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Picky eating – A risk factor for underweight in Finnish preadolescents

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ABSTRACT

Background: Picky eating (PE) is the most common cause of early-life feeding problems. However, the consequences of PE on food intake and weight development in general populations have not been established.
Objectives: This study aims to investigate the associations of PE and food neophobia (FN) with weight status in 5700 Finnish preadolescents. In addition, we described food consumption by PE/FN status.
Material and methods: We utilised the Finnish Health in Teens (Fin-HIT) cohort of 9–12-year-old preadolescents, who were categorised as having PE and FN based on answers from parental questionnaires. Weight was categorised as underweight, normal weight, and overweight/obesity based on body mass index (BMI) according to IOTF age- and sex-specific cut-offs. Eating patterns were obtained with a 16-item food frequency questionnaire. Multinomial logistic regression models were used to estimate odds ratios (OR) and 95% confidence intervals (CIs).
Results: The overall prevalence of PE and FN were 34% and 14%, respectively. PE was inversely associated with overweight/obesity (OR = 0.7; 95% CI 0.6–0.8) and led to a higher risk of underweight (OR = 2.0; 95% CI 1.7–2.4), while this was not observed with FN. Compared with preadolescents without PE/FN, those with PE/FN reported consuming unhealthy foods such as pizza, hamburgers/hot dogs, and salty snacks more frequently ($p < 0.0038$). By the same token, these preadolescents reported consuming healthy foods such as cooked vegetables, fresh vegetables/salad, fruit/berries, milk/soured milk, and dark bread less frequently.
Conclusions: Among Finnish preadolescents, only PE was associated with a higher risk for underweight and inversely with overweight/obesity. PE and FN were accompanied with unhealthy eating patterns. Management of PE in children may be explored as a potential strategy for improving healthy eating and avoiding underweight in preadolescents.

1. Introduction

The prevalence of picky eating (PE) varies between 3% and 66% in the paediatric population, but this variation is mainly due to different assessment methods. PE is considered the most common feeding problem in childhood, and the highest rate is observed among 2-3-year-old children (Gibson & Cooke, 2017). Indeed, PE tends to arise during the developmental phase, when the autonomy, self-concept, social competence, and self-regulation emerge (Cole, An, Lee, & Donovan, 2017), but it is shown to decrease with age (Cole et al., 2017; Taylor, Wernimont, Northstone, & Emmett, 2015). The definition of PE varies in the literature, but it includes several aspects, e.g., a lack of dietary variety due to self-selection, eating small amounts, food neophobia (FN), and strong food dislikes and preferences, often described as choosiness (Taylor et al., 2015). FN is defined as the reluctance to eat, or the avoidance of unfamiliar foods (Taylor et al., 2015) while PEs are choosy about both familiar and unfamiliar foods (Dovey, Staples, Gibson, & Halford, 2008). PE and FN are severe enough to "interfere with daily routines to an extent that is problematic to the parent, child, or parent-child relationship" (Ekstein, Laniado, & Glick, 2010).

The early and familiar determinants of PE have been characterised in two systematic reviews (Brown, Vander Schaaf, Cohen, Irby, & Skelton, 2016; Cole et al., 2017), while the long-term persistence and consequences are less clear. A more recent report on an 11-year

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longitudinal study stated that PE is often a chronic problem that can emerge at any age; 40% of cases persist for more than 2 years, and some cases may persist into adulthood (Mascola, Bryson, & Agras, 2010). PE is associated with food consumption most by lowering fruit and vegetable intake (Cole et al., 2017), but also by increasing the intake of highly palatable, energy-dense foods (Oliveira et al., 2015).

Long-term consequences of PE may include adverse effects on growth and development (Gibson & Cooke, 2017), although these effects are not consistent. The association between PE and childhood weight status was inconclusive in a systematic review involving 41 studies (Brown et al., 2016), while a more recent review suggested that children with PE weight less, but their weight is still within normal range based on longitudinal findings (Gibson & Cooke, 2017). Some studies have reported associations of PE with risk of depression, eating disorders, and emotional and behavioural problems as well (Brown et al., 2016; Cole et al., 2017). However, many of the recent studies have focused solely on PE in young children, and the long-term consequences of PE/FN on weight and eating habits have remained unclear.

The primary objectives of our study were to investigate the associations of PE and FN with weight status in nearly 5700 Finnish preadolescents and check if this association is more evident in subjects with persistent feeding problems. Secondarily, we described food consumption by PE/FN status.

