TITLE: Fathers' daily intake of fruit and vegetables is positively associated with children's fruit and vegetable consumption patterns in Europe: The Feel4Diabetes Study.

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ABSTRACT

Background Past research has focused on the relation between mothers' and children's eating habits, while little is known about fathers as potential agents. This study aimed to investigate the relation between fathers' and children's fruit and vegetable (FV) intake in the context of fathers' education level and family income insecurity.

Methods Cross-sectional analysis using baseline data from the multi-centre Feel4Diabetes Study collected in 2016. Participants were parent-dyads (fathers n = 10,038) and school children (n = 12, 041) from six European countries. Socio-demographic and dietary data were collected using questionnaires. Associations were assessed applying the multinomial logistic regression model.

Results Overall, European children have low FV intake especially in Southern European countries (Greece, Spain, and Hungary). Children with fathers consuming FV daily were more likely to consume fresh fruit (OR: 2.75, 95%CI: 1.95-3.88) and vegetables (OR: 2.55, 95%CI: 1.80- 3.60) 1-2 times per day. After adjusting for paternal educational level and family income insecurity significant associations remained for fresh fruit (OR_{adj}: 2.59, 95%CI: 1.82-3.69) and vegetables OR_{adj}: 1.98, 95%CI: 1.38-2.86). Country differences showed that fathers' educational level and income insecurity might be important factors worth considering for FV intake in Greece.

Conclusion This study showed that fathers' FV intake was positively associated with children's daily intake of these foods. Implementation of future population-based strategies promoting FV intake not only in mothers but also in fathers could be an effective public health initiative to increase FV intake in children. Policy-makers should give special attention to families dwelling in Southern European regions.

Keywords: Fruits, vegetables, children, fathers, education, family income insecurity.

Manuscript

INTRODUCTION

Fruit and vegetables (FV) are essential components of a healthy diet as they contain important vitamins (such as vitamin C, A, Folic acid), minerals, fibre, and bioactive compounds with antioxidant properties which have overall health benefitting effects, strengthen the immune system, as well as ensure optimal growth and development in children [(1)]. Most importantly, adequate daily intake of FV could prevent major health implications such as cardiovascular disease, cancer, premature mortality [(2)] and diabetes [(3)] in later life. Contradicting World Health Organization (WHO) guidelines, European children are not meeting the recommended fruit and vegetable intake of at least 400 g per day [(1)]. From the scant available data, school children's intake of fruit and vegetables in Ireland, the Netherlands, and the UK ranged from 221-272g/d, in Italy and Spain ranged from 341-350g/d, and in Denmark averaged 404g/d [(4)]. Given the variability in FV recommendations for school-children along with foods classified as FV and that the evidence is based on few national dietary surveys [(4)] and not on the European level, then more well-designed European population studies are warranted to address this gap.

The development of children's food preferences is multifactorial involving the complex interplay between genetics and environmental factors including the home [(5)]. Pearson et al., (2009) in a systematic review showed that parental role modelling and parental intake were positively associated with fruit, fruit juice, and vegetable intake in children and adolescents [(6)]. Contrastingly, Wang et al., (2011) in a systematic review of 24 studies investigating the resemblance between parents and children's diet, only found a weak association [(7)]. Possible limitations of the aforementioned reviews were that there was substantial variability amongst study designs, sample size (range 36-8263), children's age, dietary intake assessment tools (FFQ, food record, or 24-hr food recall) and variables assessed (individual food items, food groups, nutrients or overall dietary pattern). Some studies assessed associations between family correlates, parent-dyads and children's dietary outcomes for boys and girls combined, and others separately. Most studies were cross-sectional and at least 50% were conducted in the US. Therefore, given the high heterogeneity among studies, establishing the direction and causality of associations remains inconclusive.

