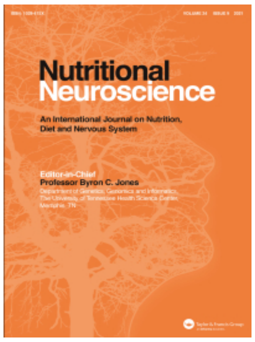

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Nutrient intake and food selectivity in children with Tourette syndrome

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ABSTRACT

Objectives: Children with Tourette syndrome (TS) have been shown to exhibit high levels of food selectivity; however, its association with nutritional status has yet to be explored. The current study explored macro and micronutrient intake and food selectivity among children with and without TS, using 24-hour dietary recall and the Child Eating Behaviour Questionnaire.
Method: Parents of 43 children diagnosed with TS and 38 age-matched children without a clinical diagnosis completed an online 24-hour food diary.
Results: Fifty-eight per cent of children with TS were identified as falling outside of the healthy BMI range (underweight = 24.2%; overweight = 27.3%; obese = 6.1%). Children with TS also consumed fewer portions of fruit and vegetables along with meeting the daily reference nutrient intake guidelines significantly less often for vitamins B_3, B_6 and C, selenium and phosphorus compared to children without TS.
Conclusions: Understanding the nutritional risk of children with TS relative to other children is important to clinicians and health care professionals who oversee nutritional inspection in primary care, and caregivers who are worried about the impact of limited or restricted diets.

KEYWORDS
Food selectivity; dietary intake; Tourette syndrome; nutrient deficiencies; diet; tics; neurodevelopmental; BMI

Introduction

Evidence suggests that dietary factors are associated with several childhood neurodevelopmental disorders [1]. For example, low levels of copper, iron, zinc, magnesium, and omega-3 fatty acids have all been reported in children with attention-deficit/hyperactivity disorder (ADHD). In children with autism spectrum disorders (ASD), research reports a lower intake of protein, minerals, and vitamins, such as B and D, compared to neurotypical children [2]. Moreover, a relationship between diet and symptoms of these disorders has also been noted. While sugar, artificial food colourings and preservatives are associated with heightened ADHD symptoms, flax oil and vitamin C supplements have been shown to improve symptoms [3]. For those with ASD, behavioural symptoms have also been reported with the use of various nutritional supplements, including vitamin C and omega-3 fatty acids [4]. Despite a high co-occurrence with both ASD and ADHD, there has been a distinct lack of research addressing nutrition and diet in Tourette syndrome.

Tourette syndrome (TS) is a neurodevelopmental disorder which is characterised by repetitive, involuntary, and non-rhythmic motor and phonic tics [5]. It is currently estimated that in the United Kingdom approximately one per cent of all school children between the ages of 5 and 17 are diagnosed with this condition [6]. However, this may be considered a conservative estimate given the increase in tic-like behaviours in adolescents reported since the COVID-19 pandemic [7].

A range of factors that increase anxiety, stress, excitement and fatigue have all been found to exacerbate tics and associated symptoms (e.g. [8]). Importantly in the context of the current study, dietary behaviour has also been implicated in the fluctuation of tics. For example, an increase in the frequency of tics has been related to the consumption of caffeine, alcohol, and refined sugars [9]. Caregiver reports have also demonstrated that children with TS compared to children without, are more likely to use special diets and/or take nutritional supplements [10].

Children with TS may be particularly vulnerable to nutritional deficiencies due to showing more atypical eating patterns compared to those without a tic disorder. For example, greater food selectivity, rejection and/or avoidance of novel and familiar food have

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been reported in children with TS [11,12]. Persistent medium and high levels of food selectivity have also only been associated with both lower and higher body mass index (BMI). Prolonged food selectivity has also been associated with micronutrient deficiencies and with unhealthy dietary patterns, including reduced consumption of vegetables [13].

In the United Kingdom, it has been estimated that less than 18% of children (5–15 years) consume the recommended five portions of fruit and vegetables a day, with an even lower intake reported in children with neurodevelopmental disorders [14]. For example, children with ASD have been shown to consume fewer vegetables and favour more unhealthy snacks and sweetened beverages compared to neurotypical peers [15]. This research is particularly relevant to children with TS, as research has suggested a reduced preference for fruit and vegetables compared to typically developing (TD) children [11]; however, research has yet to explore their consumption of these food groups. Given food preferences have been shown to provide reasonable estimates of food consumption [16,17], and health benefits attributed to fruit and vegetable consumption, it is clinically important to explore this in children with TS alongside macro- and micronutrient intake.