2. Materials and methods

We utilised data from the Finnish Health in Teens (Fin-HIT) study, a prospective cohort study which includes preadolescents in Finland who were aged 9–12 years during the enrolment period of 2011–2014 (Figueiredo et al., 2017; submitted). The Fin-HIT study includes approximately 11,500 preadolescents and 10,000 parents, mostly mothers. The overarching aim of the Fin HIT study is to understand the environmental and genetic contributors to weight gain in adolescence. Baseline data collection was conducted in schools, where parents and adolescents completed a questionnaire, and had anthropometric measurements and a saliva sample collected. The Fin-HIT study protocol was approved by the Coordinating Ethics Committee of the Helsinki and Uusimaa Hospital Districts. Informed written consent was obtained from the preadolescents and from one of their parents, according to the Helsinki Declaration.

Adolescents answered a 16-item food frequency questionnaire (FFQ) about their food choices during the preceding month (Figueiredo et al., 2017; submitted). The concept of the FFQ is similar to that used in the Health Behaviour in School-Aged Children survey in 1997–1998 (Vereecken & Maes, 2003): it contains food items that are indicators of the respondent's overall diet, specifically in relation to dietary fibre, calcium, and products that are typical in youth culture. We included 13 of the 16 food items in the FFQ: sweet pastry, biscuits/cookies, ice cream, cooked vegetables, fresh vegetables/salad, fruit/berries, juice, sugary juice drink, milk/soured milk, dark bread, pizza, hamburgers/hot dogs, and salty snacks. The remaining three food items (water, sport drinks, and chocolate/candies) were omitted due to a large number of missing values. Frequency of consumption of each food item was evaluated on a 7-point scale, and subsequently categorised as seldom (not at all or less than once a week), sometimes (once a week or 2–4 times a week), and often (5–6 times a week, once a day, several times a day).

Body mass index, BMI (in kg/m^2) was calculated and preadolescents were categorised as underweight, normal-weight, overweight, or obese according to the International Obesity Task Force classification (Cole & Lobstein, 2012). As there were too few preadolescents classified as obese (2.5%) to allow sufficient statistical precision, we combined obese and overweight preadolescents (12.0%) into one category in all analyses.

The parental questionnaire, available from 6064 subjects, collected information on allergies, number of siblings, feeding problems, PE and FN, which were assessed before school age, retrospectively. Similar to the ALSPAC study (Taylor et al., 2015) we assessed PE by parental response to a single statement in the questionnaire: “she/he was very choosy about the food she/he ate”. Response options were: 1) yes, most of the time; 2) yes, sometimes; 3) seldom or never; and 4) I do not know or remember. Responses were recoded into a dichotomous variable: when parents gave answers 1 or 2, the preadolescent was placed in the PE group; when they gave answers 3 or 4, the preadolescent was placed in the non-PE group. For sensitivity analysis, the severity of PE was classified into three categories: severe (Gibson & Cooke, 2017), moderate (Cole et al., 2017) and no-PE (3 & 4). We assessed FN by parental response to the statement “he/she liked to try different foods”, to which responses were given on a similar 4-point scale. These responses were also recoded into a dichotomous variable: when parents gave answer 3, the preadolescent was placed in the FN group, when they gave answers 1, 2, or 4, the preadolescent was placed in the non-FN group.

Feeding problems and persistence of feeding problems were assessed by two statements related to two time-points: before school age, and currently. The statements were: “did not eat a sufficient amount of food” and “refused to eat the right food” with five response options: 1) yes, worried me greatly/I agree; 2) yes, worried me a bit/I slightly agree; 3) yes, but did not worry me/neither agree nor disagree; 4) no, did not happen; and 5) I do not know or remember. These responses were recoded into a dichotomous variable, with answers 1–3 categorised as “yes” and answers 4 and 5 categorised as “no”. Preadolescents categorised as “yes” at both time-points were considered to have persistent feeding problems.

After excluding preadolescents with missing information on age, sex, BMI, PE, FN, or feeding problems, or missing data in the FFQ a total of 5675 preadolescents were included in the present analysis.

2.1. Statistical methods

Cohort characteristics (quantitative variables e.g., age, BMI, number of siblings) are shown by PE and FN groups, and comparison between these groups was tested using the *t*-test. Associations between categorical variables were tested with the chi-square test. The effect size was estimated with Cohen's d or Cramer's V for comparisons assessed by *t*-test and chi-square, respectively. Multinomial logistic regression analyses were performed to estimate the odds ratios (OR) and 95% confidence intervals (CI) for underweight and overweight/obesity by PE/FN, using normal weight as the reference category. Adjusted models included preadolescents' age, sex, and number of siblings, and parents' age, sex, BMI, and educational level as covariates and these were literature-based (Cole et al., 2017; Hafstad, Abebe, Torgersen, & von Soest, 2013). Multivariate analyses were repeated in a subgroup with persistent feeding problems. Analyses were carried out separately for both sexes, and interaction between sex and PE and FN was examined using the likelihood ratio test, comparing models with and without the respective terms of interaction.