Regardless of the weak associations reported by the aforementioned systematic reviews, parental influence has been identified as a key determinant of children's food choice and consumption patterns via food availability at home, role modelling, family rules, and their own

dietary practices and beliefs [8]. Convincing evidence from cross-sectional studies has documented that in families where parents consumed FV regularly, children also had increased intake of healthy foods [9; 10; 11]. Traditionally, mothers are viewed as the primary carers and main food providers of children, controlling what food is offered at mealtimes as well as portion size [12]. However, today with mothers in the workforce, more fathers are actively involved in the care of their children [12]. Past research has focused primarily on mothers' influence on children's eating habits, while little is known about fathers as potential agents of this behaviour [12; 13]. Therefore, given the lack of evidence, we endeavoured to investigate the relation between fathers' and children's FV intake as well as to determine whether socio-economic status as measured by fathers' educational level and family income insecurity, modified the association between fathers' daily FV intake and FV consumption patterns in children. We hypothesized that there are positive associations between fathers' FV intake and the frequency of children's intake of these foods. The findings of this study will enhance understanding of the correlates of food intake in children and provide useful insight for the development and implementation of effective intervention programs promoting healthy eating in children.

METHODS

The current study is a sub-analysis of baseline data of the Feel4Diabetes study which was a 2-year school- and community–based intervention designed to prevent type 2 diabetes in vulnerable families across Europe. In brief, the Feel4Diabetes intervention promoted healthy eating and physical activity by creating a supportive environment at three levels that included the home/family, school, and municipalities. Recruitment was based on a standardized multi-sampling procedure and was conducted in selected provinces in six European countries namely Bulgaria, Hungary, Belgium, Finland, Greece and Spain. Primary schools were randomly selected and recruited within each area. Eligibility and inclusion criteria were based on families with children attending the first three grades of primary school in the selected municipalities of each country. The screening procedure and study methodology have been described in greater detail in a previous publication [14] and for the purpose of the current study only baseline data involving all families have been used. Ethical approval was obtained from the Human Ethics committees of all participating institutions in each of the six European countries. The study protocol was conducted according to the standards set by the Declaration of Helsinki for human subjects. Prior to enrolment of participants into the study, all parents signed a written informed consent. In the current study, we posited that parenting is one of the main influential

components of the home food and social environment that define children's food consumption patterns.

Assessments

Anthropometry

Children underwent anthropometric measurements that were conducted at school by trained researchers [15] using standard procedures and equipment. Body weight was measured in children wearing light clothing and without shoes to the nearest 0.1 kg using electronic scales (SECA 813); and standing height was measured barefoot with shoulders in a relaxed position, arms hanging freely and head in the Frankfurt horizontal plane, to the nearest 0.1 cm using a portable stadiometer (SECA 217). Two readings were recorded for each measurement and the mean was used for analytical purposes. Body Mass Index (BMI) was calculated using Quetelet's equation (kg/m^2) and expressed as z-scores estimated by the International Obesity Task Force (IOTF) BMI cut-offs [16].

Socio-demographic details

Socio-demographic details that included country, fathers' and children's age, fathers' educational level and occupation status as well as family income insecurity were collected using a self-reported questionnaire. Educational level was measured by the number of years attending school or university and comprised of six categories: < 6 years or less, 7-9 years, 10-12 years, 13-14 years, 15-16 years and > 16 years. Occupation status was categorized as stay at home, employed (full-time or part-time) and unemployed. Family income insecurity was assessed by the degree of economic ease or difficulty to meet household expenses as follows: very difficult, difficult, fairly difficult, fairly easy, easy and very easy [17]. Variables related to fathers' socio-demographics were dichotomized as follows: age < 45 years vs ≥ 45 years, educational level: ≤ 14 years vs > 14 years and family income insecurity by easy vs difficulty to meet household expenses.

Fathers' daily intake of fruit and vegetables

Fathers' daily intake of FV was assessed by the question "How often do you eat vegetables, fruit or berries?" Possible responses were 'every day' or 'not every day'.

Children's fruit and vegetable intake

Children's FV intake was evaluated using a Food Frequency Questionnaire that was developed specifically for the Feel4Diabetes Study and was examined for its reliability in a pilot study [18]. Parents were used as a proxy for children's dietary habits. Respondents were instructed to report their usual frequency of consumption of 9 food groups in terms of specified serving size. The main food groups included in the questionnaire were fruit and berries (fresh or frozen), fruit and berries (canned or dried), fruit juice (freshly-squeezed or pre-packed without sugar) and vegetables. Conventional household measures were used to represent one standard portion size for each food item (1 cup, ½ cup). Frequency of food intake was recorded as weekly or daily consumption of food items which were categorized as less than one (1) time per week, 1 or 2 times per week, 3 or 4 times per week, 5 or 6 times per week, 1 or 2 times per day, 3 or 4 times per day, 5 or 6 times per day and more than 6 times per day. One serving of fruit was considered to one medium-sized fruit or ½ cup, vegetables ½ cup, canned or dried fruit ½ and ¼ cup respectively and fruit juice by 1 cup.