The few studies addressing food consumption in TS, have reported low levels of ferritin and serum iron levels in both children and adults with TS [18], while a magnesium and vitamin B_6 deficiency have been suggested in children with TS [19]. Akin to the findings showing diet to affect the symptoms of children with both ASD and ADHD, there is also a suggestion that the use of nutritional supplements could decrease the severity and/or frequency of tics [20]. More specifically, in a survey of Complementary Alternative Medicine use, 87.7% of 115 respondents used dietary supplements to control tics. The most used supplements were calcium, magnesium and vitamins B, C and E [21].

To date, limited controlled studies have been carried out investigating nutritional supplements in TS. A placebo-controlled study addressing the effect of omega-3 fatty acids supplementation in children and adolescents with TS, found to be beneficial for some tic-related symptoms [22]. Wu et al [23] probiotic supplementation was not found to significantly improve TS symptoms but was shown to improve ADHD parameters in children with this co-occurring condition. More recently, Rizzo and colleagues [24] carried out an open label study evaluating the effectiveness of supplementation of both L-Theanine and Vitamin B6 in reducing tics disorders in a sample of youth with chronic tic disorder (CTD) and TS with anxiety.

Liang and colleagues [25] carried out one of the only studies investigating nutrient intake in adults with TS. Forty-eight adults were asked to complete a 24-hour dietary recall. Results revealed over half of those surveyed reported consuming low levels of protein, calcium, zinc, retinal, thiamine, riboflavin and vitamin C. It was also noted that adults with TS reported an unhealthy level of consumption of both carbohydrates and fats, and therefore may be more prone to an unbalanced, and often energy-dense diet, which can predispose children to weight gain and its associated health complications [4]. Excessive consumption and cravings for sugars and carbohydrates are indicative of gut dysbiosis, with a recent study confirming gut microbiota in children with TS to be distinguishable from those without [26].

As there is a suggestion that individuals with TS have nutrient deficiencies, which may influence tic behaviour, it is crucial to understand their dietary intake. The current study aimed to compare nutrient intake from food consumed by children with and without TS, along with examining nutrient deficiency and excess as identified by national recommended dietary guidelines.

Method

Participants

Eighty-one caregivers (aged 26–66 y; $M = 40.77$, $SD = 6.85$), including 78 mothers, 2 fathers and 1 grandparent with parental responsibilities, reported information on their child. Caregivers reported their nationality as British ($n = 75$), American ($n = 3$), French ($n = 1$), Canadian ($n = 1$) and Slovak ($n = 1$). Forty-three children diagnosed with TS between the ages of 6 and 17 years and 38 TD children (defined as no suspected or official clinical diagnosis) between the ages of 6 and 16 years were included in the study. Permission was granted from the University of Hertfordshire University Ethical Advisory Committee, protocol number: aLMS/PGT/UH/02784(4) to conduct this study and research was performed in accordance with the Declaration of Helsinki. Caregivers were recruited through Tourettes Action charity online website in addition to online forums and local organisations who agreed to advertise the study. Caregivers volunteered to take part and gave explicit informed consent online prior to participating.

Data collection

Participants completed an online survey hosted by Qualtrics. Demographic information, including child's sex, age and medication use, was collected first. BMI was calculated from caregiver-reported height and weight (kg/m_2). Children were categorised as underweight (grade 1, 2 or 3), healthy weight, overweight or obese according to age and sex-specific international cut-offs for BMI [27]. The Premonitory Urge for Tics Scale (PUTS; [28]) and caregiver reports were used to confirm diagnosis of TS. The PUTS measures tic severity through the presence and frequency of premonitory urges, with a score above 31 indicating extremely high intensity with probable severe impairments. This scale was only administered in the TS group.