Data were missing for possible covariates: preadolescents' allergy status (n = 57) (Maslin, Dean, Arshad, & Venter, 2015), parental age (n = 5), parental sex (n = 10), parental BMI (n = 57), and parental educational level (n = 141). These values were replaced in multinomial logistic regression analysis using multiple imputation procedures, in order to maintain the full sample size. By default, the SPSS imputation runs five iterations and their pooled values were used in multinomial logistic regression models. Multiple variables e.g. relevant questionnaire data, covariates and outcome measures, were included in the imputation process. All statistical analyses were conducted using the IBM SPSS program for Windows, version 22 (IBM, Chicago, IL, USA). The statistical significance level was set at 5%. To correct multiple tests related to food consumption and PE/FN status, Bonferroni correction was applied.

Table 1
Characteristics of the study sample by picky eating (PE) status (n = 5675) with mean (± SD), if not indicated otherwise.

n	PE		non-PE		Effect size	*t*-test p-value
	1905		3770			
Male, n (%)	911	(47.8)	1843	(48.9)	0.01[a]	0.45[b]
Age, years	11.1	(± 0.8)	11.2	(± 0.8)	0.054	0.06
BMI of child, kg/m^2	17.3	(± 2.6)	18.1	(± 2.9)	0.290	< 0.001
Weight status					0.123[a]	< 0.001[b]
Underweight, n (%)	294	(15.4)	306	(8.1)		
Normal-weight, n (%)	1397	(73.3)	2856	(75.8)		
Overweight/Obese, n (%)	214	(11.2)	608	(16.1)		
Allergy-free, n (%) [c]	1589	(84.3)	3132	(83.8)	0.006[a]	0.65[b]
N of siblings	1.6	(± 1.3)	1.7	(± 1.5)	0.090	< 0.001
Parental age, y [d]	42.2	(± 5.5)	42.5	(± 5.3)	0.054	0.06
Mothers, n (%) [e]	1680	(88.4)	3359	(89.2)	0.013[a]	0.33[b]
Parental BMI, kg/m^2 [f]	24.9	(± 4.5)	25.2	(± 4.5)	0.064	0.02
Academic or university degree, n (%) [g]	677	(36.2)	1360	(37.1)	0.031[a]	0.38[b]
Food neophobia, n (%)	697	(36.6)	108	(2.9)	0.456[a]	< 0.001[b]
Persistent feeding problems, n (%)	624	(32.8)	236	(6.3)	0.349[a]	< 0.001[b]

[a] Cramer's V.
[b] Chi Square test.
[c] 57 missing values.
[d] 5 missing values.
[e] 10 missing values.
[f] 57 missing values.
[g] 141 missing values.

3. Results

Among the 5675 preadolescents in the study sample, the overall prevalence of PE was 33.6% and that of FN was 14.2%. Tables 1 and 2 show preadolescents' characteristics related to PE/non-PE and FN/non-FN groups, respectively. Persistent feeding problems were observed in 860 (15.2%) preadolescents and were more common in the PE (32.8%) and FN (39.4%) groups than in the non-PE (6.3%) and non-FN groups (11.1%) ($p < 0.001$). Preadolescents in the PE group had fewer siblings, were more often only children (12.9% vs. 10.5%, $p = 0.007$), and their parents' BMI was lower when compared the non-PE group (*t*-test $p = 0.02$) (Table 1). There were more boys in the FN group than the non-FN group (54.2% vs. 47.6%, $p < 0.001$). Preadolescents in the FN group had fewer siblings, and their parents had a higher educational level than those in the non-FN group ($p < 0.05$). Mean BMI was lower in the PE and FN groups as compared with the non-PE and non-FN groups ($p < 0.001$) (Table 2). Sensitivity analysis classified 490 PEs as severe and 1415 as moderate.

When food items (n = 13) were investigated by PE status, we observed that those in the PE group consumed pizza, hamburgers/hot dogs, and salty snacks more frequently, but less frequently cooked vegetables, fresh vegetables/salad, and fruit/berries, than preadolescents in the non-PE group. In addition, traditional Finnish healthy foods, like milk and dark bread, were less frequently consumed in the PE group than the non-PE group (Table 3). Similar eating habits were observed in the FN group, with minor exceptions (Table 4). Sensitivity analysis demonstrated that the consumption of food items differed by the severity of PE (Supplementary Table 1): the most frequent use of unhealthy food items accompanied with the lowest use healthy food items were seen in those with severe PE.

When looking at the results of the adjusted model, which included 5675 subjects, the PE group had a higher risk of underweight (OR = 1.98; 95% CI 1.66–2.36) and a lower risk of overweight/obesity (OR = 0.71; 95% CI 0.59–0.84). When considering the severity of PE, a consistent increase in OR for underweight was witnessed when moving from moderate to severe PE, while the opposite was noted in OR for overweight/obesity (Table 5). Being in the FN group associated neither with underweight (OR = 1.25; 95% CI 0.99–1.58) nor with overweight/obesity (OR = 0.83; 95% CI 0.66–1.05) (Fig. 1).

