intake, adjusted for child age. Prior to conducting a series of follow-up ANOVAs, the homogeneity of variance assumption was tested for all dietary intake subscales. Based on a series of Levene's F tests, the homogeneity of variance assumption was considered satisfied.³⁴ A series of one-way ANOVA's were conducted as a follow-up test to the MANCOVA. Finally, post-hoc analyses using Tukey's Honest Significant Difference test were performed to examine individual mean difference comparisons across all three participant groups and all four dietary measures demonstrating significant group differences. Analyses were conducted using SPSS v23.³⁵

Results

Demographic and clinical characteristics

Of 147 potential participants, complete dietary data were available for 139, resulting in the exclusion of eight potential participants. Data regarding household income was missing for 29 out of 139 participants (20.8%). To examine the potential effect of missing household income data on the association between dietary practices and depressive symptoms, sensitivity analyses were conducted, with no effect on study findings. Household income was not significantly associated with dietary practices ($r = 0.12$, $p > .5$) or depressive

Table 1. Demographics for MDD, PSYCH and HC groups

	MDD (n = 77)	PSYCH (n = 31)	HC (n = 31)
Age (years; mean [SD])	14.4 (2.1)	12.7 (2.5)	14.0 (1.7)
Sex (% female)	74.0	67.7	45.1
BMI (kg/m ² ; mean [SD])	21.8 (5.5)	20.4 (5.1)	20.7 (3.7)
Mean Household Income* (SD)	118 000 (61 000)	134 000 (62 000)	137 000 (61 000)
CES-DC mean (SD)	42.0 (10.3)	36.0 (9.4)	9.8 (4.7)
Medication use (Any; %)	28.6	32.3	9.7

*Canadian dollars, where available; BMI, Body Mass Index; CES-DC, Centre for Epidemiological Studies of Depression in Children; MDD, Major Depressive Disorder; PSYCH, non-mood psychiatric disorders; HC, healthy controls

symptoms ($r = 0.06$, $p > .5$) on univariate analyses. There were no differences in age ($p = .61$) or sex ($p = .93$) between participants with missing and complete data. Demographic characteristics of the 139 participants (77 MDD, 31 PSYCH, 31 HC) are presented in Table 1. Compared with HC, a greater proportion of children with a mental health disorder (MDD or PSYCH) were female (74.0% vs 67.7% vs 45.1%, $\chi^2 = 7.5$, $p = .02$). MDD and HC participants were of similar age (mean 14.4 [SD = 2.2] years vs 14.0 [SD = 1.7] years, $p = .37$), and were older than PSYCH participants (mean 12.7 [SD = 2.3] years, $p = .02$). Body mass index was not significantly different across diagnostic groups ($p = .22$). Participants with MDD reported higher depressive symptoms than PSYCH which was not statistically significant ($p = .07$) and significantly higher depressive symptoms compared with HC ($p < .001$) participants (Table 1). The most common primary psychiatric disorders of PSYCH participants were Anxiety disorders (52%), Attention Deficit Hyperactivity Disorder (20%), and Oppositional Defiant Disorder (10%).

Dietary behaviours of participants

Dietary behaviours as assessed by the four measurement tools (YHEI, DQ, HBT and HEHS) are presented in Table 2, with subscale scores for Healthy and Unhealthy eating presented, where applicable. Examination of the effects of dietary behaviours on depressive symptoms revealed that the overall multivariate effect was significant by diet measures, $F(16, 256) = 1.9$, $p = .02$, partial

Table 2. Comparison of dietary measure scores across MDD, PSYCH, HC groups.

	Maximum Score	MDD ($n = 77$) Mean (SD)	PSYCH ($n = 31$) Mean (SD)	HC ($n = 31$) Mean (SD)
Healthy Eating Habits Scale	22	7.9 (5.4) ^a _b	11.2 (6.5)	10.0 (5.6)
Unhealthy Eating Habits Scale	15	3.26 (1.7)	3.61 (1.9)	3.35 (1.6)
Dietary Questionnaire (Healthy)	5	2.2 (1.0) ^a _b	2.8 (1.1)	2.9 (0.8)
Dietary Questionnaire (Unhealthy)	30	8.8 (2.9)	9.0 (4.2)	8.7 (2.4)
Health and Behaviour of Teenagers (Healthy)	13	5.4 (2.8) ^a _b	7.3 (3.4)	7.2 (2.9)
Health and Behaviour of Teenagers (Unhealthy)	20	3.8 (3.0)	3.7 (3.3)	3.8 (2.7)
Youth Healthy Eating Index	90	49.5 (9.8) ^b	51.4 (11.4)	53.9 (8.9)

MDD, Major Depressive Disorder; PSYCH, non-mood psychiatric disorders; HC, healthy controls.