A single 24-hour caregiver-administered food recall with no interviewer obtained information of all food and beverage intake during the previous day. Caregivers were asked to provide as much detail as possible about the food and beverages their child consumed including the types, brand names and quantities. Participants had the option to close and revisit the survey as many times within a week before the survey automatically closed to allow for a complete dietary recall to be recorded. Caregivers also completed the Child Eating Behaviour Questionnaire (CEBQ; [29]). The food selectivity subscale from this measure was used to assess caregiver perceptions of their child's frequency of rejecting familiar and novel foods. The food selectivity subscale consists of six items and includes how difficult the child is to please with meals, how often the child refuses to taste new foods and the variety of foods the child will eat. Caregivers rated the frequency at which the child exhibits the behaviour on a 5-point Likert scale ranging from 1 (never) to 5 (always). The researchers approximate that the survey would take 30 min to complete. Participants were thanked for their time and fully debriefed on completion of the survey with the option of withdrawing their data up to three months after and detailed information where participants could reach out for on neurodiversity and eating support should they wish.

Dietary analysis

Nutrient intake was calculated using National Diet and Nutrient Survey databank via Nutritics dietary analysis software (Nutritics v4.312 Academic Edition, Ireland). Standardised portion sizes were assigned according to caregiver reports and the Foods Standards Agency (FSA) Food Portion Sizes [30]. Daily intakes of macronutrients and their components were detailed as total grams (g) per day or percentage of daily energy intake (%E). The percentage of energy contribution from macronutrients was calculated using the Atwater factors. Daily intakes of micronutrients were detailed as milligrams (mg) or micrograms (μg) per day. Comparisons between dietary intake across the two groups were explored. In addition, the adequacy of dietary intake was assessed by comparing energy and nutrient intake to age and sex-specific United Kingdom Estimated Average Requirements (EAR), Dietary Reference Values (DRV) and Reference Nutrient Intake (RNI; [31]).

Several benchmarks for macro- and micro-nutrients are proposed for different groups of healthy individuals in the United Kingdom [31]. In the current study, RNI were considered as they state the amount of a nutrient which is enough to ensure that nearly all of the group needs are met (97.5%, and RNI is used for recommendations of vitamins and minerals; [32]). The EAR, an average requirement, was used to compare energy intake and DRV was used to compare percentage consumption per energy intake for free sugars, carbohydrates and fat. Based on specific sex and age group dietary recommendations, participants were categorised into subgroups of children with the ages between 4 and 6 years and 7 and 10 years, males between 11 and 14 years, females between 11 and 14 years, males between 15 and 18 years and females between 15 and 18 years when comparing nutrients against dietary recommendations. For some nutrients dietary recommendations were unavailable meaning comparisons could not be made. One author, blinded to the case and control status, categorised the fruit and vegetable food groups using the standard portion being 80 grams for fresh fruit and vegetables and 30 grams for dried fruit and collaboration with a registered nutritionist.

Statistical analysis

Analysis was conducted using SPSS IBM version 25 (SPSS Inc., Chicago, IL, USA) with statistical significance set at $p < .05$. Firstly, independent t-tests were conducted to examine differences in baseline characteristics of participants. Secondly, a series of independent t-tests were conducted to examine differences in nutrient intake, the number of children meeting the dietary recommendations, fruit and vegetable portion sizes and food selectivity between children with TS and TD children. Levene's test examined homogeneity of variance and significance was reported appropriately. Two-tailed Pearson's correlations were conducted to explore food selectivity and BMI in relation to each nutrient.

Results

Baseline characteristics

Forty-three children diagnosed with TS (*M* = 10.83, *SD* = 2.78 y; 35 males, 8 females) and 38 children with TD (*M* = 9.80, *SD* = 2.30 y; 25 males, 13 females) were included in the study. There was no significant difference in age between the two groups, *t* (76) = 1.77, *p* = .081. Data from children with a confirmed eating disorder diagnosis were excluded from the current study. No exclusionary criteria were given for special diets. In children with TS, PUTS scores ranged between 9 and 36 (*M* = 22.86, *SD* = 6.74), with 19 children who had medium intensity, four had high intensity and four had extremely high intensity with probable serve impairment of premonitory urges for tics. In addition to confirming their child's TS diagnosis, caregivers reported the following co-occurring conditions experienced by their children: Obsessive compulsive disorder (OCD; *n* = 3), dysgraphia and dyspraxia and OCD (*n* = 1), mild anxiety disorder (*n* = 1), ADHD (n = 1) ASD (*n* = 1), ASD & ADHD (*n* = 2) and anxiety disorder, OCD & ASD (*n* = 2). Of the children with TS taking medication (*n* = 15), melatonin (*n* = 7), clonidine hydrochloride (*n* = 1), methylphenidate (*n* = 2), aripiprazole (*n* = 2), sertraline (*n* = 3) and fluoxetine (*n* = 1). Medical conditions reported in the control group included coeliac disease (*n* = 1) and asthma with corresponding inhaler use (*n* = 1). In the TD group, one caregiver noted that their child is 'predominantly vegetarian' and another gluten-free. In the TS group, caregivers reported one child did not consume pork due to religious reasons, another has a 'bland beige diet of <10 foods' and another child is highly concerned with 'food presentation e.g. peeled pear or apple, deskinned sausages'.