Table 2
Characteristics of the study sample by food neophobia (FN) status with mean (± SD), if not indicated otherwise.

n	FN		non-FN		Effect size	*t*-test p-value
	805		4870			
Male, n (%)	436	(54.2)	2318	(47.6)	0.046[a]	0.001[b]
Age, years	11.1	(± 0.8)	11.2	(± 0.8)	0.008	0.84
BMI of child, kg/m^2	17.5	(± 2.6)	17.9	(± 2.8)	0.140	< 0.001
Weight status					0.033[a]	< 0.001[b]
Underweight, n (%)	101	(12.5)	499	(10.2)		
Normal-weight, n (%)	604	(75.0)	3649	(74.9)		
Overweight/Obese, n (%)	100	(12.4)	722	(14.8)		
Allergy-free, n (%) [c]	652	(82.1)	4062	(84.2)	0.020	0.13
N of siblings	1.5	(± 1.1)	1.7	(± 1.4)	0.140	< 0.001
Parental age, y [d]	42.2	(± 5.3)	42.4	(± 5.4)	0.030	0.45
Mothers, n (%) [e]	695	(88.4)	4344	(89.4)	0.034[a]	0.01[b]
Parental BMI, kg/m^2 [f]	25.0	(± 4.6)	25.1	(± 4.5)	0.020	0.56
Academic or university degree, n (%) [g]	320	(40.8)	1717	(36.2)	0.045[a]	0.05[b]
Picky eating, n (%)	697	(86.6)	1208	(24.8)	0.456[a]	< 0.001[b]
Persistent feeding problems, n (%)	317	(39.4)	543	(11.1)	0.275[a]	< 0.001[b]

[a] Cramer's V.
[b] Chi Square test.
[c] 57 missing values.
[d] 5 missing values.
[e] 10 missing values.
[f] 57 missing values.
[g] 141 missing values.

Since persistent feeding problem and PE/FN were related, only a subgroup analysis focusing on those with persistent feeding problem (n = 860) was performed: PE was accordingly associated with

Table 3
Consumption of selected foods by picky eating (PE) status in 5675 preadolescents in the Fin-HIT study.

		PE		non-PE		Total	Effect size	Chi-Square p-value
Sweet pastry							0.026	0.15
	seldom	1146	60.20%	2360	62.60%	3506		
	sometimes	683	35.90%	1283	34.00%	1966		
	often	76	4.00%	127	3.40%	203		
Biscuits/cookies							0.039	0.014
	seldom	799	41.90%	1723	45.70%	2522		
	sometimes	908	47.70%	1713	45.40%	2621		
	often	198	10.40%	340	8.90%	538		
Ice cream							0.041	0.009
	seldom	1091	57.30%	2289	60.70%	3380		
	sometimes	793	36.90%	1316	34.90%	2109		
	often	111	5.80%	165	4.40%	276		
Cooked vegetables							0.148	< 0.001*
	seldom	975	51.20%	1358	36.00%	2333		
	sometimes	704	37.00%	1731	45.90%	2435		
	often	226	11.90%	681	18.10%	907		
Fresh vegetables/salad							0.126	< 0.001*
	seldom	237	12.40%	228	6.00%	465		
	sometimes	638	33.50%	1119	29.70%	1757		
	often	1030	54.10%	2423	64.30%	3453		
Fruit/berriers							0.094	< 0.001*
	seldom	257	13.50%	315	8.40%	572		
	sometimes	804	42.20%	1496	39.70%	2324		
	often	844	44.30%	1959	52.00%	2848		
Juice							0.035	0.03
	seldom	524	27.50%	915	24.30%	1439		
	sometimes	760	39.90%	1571	41.70%	2331		
	often	621	32.60%	1284	34.10%	1905		
Sugary juice drink							0.020	0.33
	seldom	827	43.40%	1680	44.60%	2507		
	sometimes	823	43.20%	1636	43.40%	2459		
	often	255	13.40%	454	12.00%	709		
Milk and soured milk							0.063	< 0.001*
	seldom	175	9.20%	219	5.80%	394		
	sometimes	126	6.60%	267	7.20%	393		
	often	1604	84.20%	3284	87.10%	4888		
Dark bread							0.075	< 0.001*
	seldom	291	15.30%	416	11.00%	712		
	sometimes	820	43.00%	1536	40.70%	2377		
	often	794	41.70%	1818	48.20%	2637		
Pizza							0.050	0.001*
	seldom	1616	84.80%	3278	86.90%	4894		
	sometimes	262	13.80%	472	12.50%	734		
	often	27	1.40%	20	0.50%	47		
Hamburgers/hotdogs							0.061	< 0.001*
	seldom	1606	84.30%	3340	88.60%	4946		
	sometimes	277	14.50%	403	10.70%	680		
	often	22	1.20%	27	0.70%	49		
Salty snacks							0.050	0.001*
	seldom	972	51.00%	2110	56.00%	3082		
	sometimes	881	46.20%	1586	42.10%	2467		
	often	52	2.70%	74	2.00%	126		