Statistical analysis

SPSS version 20 (IBM Incorp, Chicago, IL USA) was used for all statistical analyses. Continuous variables were assessed for normality using the Kolmogorov-Smirnov test and graphically by their histograms. In the case of non-normally distributed continuous variables, group differences were determined using the non-parametric Mann-Whitney test, while the Chi-Squared test was used for categorical variables. Socio-demographic and anthropometric characteristics of the sample are presented as medians, 25th and 75th percentiles, total counts (n), and frequencies (%). Correlation between fathers' and children's frequency of food intake was examined using Spearman's rank coefficient (rho) where values ranging from 0.10-0.29 indicate moderate correlation and ≥ 0.30 strong correlation [19]. Given that the assumptions for ordinal logistic regression were violated [20], associations between fathers' daily intake of FV and frequency of these foods by children were evaluated by performing a multinomial logistic regression setting each food item from the children's FFQ as the dependent variable and fathers' intake of FV as the dichotomous independent variable. According to previous research, factors such as parental educational level and income status are known to influence family dietary habits, especially FV [21]. Dummy variables were created for independent categorical variables (education level and family income insecurity) and then entered into the regression analysis. Model 1 represents the crude analysis (unadjusted), model 2 adjusting for fathers' educational level and family income insecurity. Reference values for frequency of FV intake were based on WHO nutritional guidelines for children and adolescents [1]. Multicollinearity

amongst predictors was measured using the variance inflation factor (VIF), tolerance statistic, and condition index [22]. The goodness of fit of the model was checked using Pearson and likelihood ratio chi-square statistics [22]. Furthermore, the degree of variation of the outcome as explained by the predictors was reflected by the Nagelkerke coefficient R^2 [22]. The magnitude of the association is represented by the β coefficient, odds ratio (OR), and 95% confidence intervals (CI). In order to explore country differences in associations, data was stratified by country and the regression analysis was repeated investigating the association between fathers' daily FV intake and children's frequency of consumption patterns of these foods. The level of significance was set at $p < 0.05$. All reported p-values were two-tailed.

RESULTS

Of the 12,041 European families (parent-dyads) participating in this study, 14.8% (1,787/12,041) dwelled in Belgium, 12.5% (1,504/12,041) in Finland, 19.0% (2,283/12,041) in Greece, 15.2% (1828/12,041) in Hungary, 24.7% (2972/12,041) in Bulgaria and 13.8% (1,667/12,041) in Spain. From data of 10,038 fathers, the majority of fathers (77.7%) were under 45 years old, 46.1 % were well-educated (> 14 years of study), 87.0% worked full-time and 50% of families found it 'difficult' to cover household expenses. The sample comprised of 12, 041 children, median age 8.2 years (interquartile range 1.5 years) of which 49.3% (5942/12,041) were boys. Socio-demographic and anthropometric characteristics of the sample and per children's sex are displayed in Table 1.