Independent *t*-test revealed a significant difference in BMI between children with TS (M = 18.67, *SD* = 4.79) and TD children (*M* = 16.55, *SD* = 3.63), *t*(63) = 2.001, *p* = .049. Of the TS sample who provided child BMI data (*n* = 33), 24.2% were categorised as underweight (grade 1 = 3.0%, grade 2 = 12.1%, grade 3 = 9.09%), 42.4% classified as healthy weight, 27.3% were overweight and 6.1% were classified as obese. Of the TD sample who provided child BMI data (*n* = 32), 28.1% were categorised as underweight (grade 1 = 6.3%, grade 2 = 12.5%, grade 3 = 9.4%), 59.4% classified as healthy weight and 12.5% were classified as overweight but none were obese. Although there was no significant difference in the number of children in the TS and TD group categorised as being in the healthy range X^2 (1, N = 65) = 1.24, *p* = .26, significantly more children with TS were categorised as being overweight and obese compared to TD, X^2 (1, N = 65) = 3.97, *p* = .046.

Differences in nutrient intake and comparison of intake against dietary recommendations

Mean consumption for macro- and micronutrients for children with TS and TD children are presented in Table 1, along with the proportion of participants meeting the dietary recommendations for these nutrients. In children with TS, the contribution of protein, fat and carbohydrate ranged from 8% to 24.9%, 15.8% to 58.2% and 21.4% to 69.1% of the energy intake, respectively. In children with TD, the contribution of protein, fat and carbohydrate ranged from 10.5% to 31.3%, 12.1% to 58.8% and 30.7% to 64.3% of the energy intake, respectively. The percentage energy of protein intake was significantly lower in children with TS compared to TD children, *t*(66) = −3.40, *p* = .001. Independent t-tests also revealed that on average children with TS consumed significantly more starch, *t*(79) = 2.21, *p* = .030, compared to TD children. There were no other significant differences on nutrient consumption between children with TS and TD children.

Independent t-tests were conducted to examine differences in the number of children who met the DRV and RNI for the given nutrients between the two groups. Children with TS were significantly less likely to consume the daily reference nutrient intake of vitamin B6, *t*(78.91) = 2.84, *p* = .01, vitamin C, t (77.89) = 2.55, *p* = .012, Vitamin B3, *t*(55) = 2.93, *p* = .01, selenium, *t*(76) = 2.07, *p* = .042, and phosphorus, t(54) = 3.413, *p* = .001, in comparison to TD children. There were no other significant differences in the proportion of children who met dietary recommendations in other nutrients between the two groups (*p* > .05).

Differences in fruit and vegetable consumption

Independent t-tests revealed children with TS consumed significantly less portions of fruit (*M* = .84, *SD* = .90), *t*(79) = −2.62, *p* = .011, and total fruit and vegetables combined (*M* = 1.93; *SD* = 1.45), *t*(79) = −2.23, *p* = .028, than TD children (*M* = 1.42, *SD* = 1.11; *M* = 2.66, *SD* = 1.47). There was no difference in the number of servings of vegetables between the children with TS (*M* = 1.09, *SD* = 1.06) and TD children (*M* = 1.26, *SD* = .98).

Table 1. Mean (standard deviation) consumption of macro- and micro-nutrients per day and the proportion meeting the dietary recommendations (according to sex and age) in children with TS and TD children.