*p < 0.0038 (significance level after Bonferroni correction).

underweight (OR = 1.53; 95% CI 1.01–2.32), but not with overweight/obesity (OR = 0.62; 95% CI 0.36–1.08), whereas FN was not associated with either one (Fig. 1).

Since an interaction between PE and sex (p = 0.03) was observed, the association of PE with weight status was studied separately in 2921 girls and in 2754 boys. The association of PE with underweight was OR = 2.47; 95% CI 1.88–3.22 in boys, and OR = 1.68; 95% CI 1.33–2.12 in girls, while an inverse association with overweight/obesity was found in boys and girls (OR = 0.75; 95% CI 0.56–0.95 and OR = 0.65; 95% CI 0.50–0.84, respectively). No interaction was seen between FN and sex (p = 0.46).

4. Discussion

Primary we investigated the association between PE and weight status in nearly 5700 Finnish preadolescents. The analyses also covered FN, a specific aspect of PE. Secondarily, we observed that both PE and FN were associated with higher consumption of unhealthy foods accompanied by lower consumption of healthy foods. But despite these eating habits and food preferences, PE was associated with a higher risk of underweight and lower risk of overweight/obesity, while this was not observed with FN.

Of the entire cohort, 33.6% were placed in the PE group and 14.2% were placed in the FN group, based on responses in the parental questionnaire. In general, the prevalence of PE in a population varies depending on the age of children, the culture, parental education, and methodological issues (Taylor et al., 2015). The prevalence of PE in our study is similar to that reported in the USA (28–36%) (Marchi & Cohen, 1990; Reau, Senturia, Lebailly, & Christoffel, 1996) and Sweden (30%) (Rydell, Dahl, & Sundelin, 1995) despite wider variation in the age of children in these studies. While the prevalence of FN here was only a fraction of that reported among preschool-aged children (Faith, Heo,

Table 4
Consumption of selected foods by food neophobia (FN) status in 5676 preadolescents in the Fin-HIT study.

		FN		non-FN		Total	Effect size	Chi Square p-value
Sweet pastry							0.020	0.32
	seldom	478	59.40%	3028	62.20%	3506		
	sometimes	297	36.90%	1669	34.30%	1966		
	often	30	3.70%	173	3.60%	203		
Biscuits/cookies							0.021	0.29
	seldom	341	42.40%	2181	44.80%	2522		
	sometimes	379	47.10%	2242	46.00%	2621		
	often	85	10.60%	447	9.20%	532		
Ice cream							0.042	0.007
	seldom	452	56.10%	2928	60.10%	3380		
	sometimes	298	37.00%	1721	35.30%	2019		
	often	55	6.80%	221	4.50%	276		
Cooked vegetables							0.128	< 0.001*
	seldom	453	56.30%	1880	38.60%	2333		
	sometimes	273	33.90%	2162	44.40%	2435		
	often	79	9.80%	828	17.00%	907		
Fresh vegetables/salad							0.108	< 0.001*
	seldom	119	14.80%	346	7.10%	465		
	sometimes	272	33.80%	1485	30.50%	1757		
	often	414	51.40%	2039	62.40%	2453		
Fruit/berries							0.111	< 0.001*
	seldom	139	17.30%	433	8.90%	572		
	sometimes	351	43.60%	1509	40.00%	1860		
	often	315	39.10%	2488	51.10%	2803		
Juice							0.014	0.59
	seldom	212	26.30%	1227	25.20%	1439		
	sometimes	335	41.60%	1996	41.00%	2331		
	often	358	32.00%	1647	33.80%	2005		
Sugary juice drink							0.015	0.53
	seldom	342	42.50%	2165	44.50%	2507		
	sometimes	356	44.20%	2103	43.20%	2459		
	often	107	13.30%	602	12.40%	709		
Milk and soured milk							0.049	0.001*
	seldom	80	9.90%	314	6.40%	394		
	sometimes	50	6.20%	343	7.00%	393		
	often	675	83.90%	4213	86.50%	4888		
Dark bread							0.080	< 0.001*
	seldom	136	16.90%	571	11.70%	707		
	sometimes	371	46.10%	1985	40.80%	2356		
	often	298	37.00%	2314	47.50%	2612		
Pizza							0.055	< 0.001*
	seldom	667	82.90%	4227	86.80%	4894		
	sometimes	123	15.30%	611	12.50%	734		
	often	15	1.90%	32	0.70%	47		
Hamburgers/hotdogs							0.062	< 0.001*
	seldom	661	82.10%	4285	88.00%	4946		
	sometimes	133	16.50%	547	11.20%	680		
	often	11	1.40%	38	0.80%	49		
Salty snacks							0.024	0.21
	seldom	414	51.40%	2668	54.80%	3082		
	sometimes	372	46.20%	2095	43.00%	2467		
	often	19	2.40%	107	2.20%	126		

*p < 0.0038 (significance level after Bonferroni correction).