^a $p < .05$ vs. PSYCH; ^b $p < .05$ vs. HC.

$\eta^2 = 0.12$, with differences across diagnostic groups on consumption of healthy dietary intake, and demonstrated minimal between-measure variability (Table 3). On subgroup analyses, MDD children had decreased consumption of healthy foods compared with HC participants on three (YHEI, DQ, HBT) out of four dietary instruments ($p < .001$, $p = .008$, $p = .02$, respectively) and decreased consumption of healthy foods compared with PSYCH participants on three (DQ, HBT, HEHS) of the four dietary instruments assessed ($p = .02$, $p = .006$, $p = .006$, respectively; Table 4). There was no difference in consumption of unhealthy foods across diagnostic groups (Table 3).

Discussion

This study examined, for the first time, the dietary behaviours of a clinical population of children with MDD and other mental health disorders in comparison with those of healthy children. This study finds that children and adolescents with MDD consume fewer healthy foods compared with healthy children. Results from this study also suggest that children with MDD may also have a decreased intake of healthy foods when compared children without MDD who have other mental health disorders.

These findings add to an emerging body of research noting an association between dietary behaviours and depression among children and adolescents. Many, but not all, previous studies have reported an association between increased healthy dietary quality and behaviours and decreased depressive symptoms.²⁶ To date, however, studies have been conducted in community samples of children and adolescents with an overall low burden of depressive symptoms.¹⁴ The current study confirms this finding in a clinical population of youth with MDD, thus underscoring its potential clinical relevance. Moreover, this is the first study to compare dietary behaviours of children with MDD, with

Table 3. Multivariate effects of dietary behaviours on depressive symptoms*

Predictors	F	df	p	Partial η^2
Youth Healthy Eating Index (YHEI)				
Unhealthy	2.3	3	0.08	0.05
Healthy	5.4	3	0.002	0.11
Dietary Questionnaire (DQ)				
Unhealthy	0.61	3	0.61	0.01
Healthy	5.5	3	0.001	0.11
Health Behaviour of Teenagers (HBT)				
Unhealthy	0.47	3	0.71	0.11
Healthy	5.5	3	0.001	0.01
Healthy Eating Habits Scale (HEHS)				
Unhealthy	0.3	3	0.83	0.01
Healthy	3.8	3	0.012	0.08

*adjusted for participant age.

Table 4. Comparison of healthy dietary behaviours among diagnostic groups by dietary instrument.

Predictors	Group	Group	Mean		95% Confidence Interval	
			Difference	<i>p</i>	Lower Bound	Upper Bound
Youth Healthy Eating Index (YHEI)	MDD	PSYCH	-1.97	.257	-4.93	0.98
		HC	-4.59	<.001	-7.31	-1.86
Dietary Questionnaire (DQ)	MDD	PSYCH	-0.59	.023	-1.11	-0.07
		HC	-0.62	.008	-1.10	-0.14
Health Behaviour of Teenagers (HBT)	MDD	PSYCH	-2.10	.006	-3.70	-0.50
		HC	-1.75	.02	-3.22	-0.27
Healthy Eating Habits Scale (HEHS)	MDD	PSYCH	-4.00	.006	-7.04	-0.96
		HC	-2.02	.21	-4.80	0.79

MDD, Major Depressive Disorder; PSYCH, non-mood psychiatric disorders; HC, healthy controls.

non-mood psychiatric disorders, and healthy children. Results from this study suggest that children with MDD consume the fewest healthy foods of all groups, consistent with a dose-response relationship reported in previous population-based research.³⁶