	TS ($n = 43$) Mean (SD)	TD ($n = 38$) Mean (SD)
Energy (kcal)	1449(448)	1363(376)
Energy (kJ)	6088(1880)	5728(1576)
% meeting EAR	9.3	15.8
Total fat (%E)	33.5(8.4)	32.4(9.8)
% meeting DRV	24(55.8)	26(68.4)
SFA (%E)	12.4(3.4)	12.2(3.9)
% meeting DRV	37.2	47.4
PUFA (%E)	4.6(2.7)	4.6(2.8)
n-3 PUFA (%E)	.5(.5)	.5(.5)
n-6 PUFA(%E)	3.2(2.6)	2.3(1.7)
Trans fat (%E)	.5(.9)	.4(.2)
Cholesterol (mg)	135.1(101.5)	177.6(129.2)
Protein (g)	53.65(22.9)	59.66(17.8)
Protein (%E)	14.7(3.5)*	17.9(5.0)
% meeting RNI	81.4	97.4
Total carbohydrates (%E)	51.8(8.7)	49.7(9.0)
% meeting DRV	58.1	57.8
Dietary fibre (g)	14.79(6.2)	14.51(6.5)
% meeting DRV	7	13.2
Free sugars (%E)	7.5(6.5)	7.2(4.2)
% meeting DRV	25.6	34.2
Starch (g)	108.76(32.4)*	93.03(31.4)
Sodium (g)	1.5(.8)	1.3(.5)
% meeting RNI	53.5	47.4
Potassium (mg)	1744.82(695.1)	1976.96(642.7)
% meeting RNI	25.6	34.3
Calcium (mg)	603.50(293.3)	578.30(251.1)
% meeting RNI	27.9	42.1
Phosphorus (mg)	815.7(325.9)	880.4(226.7)
% meeting RNI	72.1*	97.4
Magnesium (mg)	162.73(57.8)	171.19(55.8)
% meeting RNI	7	15.8
Iron (mg)	8.73(8.23)	7.18(2.39)
% meeting RNI	20.9	21.1
Zinc (mg)	5.15(2.6)	6.20(2.45)
% meeting RNI	16.3	28.9
Folate (µg)	161.6(70.4)	183.1(75.4)
% meeting RNI	37.2	57.9
Iodine (µg)	96.4(60.7)	87.0(40.3)
% meeting RNI	23.3	21.1
Selenium (µg)	35.2(29.3)	34.9(18.4)
% meeting RNI	30.2*	52.6
Vitamin A (RAE; µg)	439.27(403.5)	560.46(456.1)
% meeting RNI	23.3	39.5
Vitamin D (µg)	1.77(2.03)	2.03(2.3)
% meeting RNI	0	0
Vitamin E (mg)	6.69(4.0)	6.16(3.2)
Vitamin K_1 (µg)	26.31(39.9)	36.76(43.8)
Vitamin B_6 (mg)	1.28(1.0)	1.43(.7)
% meeting RNI	46.5*	76.3
Vitamin B_{12} (µg)	4.96(11.7)	3.40(1.9)
% meeting RNI	86.0	92.1
Thiamin B_1 (mg)	1.0(.5)	1.1(.5)
% meeting RNI	65.1	78.9
Riboflavin B_2 (mg)	1.2(.6)	1.1(.4)
% meeting RNI	48.8	55.3
Vitamin B_3 (mg)	25.2(15.4)	28.8(11.2)
% meeting RNI	76.7*	97.4
Vitamin C (mg)	64.76(68.7)	92.39(62.9)
% meeting RNI	55.8*	81.6
Caffeine (mg)	6.46(27.8)	12.72(59.1)

Note: SFA, saturated fats; PUFA, polyunsaturated fats; n-3, omega-3; n-6, omega-6; RAE, retinol activity equivalent. *Significant differences.

Table 2. Two-tailed Pearson's correlations between food fussiness and nutrient intake per day in children with TS and TD children.