Keller, & Pietrobelli, 2013; Johnson, Davies, Boles, Gavin, & Bellows, 2015).

At present, PE is considered a trait of strong satiety response that causes feeding problems, especially in early childhood and dilutes with time (Ashcroft, Semmler, Carnell, van Jaarsveld, & Wardle, 2008). Based on the parental questionnaire, persistent feeding problems (considering two periods: before school age and preadolescence) were noted in 15.2% of our study sample. Of these, 33% and 39% presented with PE and FN, respectively. However, those with persistent feeding problem, appeared to have similar, but not higher, risk for underweight

Table 5
Associations of the severity of PE with underweight and overweight/obesity with OR.

	Normal-weight		Underweight		Risk of underweight [a]				Overweight/Obesity		Risk of overweight/obesity [a]			
Severity of PE	n	%	n	%	Exp(B)	95% CI for Exp(B)		p value	n	%	Exp(B)	95% CI for Exp(B)		p value
Severe	359	8.40%	83	13.80%	2.29	1.75	3.00	< 0.001	48	5.80%	0.56	0.41	0.78	0.001
Moderate	1038	24.40%	211	35.20%	1.88	1.55	2.27	< 0.001	166	20.20%	0.76	0.63	0.92	0.005
No	2856	67.20%	306	51.00%	1				608	74.00%	1			

[b]The model includes following covariates: preadolescents' age, sex, and number of siblings, and parents' age, sex, BMI, and educational level.
[a] The reference category is normal-weight adolecents.