174 Table 1 Socio-demographic, anthropometric and dietary intake characteristics of the sample

Characteristic	Total	Boy	Girl	P[a]
Children' s details				
Sex % (n)		49.4% (5942/12041)	50.6% (6097/12041)	
Age (years)	8.2 (7.4, 8.9)	8.2 (7.5, 9.0)	8.1 (7.4, 8.9)	0.05[b]
Weight (kg)	28.3 (24.7, 33.2)	28.5 (25.1, 33.5)	28.0 (24.4, 33.0)	**<0.001[b]**
Height (cm)	130.2 (125.0, 136.0)	130.8 (125.8, 136.4)	129.6 (124.3,135.4)	**<0.001[b]**
BMI z-score	0.47 (-0.20, 1.3)	0.46 (-0.21, 1.2)	0.48 (-0.17, 1.3)	0.16[b]
Children's FV intake (1-2 times/day)				
Fresh fruit intake (1 fruit or ½ cup) %(n)	45.6% (5159/11300)	44.5% (2477/5566)	46.8% (2681/5732)	**0.01**
Canned/dried fruit (½ and ¼ cup) %(n)	4.6% (503/1081)	4.4% (238/5351)	4.8% (265/5465)	0.56
Fruit juice (1 cup) %(n)	13.3% (1472/11083)	14.1% (771/5415)	12.5% (701/5627)	0.25
Vegetables (½ cup) %(n)	37.7% (4220/11194)	36.3% (2001/5508)	39.0% (2219/5684)	0.09
Fathers' details				
Age %(n)				
< 45 years	77.7% (7800/10038)	77.4% (3841/4961)	78.0% (3959/5076)	0.49
Education %(n)				
> 14years	46.1% (4511/9779)	47.2% (2281/4835)	45.1% (2230/4944)	**0.04[ł]**
Occupation % (n)				
Stay at home	8.1% (798/9787)	8.2% (397/4843)	8.1% (401/4943)	0.52
Employed	87.0% (8520/9787)	87.3% (4226/4843)	86.8% (4293/4943)	
Unemployed	4.8% (469/9787)	4.5% (220/4843)	5.0% (249/4943)	
Fruit/vegetable intake %(n)				
Everyday	65.9% (6646/10083)	66.2% (3297/4983)	65.6% (3347/5098)	0.62
Family income insecurity				
Covering household expenses* %(n)				
Difficult	49.4% (5637/11402)	48.7% (2727/5595)	50.1% (2910/5806)	0.14

175 * Values are expressed as medians, 25th and 75th percentiles, total counts (n) and frequencies (%).

176 For dichotomous variables fathers' age, fathers' educational level, family income insecurity, and fathers' FV intake,

177 only one category is presented in Table 1.

178 [a] P-value estimated using Chi-Square test; [b] Mann-Whitney test

179 P-values in bold text indicate statistically significant sex-differences

180 [ł] Significant differences in fathers' educational level when comparing educational attainment ≤ 14 years vs > 14 years

181 Concerning fathers' FV intake, in the total sample, only 65.9% of fathers (6646/10083)
182 consumed FV daily. Investigation of daily FV intake according to country showed that 79.8%
183 (1267/1588) of fathers' in Belgium responded that they consumed FV daily, 76.6%
184 (1966/2568) in Bulgaria, 71.8% (789/1099) in Finland, 68.6% (968/1411) in Spain, 52.2%
185 (994/1855) in Greece and 43.8% (662/1512) in Hungary ($p < 0.001$).

186 Collectively, children had low intake of FV with only 45.6% (5159/11300) consuming fresh
187 fruit 1-2 times per day and 37.7% (4220/11194) vegetables at the same frequency. Differences
188 were observed amongst countries (fresh fruits: $p < 0.001$; vegetables: $p < 0.001$). Children's
189 fresh fruit intake of 1-2 times/day ranged from 61.1% (1057/1731) in Belgium, 49.3%

(635/1288) in Spain, 49.4% (1434/2902) in Bulgaria, 42.6% (931/2185) in Greece, 35.1% (521/1483) in Finland and 34.0% (581/1711) in Hungary; while 61.6% of children (1065/1729) consumed vegetables 1-2 times/day in Belgium, 47.1% (1362/2890) in Bulgaria, 44.0% (655/1487) in Finland, 24.8% (321/1296) in Spain, 23.5% (383/1633) in Hungary and 20.1% (434/2159) in Greece.

Nevertheless, moderate-strong correlations were observed between fathers' daily FV intake and children's intake of fresh fruit (rho = 0.46, $p < 0.001$), vegetables (rho = 0.54, $p < 0.001$), canned/dried fruit (rho = 0.61, $p < 0.001$) or fruit juice (rho = 0.54, $p < 0.001$).

The association between fathers' daily FV intake and children's daily FV intake

Associations between fathers' daily FV intake and children's frequency of intake are presented in Table 2. Applying the multinomial logistic regression model to explore associations of fathers' daily FV intake and children's frequency of food intake revealed significant positive associations in the crude analysis for children's fresh fruit intake ($p < 0.001$) and vegetables ($p < 0.001$). When fathers consumed daily FV, children were 2.75 times and 2.55 times more likely to consume fresh fruit or vegetables, respectively, 1-2 times per day. Addition of fathers' educational level and family income insecurity did not modify the associations for children's fresh fruit and vegetable intake. The same trend was observed for children's fruit juice intake, although marginally significant in the crude and adjusted analyses (crude OR: 1.46, 95%CI: 0.94-2.28, $p = 0.09$); (adjusted OR: 1.52, 95%CI: 0.96-2.42, $p_{adj} = 0.08$). In contrast, no associations were found for canned/or dried fruits.