(1)	TS		TD	
	Food fussiness		Food fussiness	
	R	*P*	*R*	*P*
Energy (kcal)	−.46	.013	−.13	.561
Energy (kJ)	−.46*	.013	−.12	.568
Total fat (%E)	−.23	.235	−.15	.492
Saturated fat (%E)	−.01	.949	−.13	.546
Trans fat (%E)	−.10	.626	.08	.723
Cholesterol (mg)	−.59*	.001	.06	.779
Protein (g)	−.71*	<.001	−.05	.814
Protein (%E)	−.61*	.001	.01	.953
Polyunsaturated fatty acids (%E)	−.20	.307	−.10	.642
Omega−3 (%E)	−.55*	.002	−.15	.478
Omega−6 (%E)	−.21	.289	.06	.785
Total carbohydrates (%E)	.47*	.011	.15	.487
Fibre (g)	−.43*	.024	−.11	.625
Free sugars (%E)	.21	.278	.39	.057
Starch (g)	−.26	.190	−.16	.455
Sodium (g)	−.50*	.007	−.21	.329
Potassium (mg)	−.45*	.017	−.15	.498
Calcium (mg)	−.22	.255	.14	.526
Phosphorus (mg)	−.54*	.003	−.04	.846
Magnesium (mg)	−.47*	.012	−.14	.515
Iron (mg)	−.59*	.001	−.24	.258
Zinc (mg)	−.64*	<.001	−.18	.410
Folate (µg)	−.33	.086	−.16	.469
Iodine (µg)	−.47*	.012	−.01	.966
Selenium (µg)	−.61*	.001	−.19	.365
Vitamin A (RAE; µg)	−.34	.081	−.05	.814
Vitamin D (ug)	−.50*	.006	−.27	.210
Vitamin E (mg)	−.55*	.002	−.18	.408
Vitamin K_1 (µg)	−.21	.288	.09	.675
Vitamin B_6 (mg)	−.19	.324	−.21	.333
Vitamin B_{12} (µg)	−.50*	.007	−.09	.680
Thiamin B_1 (mg)	−.33	.084	−.34	.105
Riboflavin B_2 (mg)	−.39*	.042	−.20	.350
Vitamin B_3 (mg)	−.48*	.009	−.18	.407
Vitamin C (mg)	−.01	.951	−.07	.742
Caffeine (mg)	.38*	.048	−.32	.131

Relationships between food selectivity, nutrient intake, fruit and vegetable consumption and BMI

In terms of food selectivity, children with TS ($M = 3.53$, $SD = 1.07$) scored significantly higher than TD children ($M = 2.64$, $SD = .91$), $t(50) = 3.17$, $p = .003$. As shown in Table 2, two-tailed Pearson's correlations revealed greater food selectivity was associated with reduced consumption of several nutrients in children with TS, including total energy, vitamins D, E and B_{12}, sodium and fibre. Greater food selectivity was associated with higher mean consumption of caffeine intake in children with TS. There were no significant relationships between nutrients and food selectivity in TD children. There were no significant relationships between the number of fruit and vegetable servings consumed and food selectivity in either children with TS, $r(28) = .017$, $p = .93$, or TD children, $r(24) = -.18$, $p = .405$. Importantly, food selectivity was not significantly associated with BMI in either the children with TS, $r(24) = -.11$, $p = .621$, or TD children, $r(22) = -.04$, $p = .861$.

Discussion

Summary of main findings

The current study aimed to explore the nutrient intake of children with TS. While children with TS had a lower protein intake and a higher starch intake than TD children, the intake of other macro- and micronutrients appeared similar between the two groups. Compared to controls, children with TS consumed fewer portions of fruit and vegetables, along with meeting the national recommended guidelines significantly less often for vitamins B_3, B_6 and C, selenium and phosphorus. In children with TS, food selectivity was found to be inversely associated with a range of macro- and micro-nutrients including total energy, protein, fibre, cholesterol, omega-3 fatty acids, a range of vitamins including B_2, B_3, B_{12}, D and E, and minerals, such as sodium, potassium, magnesium, zinc, iron, iodine, selenium and phosphorus. Food selectivity was positively associated with both the total carbohydrates and caffeine intake in the TS group only.

Comparison with existing literature

Aligned with the research in adults with TS [33], children with this diagnosis were found to have greater consumption of starch compared to TD children. These findings echo research in other neurodevelopmental disorders, that has shown a preference for energy-dense, high carbohydrate-rich food intake and associated with increased weight gain in children with ASD [34]. The increased starch intake identified could also potentially be linked with an adverse metabolic profile and may account differences found in gut microbiota [26]. Although it is difficult to ascertain the food source and type of starch in this study, children with TS are more likely to prefer foods that contain higher levels of rapidly digestible starch that could adversely impact their metabolic health via higher postprandial blood glucose and insulin responses. Children with TS were also found to have a lower protein percentage of energy intake compared to TD children, which may be accounted for by their reduced preference for meat that has been previously reported [11].