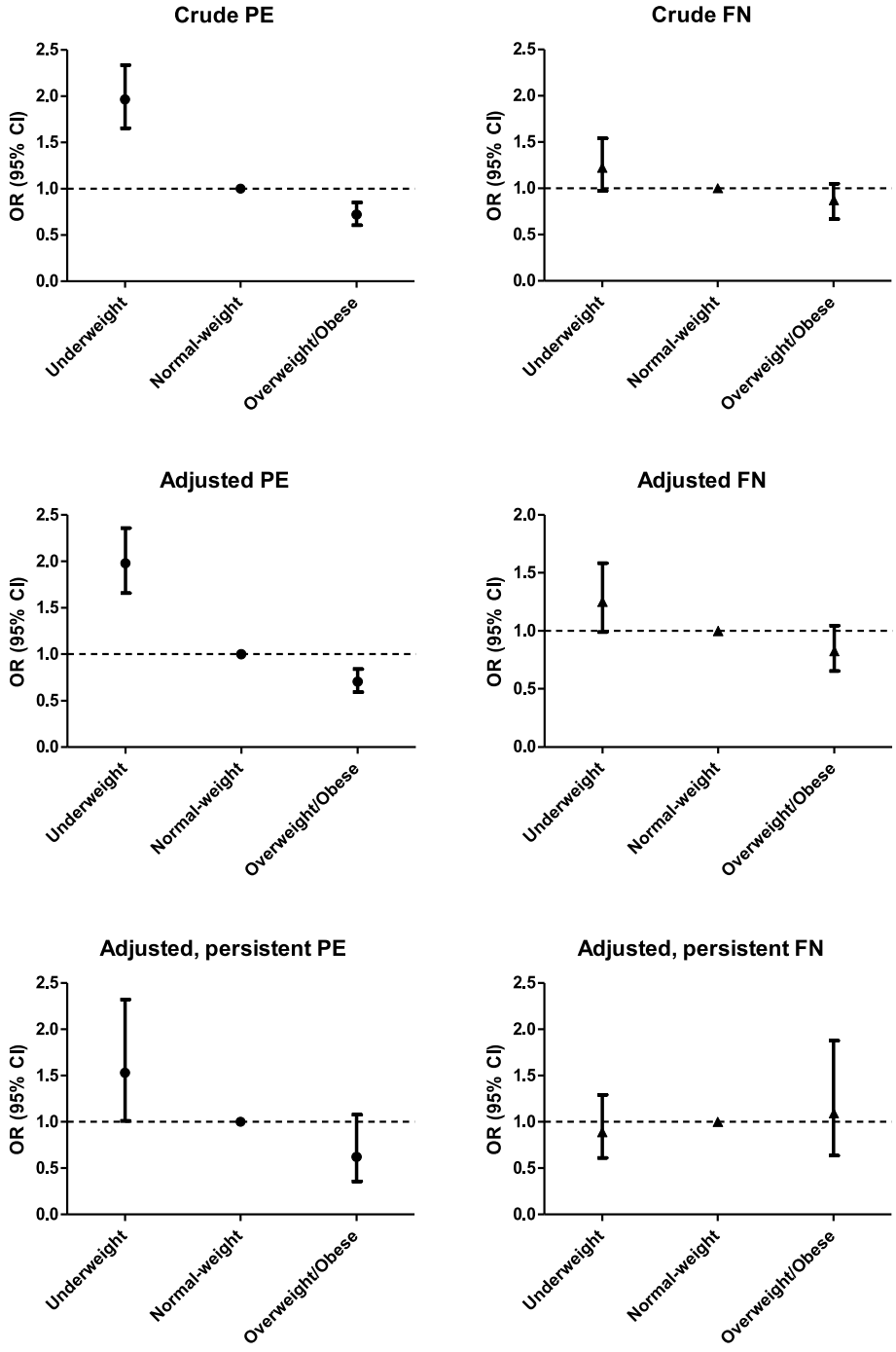

Fig. 1. Picky eating (PE) is associated with a higher odds ratio (OR) for underweight and lower OR for overweight/obesity in crude and adjusted (=preadolescents' age, sex, and number of siblings, and parental age, sex, BMI, and educational level) models (n = 5675) and when limiting to those with persistent feeding problems (n = 860). Food neophobia (FN) was associated with a higher OR for underweight in adjusted model only, but not in other models.

than the whole group. This may imply that other factors than the duration of the PE/FN are contributing to the weight. Although the persistence of PE traits has been reported to decrease with age in some studies (Mascola et al., 2010; Taylor et al., 2015), our findings suggest that PE also contributes to long-standing feeding problems in adolescence, as it does in other age groups (Ashcroft et al., 2008; Oliveira et al., 2015). In fact, nearly every third adult self-reported PE in a web-based questionnaire study of more than 6800 individuals in the UK, the USA, and Canada (Wildes, Zucker, & Marcus, 2012) and a similar prevalence has been verified in more recent study (Kauer, Pelchat, Rozin, & Zickgraf, 2015).

In our study, both the PE and FN groups had similar, but clearly distinctive eating habits: those in the PE group consumed pizza, hamburgers/hot dogs, and salty snacks more frequently, and had a lower consumption of vegetables, fruits/berries, milk/soured milk, and dark bread as compared with those in the non-PE group. It has been proposed that PE is characterised by strong food preferences and dislikes (Kwon, Shim, Kang, & Paik, 2017; Oliveira et al., 2015) and our data on the severity of PE supports this. With this perspective, it is understandable that sugary, highly palatable fatty foods are more enjoyable for people in the PE group, as they do not lead to strong dislikes, while vegetables, fruits, berries, milk, and dark bread, vary in their mouthfeel, sourness, etc., and may evoke stronger responses. As known, these foods also have distinctive health profiles, which vary in terms of

energy density, added sugar, saturated fat, salt, micronutrient, and dietary fibre content. In fact, previous studies have reported low intakes of protein, several micronutrients, dietary fibre in children (Gibson & Cooke, 2017; Perry et al., 2015; Taylor et al., 2016a, 2016b), and aberrant food consumption patterns in adults (Zickgraf, Franklin, & Rozin, 2016) with PE, which are in accordance with our data. Several Finnish studies have reported that consumption of vegetables, fruits, and berries among Finnish children and preadolescents is low (Hoppu, Lehtisalo, Tapanainen, & Pietinen, 2010; Lehto et al., 2014), and the quality of snacks or foods consumed in-between meals is of concern (Eloranta et al., 2011; Hoppu et al., 2010). Here, we show that PE and FN are obstacles to healthy eating, especially in preadolescents. To overcome PE, behavioural interventions targeting both parents and children, at home and childcare locations are warranted (Chao & Chang, 2017; Luchini, Musaad, Lee, & Donovan, 2017).