Table 2 Association between fathers' daily FV intake and frequency of children's FV intake derived from the crude multinomial logistic regression analysis (Model 1) and after adjusting for fathers' educational level and family income insecurity (Model 2).

	Model 1				**Model 2**			
Food item /Frequency of children's food intake	**β**	**R^2**	**OR (95%CI)**	**P[a]**	**β**	**R^2**	**OR (95%CI)**	**P[b]**
Fruits/berries (Fresh/frozen)								
3-4 times/week	Ref							
1-2 times/day	1.01	8.1%	2.75(1.95, 3.88)	**<0.001**	0.95	14.6%	2.59(1.82, 3.69)	**<0.001**

Fruits/berries (canned/dried)								
3-4 times/week	Ref							
1-2 times/day	-0.54	0.70%	0.58 (0.28, 1.20)	0.140	-0.40	12.0%	0.67 (0.31, 1.44)	0.300
Fruit juice								
3-4 times/week	Ref							
1-2 times /day	0.38	0.80%	1.46 (0.94, 2.28)	0.090	0.42	5.0%	1.52 (0.96, 2.42)	0.080
Vegetables								
3-4 times/week	Ref							
1-2 times/day	0.93	8.50%	2.55 (1.80, 3.60)	**<0.001**	0.68	0.0%	1.98 (1.38, 2.86)	**<0.001**

Ref- Reference

Independent dichotomous variable- father consumes fruit and vegetables (every day/ not every day)

Dependent variable: Children's frequency of fruit and vegetable intake from FFQs

β Unstandardized beta coefficient; OR: Odds ratio; 95%CI: 95% Confidence Interval for Exp(B)

R^2 Model fit as represented by the Nagelkerke coefficient

[a] Model 1 P-value estimated from the unadjusted multinomial logistic regression

[b] Model 2 P-value adjusted for fathers' educational level and family income insecurity.

Statistically significant P-values are indicated in bold.

Regarding the impact of fathers' daily FV intake and children's consumption patterns, disparities were found across countries (Table 3). In the crude and adjusted regression analyses there were positive associations between fathers' daily FV intake and children's intake of fresh fruit 1-2 times per day in Belgium, Greece and Bulgaria only [(Adjusted) children's fresh fruit intake: Belgium OR: 3.95, 95%CI: 1.35-11.51, $p_{adj} = 0.012$; Greece OR: 3.31, 95%CI: 1.59-6.86, $p_{adj} = 0.001$; Bulgaria OR: 4.24, 95%CI: 1.39-12.95, $p_{adj} = 0.011$)]. The same trend was observed for children's vegetable intake 1-2 times per day in Belgium and Hungary [(Adjusted) children's vegetable intake: Belgium OR: 3.44, 95%CI: 1.28-9.28, p = 0.015; Hungary OR: 3.20, 95%CI: 1.16-8.83, p = 0.024)]. Interestingly, for Greece, a positive association was observed in the crude analysis between fathers' daily FV intake and children's vegetable intake (OR: 2.31, 95%CI: 1.09-4.87, p = 0.029) which became non-significant after adjustment (p = 0.270). Hence, it appears that fathers' educational level and income insecurity might be important factors worth considering for FV intake in Greece. No significant associations were noted for canned/dried fruit or fruit juice in any country, which coincides with the original analyses.

240 Table 3 Associations between fathers' daily FV intake and children's frequency of FV intake by country, derived from the crude multinomial logistic regression
241 analysis (Model 1) and after adjusting for fathers' educational level and family income insecurity (Model 2).