In addition to consuming fewer portions of fruit and vegetables, fewer children with TS also met these dietary recommendations amounts compared to the TD children, except for fat and sugars, in which a greater number exceeded the RNI. Children with TS met the RNI less often for some minerals including selenium and phosphorus and specific vitamins including vitamin B_3, vitamin B_6 and vitamin C, were nutrients which children with TS than TD children, a trend mirrored in children with ASD (e.g. [35]). Therefore, children with TS appear to be at greater risk of micronutrient-related malnutrition which could have important growth and health consequences. For example, vitamin B_6, vitamin C and selenium all contribute to the typical functioning of the immune system, whereas low vitamin C levels can be linked with deficiency has been associated with weakness, fatigue and aching joints and muscles. The reduced vitamin C intake in children with TS may be accounted for by the low consumption of fruit and vegetables observed in the current study. Niacin B_3 and phosphorus also provide important functions with both contributing to how the body uses and breaks down carbohydrates, proteins and fats into energy [19]. It is also important to note that none of the children in either group met the RNI for vitamin D; however, vitamin D in children and adolescents is generally significantly below the recommendations in the United Kingdom [36].

Strength and limitations

While food selectivity has previously been reported in children with TS [11,12], this is the first study to associate this eating behaviour with poorer nutrient intake. More specifically, greater food selectivity was associated with greater caffeine intake, which has previously been found to worsen the severity and frequency of tics [8]. Therefore, the current results are seemingly supportive of anecdotal reports that food selectivity may indirectly influence some tic-related behaviours; however, further research is needed to confirm this suggestion. In addition to this, greater food selectivity was also associated with lower energy, protein and omega-3 fatty acids intake as well as many vitamins and minerals in children with TS. Therefore, managing underlying predictors of heightened food selectivity in children with TS may help to support an adaptive nutritional intake.

A significant difference in BMI levels between children with TS and TD children was also identified in the current study, with significantly more children with TS likely to fall outside the healthy range and fall within the overweight and obese categories. In the current study, food selectivity was not associated with BMI in either group, suggesting that there are other factors which may influence BMI and dietary intake; for example, the effect of medication on body growth and weight in TS has also been noted. Neuroleptic drugs have been found to increase both BMI and waist circumference percentiles in individuals with TS [37]. This is important as there appears little guidance for professionals to follow changes in weight in this population and any resultant effects on their dietary behaviour. There also exists a clear need for more longitudinal studies, not only addressing changes in weight following medication but also studies that examine its impact on diet and those choosing to follow restricted diets and/or supplement use in TS.

This study has several limitations. Whilst using a 24-hour dietary recall offers insight into food consumption and often more accurate information than food frequency questionnaires or retrospective recall (e.g. [38]), to fully understand food intake four-day repeated food diaries or methods involving direct observation may offer more accurate nutritional values. Repetition of methods accounts for variability in daily intake, which is particularly important for assessing some vitamins. Moreover, portion sizes were measured using a standardised measure; there is greater variability in the heterogeneity of eating patterns which should be evaluated for individual differences due to unique dietary patterns.

Implications for future research and clinical practice

Given some differences were found in children with TS macro- and micronutrient intake, along with previous research showing children with TS to be more selective eaters, further research is warranted to explore the nutrient intake in children with TS and subsequently, explore potential intervention strategies which may help to improve nutritional status. Whilst authors acknowledge nutritional status does not solely depend on nutrient consumption but also absorption and metabolic processing and demand [39], determining nutrient intake is a start for taking action to improve nutrition and subsequently, health and wellbeing in children with TS.

It is encouraged that clinicians are willing to openly integrate discussions with individuals and families regarding dietary intake, weight, and wider nutritional concerns in the initial stages of diagnosis and treatment. An accurate understanding of the unique nutritional risk of children with TS relative to neurotypical children is important to clinicians overseeing nutritional inspection in primary care and caregivers concerned about the impact of limited or restricted diets.

Conclusion

This is the first study, to our knowledge, to explore differences in macro- and micronutrient intake in children with TS. These results suggest that children with TS could have a tendency for a more nutritionally unbalanced diet and could represent an important public health concern as poor food choices in childhood have been linked to adverse physical and mental implications later in life (e.g. [13]). Further research to confirm initial findings and integration of nutritional intake conversations within clinics will aid in the management of nutritional deficiencies in children with TS.

Data availability

The participants of this study did not give written consent for their data to be shared publicly, so due to the sensitive nature of the research supporting data are not available.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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