In the present study, those in the PE group had a higher risk of underweight and a lower risk of overweight/obesity and the severity of PE seems to modify these risks. Our findings on underweight are in line with the systematic review on (Brown et al., 2016) as well as with original studies from the Netherlands among 4-year-old children (Jansen et al., 2012), English children between ages of 7 and 12 years (Webber, Hill, Saxton, Van Jaarsveld, & Wardle, 2009). However, our results differ from those of an Italian study of 2-to-6-year-old children, which observed that PE was more prevalent in overweight/obese children (Finistrella et al., 2012). In addition, several studies have reported no association at all between PE and weight status in children (Gregory, Paxton, & Brozovic, 2010; Rohde et al., 2017; Svensson et al., 2011), or in adults (Zickgraf et al., 2016). Our findings regarding the association between PE and lower risk of overweight/obesity in preadolescence are also supported by five studies included in the systematic review (Brown et al., 2016). Since accelerated weight development typically starts in preadolescence, this age might be too early to determine the definitive consequences of PE. As they age, those with PE have more power to decide what they will eat, which may partly explain our findings. When our analysis was limited to those with persistent feeding problems, the associations with PE mostly remained, but long-term PE did not lead to a higher risk of underweight. Several studies have reported that early eating habits are maintained throughout childhood (Lien, Lytle, & Klepp, 2001; Mikkila, Rasanen, Raitakari, Pietinen, & Viikari, 2005), but whether this is also true for PE warrants further study. In the present study, FN was not associated with underweight nor overweight/obesity, which are in line with a systematic review (Brown et al., 2016).

The association of PE with weight appeared differently in boys and girls, but our analysis did not allow the comparison of gender specific ORs. A markedly stronger inverse correlation between food fussiness score and weight has been reported in boys compared with girls in United Kingdom (Webber et al., 2009). Severity of PE in terms of higher fussiness scores derived from the Child Eating Behaviour Questionnaire (CEBQ) has been shown to vary between the sexes in some European (Sleddens, Kremers, & Thijs, 2008) and Chinese populations (Cao et al., 2012), but a recent systematic review did not classify male gender as a risk factor for PE nor for FN (Cole et al., 2017). Boys outnumbered girls in our FN group. Taken together, our findings suggest that the relationship of PE with weight varies by gender.

Family and parental aspects differed between the PE and FN groups, although with small effect sizes. Those in the PE and FN groups had fewer siblings, and those in the PE group especially were more likely to be only children. Having siblings is shown to protect against PE (Gibson & Cooke, 2017; Hafstad et al., 2013), and a proposed prevention strategy involves using the older children as role models for children with PE. Among parental characteristics, lower age, lower BMI, and higher educational level have been positively related to PE (Cole et al., 2017); a child's feeding problem seems to cause more distress/anxiety among younger mothers and mothers with higher education level. While maternal BMI might be a loose proxy for a mother's eating behaviour (Gibson & Cooke, 2017), these traits are likely passed from one generation to another (Finistrella et al., 2012).

One of our ultimate strengths is our large population-based sample of preadolescents, in whom we assessed PE by two different aspects and observed their association with food consumption and weight status. One of the limitations of our study was that the parental questionnaire was available for only approximately 50% of the preadolescents at baseline, resulting in a study sample of only about 5700. PE and FN were assessed by a single question adopted and modified from Avon Longitudinal Study of Parents and Children (ALSPAC) questionnaires (Taylor et al., 2015), which is not a validated questionnaire like the CEBQ (Ashcroft et al., 2008; Jansen et al., 2012; Taylor et al., 2015). On the other hand, single questions on PE and FN are straightforward and easy to handle in a large cohort like Fin-HIT. Moreover, parents of children with PE or FN may recall things differently than parents of children without these obstacles. However, we were not fully able to define the severity, extent, and inflexibility of the PE/FN behaviours. The FFQ was limited and gave a rough overview of adolescents' diet on group level only. Typically, FFQ is used to rank individuals according to their food intake, but it is shown to overestimate the actual frequency of consumption (Rockett & Colditz, 1997; Vereecken & Maes, 2003), thus comparisons with other studies should be done cautiously. Despite significant differences between groups, the effect sizes were small, illuminating rather small differences between groups that become visible with big sample size. Our FFQ contained indicator food items, mostly snack foods and side dishes, which may be harder to recall than main dishes (Vereecken & Maes, 2003), that might be causing some bias here as well. In addition, we were unable to estimate portion sizes, which are meaningful to address the research questions more detailed. Nevertheless, our findings are in line with large cohort studies like generation R, where the CEBQ was utilised (Jansen et al., 2012). Despite unhealthy eating habits, those in the PE group had a higher risk of underweight and lower risk of overweight/obesity compared with those in the non-PE group, and these were further supported when considering the severity of PE, which raises questions about portion sizes and parental behaviour and practices (Ellis, Galloway, Webb, Martz, & Farrow, 2016), which might confound our result.

5. Conclusions

Our study shows that PE is an obstacle to healthy eating in Finnish preadolescents, as it presents with unhealthy eating habits, including favouring sugar-rich and fatty foods and disliking vegetable, fruits, and berries. Only PE was associated with a higher risk for underweight and inversely with overweight/obesity. Since obesity rebound typically occurs in teenage years, a longer follow-up of our cohort is needed to determine the definitive consequences of PE on health and weight status.

Declarations of interest

None.

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Appendix A. Supplementary data

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