		Children's frequency of food intake							
		Model 1				Model 2*			
Food item/ Frequency of intake	**Country**	**β**	**R^2**	**OR(95%CI)**	**P**	**β**	**R^2**	**OR(95%CI)**	**P_{adj}**
Fruits/berries (Fresh/frozen)									
3-4 times/week	Ref								
1-2 times/day	Belgium	1.21	12.3%	3.36(1.27, 8.89)	**0.015**	1.37	40.0%	3.95(1.35, 11.51)	**0.012**
	Finland	0.39	4.6%	1.47(0.56, 3.84)	0.429	0.51	33.3%	1.67(0.55, 5.09)	0.364
	Greece	1.18	10.8%	3.26(1.69, 6.29)	**<0.001**	1.20	18.6%	3.31(1.59, 6.86)	**0.001**
	Hungary	0.60	10.4%	1.82(0.78, 4.26)	0.165	0.55	43.6%	1.73(0.68, 4.44)	0.253
	Bulgaria	1.28	10.5%	3.61(1.30, 9.99)	**0.014**	1.44	39.6%	4.24(1.39, 12.95)	**0.011**
	Spain	0.60	15.5%	1.81(0.59, 5.57)	0.297	0.61	43.7%	1.83(0.56, 5.95)	0.315
Fruits/berries (canned/dried)									
3-4 times/week	Ref								
1-2 times/day	Belgium	-0.13	1.8%	0.87(0.14, 5.58)	0.888	0.02	35.5%	1.02(0.12, 8.92)	0.990
	Finland	-0.56	1.3%	0.57(0.11, 3.07)	0.511	-0.92	30.0%	0.40 (0.06, 2.89)	0.360
	Greece	-19.46	5.3%	Not computable		-1.73	2.5%	0.18(0.00, 15.98)	0.450
	Hungary	-0.98	7.9%	0.37(0.08, 1.80)	0.220	-0.35	46.4%	0.70(0.13, 3.88)	0.680
	Bulgaria	-0.85	3.2%	0.43(0.05, 3.52)	0.430	-0.51	0.0%	0.60(0.04, 8.55)	0.710
	Spain	0.47	3.7%	1.60(0.24, 10.81)	0.630	0.80	7.8%	2.22(0.25, 19.77)	0.470
Fruit juice									
3-4 times/week	Ref								
1-2 times /day	Belgium	-0.19	5.4%	0.83(0.23, 2.98)	0.771	0.36	35.2%	1.43(0.33, 6.10)	0.630
	Finland	-0.37	5.4%	0.69(0.08, 5.64)	0.727	-1.05	29.5%	0.35(0.03, 3.84)	0.390
	Greece	0.44	5.3%	1.55(0.79, 3.03)	0.205	0.45	17.6%	1.57(0.76, 3.21)	0.220
	Hungary	0.78	3.9%	2.18(0.53, 9.02)	0.283	0.99	11.3%	2.70(0.54, 13.63)	0.230
	Bulgaria	0.77	2.3%	2.17(0.39, 12.06)	0.377	0.47	25.2%	1.60(0.25, 10.09)	0.620
	Spain	0.74	5.7%	2.10(0.59, 7.45)	0.251	0.54	39.1%	1.71(0.45, 6.47)	0.430
Vegetables									
3-4 times/week	Ref								
1-2 times/day	Belgium	1.17	8.0%	3.24(1.28, 8.19)	**0.013**	1.24	39.7%	3.44 (1.28, 9.28)	**0.015**

Finland	0.74	5.0%	2.09(0.78, 5.61)	0.141	0.83	34.0%	2.29(0.76, 6.91)	0.140
Greece	0.83	10.1%	2.31(1.09, 4.87)	**0.029**	0.42	7.1%	1.52(0.72, 3.19)	0.270
Hungary	0.93	10.6%	2.53(1.03, 6.20)	**0.043**	1.16	49.9%	3.20(1.16, 8.83)	**0.024**
Bulgaria	0.97	9.2%	2.64(0.96, 7.20)	0.059	1.01	0.0%	2.74(0.87, 8.64)	0.090
Spain	-0.13	5.2%	0.88(0.32, 2.41)	0.796	-0.03	42.5%	0.97 (0.34, 2.76)	0.950

Ref- Reference

Independent dichotomous variable- father consumes fruit and vegetables (every day/ not every day)

Dependent variable: Children's frequency of fruit and vegetables intake from FFQs

β Unstandardized beta coefficient; OR: Odds ratio; 95%CI: 95% Confidence Interval for Exp(B)