There are several mechanisms that may underpin the association between dietary behaviours and depression, the direction of which cannot be determined in the current study due to its cross-sectional design. As such, it is possible that MDD leads to decreased healthy diet and also possible that decreased healthy diet behaviours lead to greater depressive symptoms. Depressive symptoms, including amotivation, fatigue, anhedonia and negative self-cognitions may lead to more frequent choice of processed convenience foods or reward-seeking via carbohydrate-rich foods,³⁷ with these foods replacing healthy foods in the diet. Conversely, an unhealthy diet has been associated with increased markers of an inflammatory state,³⁸ whereas a healthy diet has been reported to reduce inflammation.³⁹ As increased pro-inflammatory markers have been found to predict depressive symptoms among children and adolescents,⁴⁰⁻⁴² decreased healthy dietary behaviours may increase depressive symptoms via increased inflammation. Additional hypothesized mechanisms by which decreased healthy diet may be associated with MDD include via deleterious changes in the gut microbiome or by decreased synthesis of brain-derived neurotrophic factor (BDNF),^{43,44} a protein implicated in the pathophysiology of MDD.⁴⁵ This study also found a decrease in healthy dietary behaviours among children with MDD compared with children with other psychiatric disorders in three of the four instruments applied. This suggests that MDD may be more vulnerable to the systemic effects of dietary intake compared with other mental health disorders, such as anxiety disorders, in keeping with previous research.⁴⁶

Recent systematic reviews of the association between dietary intake and mental health disorders among children and adolescents have highlighted that the inconsistency in nutritional assessment and reporting methods

is a notable challenge to the advancement of knowledge in this area.^{14,47} Children and adolescents may require parental assistance in measure completion, and/or parents may not always be aware of the full extent of their child's intake. To address these concerns, the current study examined dietary behaviours using measures that have been previously validated among children and adolescents with mental health symptoms, and compared the association of dietary behaviours with mental health disorder across instruments as well as across diagnostic groups. We found consistent associations between diet and MDD, in the direction of decreased healthy eating, compared with healthy children among three out of the four measures examined. In comparison, MDD children and adolescents also demonstrated decreased healthy eating compared with children and adolescents with other psychiatric disorders (PSYCH) in three out of the four measures examined.

Compared with the HBT, DQ, and YHEI measures, the HEHS did not detect a MDD-specific diet association when compared with healthy controls. In contrast to the other measures, which incorporate questions regarding intake of whole grains, dairy products, and include at least one item regarding dietary patterns, the HEHS is focused almost exclusively on fruit and vegetable intake, and as a result may be less sensitive in its overall assessment of healthy dietary behaviours. There were no differences between diagnostic groups with respect to unhealthy eating behaviours regardless of measurement tool employed. Taken together, these data increase confidence in the finding of decreased healthy food intake among MDD children and adolescents and suggest that while a gradient effect among groups from healthy to non-MDD psychiatric disorder to MDD in this decrease may be present, further research among larger non-MDD clinical samples of children with mental health disorders is needed.

Strengths & Limitations. To our knowledge, this is the first study to examine the association of dietary behaviours with MDD in a clinical population of children, across diagnostic categories, and across dietary

assessment instruments. Other strengths of this study include the use of gold-standard methodology to confirm the presence, absence, and diagnosis of psychiatric disorder, providing confidence in the validity of the diagnostic group comparisons. This study is also subject to limitations. The non-MDD groups were small in size, limiting the generalizability of study results. However, consistent findings across measures increases confidence in the findings overall. The primary source for dietary behaviour data was via collection from a single, comprehensive, self-report measure that included both food frequency and 24-hour recall items. Individual measures were then completed using these data, as asking participants to complete multiple dietary measures was felt to be burdensome and possibly confusing for an unwell group of children and families. Self-report of dietary behaviours is also subject to recall and social desirability biases, as individuals may minimize their unhealthy dietary behaviours or over-report healthy dietary practices.^{48–50} Finally, data was collected cross-sectionally for all groups, limiting the ability to make causal inferences or determine the temporal association between decreased healthy eating and MDD among children and adolescents.

Conclusion

Dietary practices among children and adolescents with MDD are different from those with other psychiatric conditions and healthy youth. Youth with MDD consume fewer healthy foods than their non-depressed peers, and may have poorer dietary quality compared with youth with non-mood psychiatric disorders. However, we find no differences in unhealthy dietary behaviours between groups, suggesting that MDD youth do not simply replace healthy with unhealthy dietary practices. Research examining the directionality and putative mechanism of association between decreased healthy diet and depressive symptoms among youth with MDD is needed to determine the temporal association between these factors and identify potential targets for intervention.

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