R^2 Model fit as represented by the Nagelkerke coefficient

Model 1 Crude regression analysis

*Model 2 Regression analysis adjusted for fathers' educational level and family income insecurity

Statistically significant P-values are indicated in bold

DISCUSSION

The promotion of healthy eating in children is crucial, since food habits established in childhood may track into adolescence and adulthood [23]. There is substantial evidence that children's dietary intake and behaviours are influenced by parents, especially mothers, who are key components in the environmental and social context. However, the extent to which fathers' dietary intake influences children's food consumption patterns is unclear. This is of considerable importance given the changes in family structure with more mothers employed and fathers responsible for daily care and rearing of their children [12]. The findings of this study support the primary hypothesis that there are positive associations between fathers' FV intake and frequency of children's intake of these foods. This suggests that, apart from mothers, fathers should be considered as potential agents for the implementation of positive feeding practices in children. Even though convincing evidence indicates that fathers exert a positive influence on children's eating habits, direct comparisons are difficult due to the lack of studies examining specific father-child FV intakes [24; 25]. According to a recent systemic review of 23 studies, fathers' dietary intake was predictive of children's intake, while fathers' food parenting style as represented by their own intake of FV, availability of healthy foods at home, and encouragement to consume healthy foods, influenced children's eating behaviours [26]. Co-parenting by mothers and fathers and when household rules concerning food were reinforced by both parents produced healthier child food choices. Unfortunately, we did not assess co-parenting and this would be worth future investigation. It has been advocated that parenthood could instigate health awareness and motivate the adoption of healthier eating habits such as increased intake of FV by fathers [27].

Intriguingly, country differences were observed in associations between fathers' FV intake and children's daily intake of fresh fruit and vegetables which may be an important factor to consider when devising health promotion strategies. Strong associations were observed for Belgium, Greece, Bulgaria, and Hungary. One might speculate that fathers' educational level and income insecurity might be important factors worth considering for FV intake in Greece. A feasible explanation for associations observed between fathers' FV intake and children's consumption patterns of FV might be that with more women in the workforce, fathers expend more time interacting with children especially during mealtimes and in the preparation, cooking of meals including grocery shopping [12]. In this context, paternal dietary behaviour is likely to play an important role in shaping children's diets through positive role modelling of eating

habits and by controlling the type and amount of food made accessible and available within the home [8]. From another point of view, fathers' health-related nutrition knowledge is another determinant of children's FV intake. Wolincka et al., documented positive correlations between parent's knowledge of the recommended intakes of FV and children's frequency of consumption of FV [28].

These observations bring to our attention that fathers should be aware of the multiple correlates that can influence their children's food intake including the impact of their own food choices and eating behaviour. Ultimately, foods preferred and consumed by parents (both mothers and fathers) are those foods that children are habitually exposed to and define children's choices and intake [26; 29]. School children are likely to be consuming 2/3 of meals at home with parents mostly controlling children's diets rather than peers and the school environment. So, explicit displays of good paternal eating behaviours, home availability and accessibility of FV, combined with encouragement that promotes consumption of healthy foods in children might be a useful parenting strategy for the adoption of desirable eating habits in children [30]. On the other hand, non-adherence to healthy eating guidelines in parents could undermine attempts to ensure healthy eating in children. Therefore, interventions focusing to improve the quality of both parents' diet could be effective in improving their children's eating habits.

Unexpectedly, we found that educational level and family income insecurity did not alter our observations. In contrast, Petrauskienė et al. in a national survey of school children participating in the COSI study found that the odds ratio of daily fresh fruit consumption was 1.4 times higher in children with fathers of high educational level than those of low educated parents [21]. The odds ratio of children's fresh fruit consumption was 1.5 times higher in families with high income compared to low income. A plausible explanation for differences between our study and previous research might be attributed to population differences, variability in definition of SES status, categorization of educational levels and measurement of family income (quantitative versus qualitative).

Despite the overwhelming evidence of the positive health benefits of consuming a varied diet abundant in FV, in our study, overall 60% of fathers and less than 50% of children consumed FV 1-2 times/day which does not comply with the current WHO recommendations to consume an abundance of FV as part of a healthy diet [1]. Interestingly, families in Southern European countries (i.e. Greece and Spain), as well as in Hungary continue to have poor dietary habits as evident by the low intake of FV. This is consistent with the findings of dietary surveys in Europe reporting considerable variability in FV intake across and within countries reflecting the prevailing economic, cultural, geographical and agricultural diversity [31]. Nevertheless, there is a propensity for people with high educational attainment to eat more fruit and vegetables compared to those with low educational levels (14% vs 10% respectively) [32]. Our observation is highly significant because childhood is a critical period during which eating behaviours and food preferences evolve providing an opportunity to develop and foster healthy eating habits that carries into adulthood.

Strengths/limitations

The present study endeavoured to unravel the complex environment-dietary behaviour interaction in the research area of food parenting. Traditionally, past research has focused on the influence of maternal eating habits on children's food intake and our study is unique in that it explored the impact of fathers, thereby extending to the literature [12]. Although FV intake was not assessed quantitatively (g/day), the European Prospective Investigation into Cancer and Nutrition (EPIC) study demonstrated that, in adults, the frequency of FV consumption was more important than serving size in distinguishing between increased and decreased intake of these foods [33]. Another forte of the present study was the large sample size comprising of data from six European countries, homogeneity amongst participants with respect to age, and selection (all school children) along with the use of standardized assessment tools which guarantees higher internal validity. From a statistical point of view, in the regression analysis, assessment of the model fit as described by low values of the R^2 coefficient suggest that variation in the dependent variable cannot be exclusively explained by the predictors and that there might be other factors affecting children's intake of FV warranting further investigation. Nevertheless, assessment of multicollinearity amongst predictor variables yielded no collinearity as represented by values of VIF < 4, tolerance statistic > 0.2, and condition index < 15 [22].

In light of limitations in the current study, the direction of the relationship between fathers' and children's FV intake cannot be established due to the cross-sectional nature of the data. There is a possibility that the association between fathers' FV consumption and children's might be bi-directional modified through social interaction. Another drawback, we did not evaluate concepts such as household norms regarding the serving of FV daily as part of family meals as well as home support (encouragement) for the consumption of healthy foods [34]. Then again, parental feeding practices were beyond the scope of our study but deserve consideration in future studies to determine parental traits that favour the fostering of healthy eating patterns in children. In addition, we did not have data concerning country differences in availability and variety of FV consumed in the family setting. Furthermore, we used family income insecurity in lieu of family income as a socio-economic status index, and therefore it is unknown how much of the family income was spent on food. It has been reported that food expenditure was strongly related to children's FV consumption [10]. Alternatively, we did not have details on the cost of FV and average family income per country which could be a source of bias. One more factor, details on family structure were not collected. Previous studies have shown that consumption of FV amongst children from single-parent families was lower than in those with two parents [35; 36] due to low income and the higher cost of healthy foods such as FV [37]. Concerning dietary assessment methods using self-administered FFQs, the scale used to categorize frequency of food intake, reporting, and social desirability bias are common disadvantages that may lead to overestimation of healthy food intake and underestimation of unhealthy foods in parents and children [38; 39]. Furthermore, children's FFQ could resemble that of the parent completing the questionnaire [40]. Nonetheless, uniform to all dietary guidelines of the participating countries is the recommendation for increased intake of FV for health benefits and in the prevention of future chronic disease [4].

Conclusions

Family is an important social environment where children learn and adopt their eating habits. Parents play a crucial role as health promoters, role models, and educators influencing the food choices of their children. Baseline data from the large-scale Feel4Diabetes study highlighted that families in Southern European countries (i.e. Greece and Spain), as well as in Hungary continue to have poor dietary habits as evident by the low FV intake. This study showed that fathers' daily FV intake was positively associated with children's intake of these foods. Implementation of future population-based strategies promoting FV intake not only in mothers

but also in fathers could be an effective public health initiative to increase FV intake in children. Policy-makers should give special attention to families dwelling in Southern European regions.

Transparency Declaration: The lead author affirms that this manuscript is an honest, accurate, and transparent account of the study being reported. The reporting of this work is compliant with the STROBE guidelines. The lead author affirms that no important aspects of the study have been omitted and that any discrepancies from the study as planned have been explained.

Conflict of Interest: The authors have no conflict of interests to declare

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