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Early-life family meal participation and anthropometric measures at 4 years of age

Elisabet Rudjord Hillesund[1], Linda Reme Sagedal[2] and Nina Cecilie Øverby[1]

[1]Department of Nutrition and Public Health, University of Agder, Kristiansand, Norway and [2]Department of Obstetrics and Gynecology/Department of Research, Sørlandet Hospital, Kristiansand, Norway

Original Article

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Corresponding author:
Elisabet Rudjord Hillesund;
Email: elisabet.r.hillesund@uia.no

Abstract

Early-life family meal participation has been associated with several aspects of nutritional health, but longitudinal associations with linear growth have not yet been investigated. The aim of this study was to investigate whether family meal participation at 12 months of age associates with anthropometric measures 3 years later. We used follow-up data from children born to mothers in the Norwegian Fit for Delivery trial (NFFD) and included 368 first-borns with dietary and anthropometric data at 12 months and 4 years of age. We treated the sample as a cohort and conducted subgroup analyses by randomization status. A family meal participation score was used as exposure, and weight, height, and body mass index (BMI) as outcomes in crude and multivariable linear regression models adjusted for maternal education, randomization status, and child sex.

Higher family meal participation score at 12 months was positively associated with length at 12 months ($B = 0.198$, 95% CI 0.028, 0.367, $p = 0.022$) and 4 years ($B = 0.283$, 95% CI 0.011, 0.555, $p = 0.042$) in multivariable models. After additional adjustment for maternal height the associations attenuated and were no longer significant. An inverse association with BMI at 4 years of age was observed in children born to mothers that had been exposed to the NFFD intervention ($B = -0.144$, 95% CI −0.275, −0.014, $p = 0.030$), but attenuated after adjustment for maternal BMI.

The longitudinal association observed between early family meal participation and child height was largely explained by maternal height. The relationship with BMI differed according to maternal participation in a lifestyle intervention trial during pregnancy.

Introduction

A substantial part of family life revolves around meals and eating. The family meal, often defined as eating together with at least one family member, represents a rich opportunity to expose children to healthy foods.[1] The family meal has also been described as a platform for child development and learning related to nutritional health and the promotion of healthy eating behaviors[2] and a regular occasion in which children may be nourished physically, emotionally, and socially.[3]

In a meta-analysis comprising 17 studies and 182 836 children, Hammons *et al.* (2011) demonstrated that children and adolescents who shared family meals three or more times per week were more likely to be in a normal weight range and have healthier dietary and eating patterns than those who shared fewer than three meals per week with their family.[4] Children and adolescents who had more frequent family meals were also less likely to engage in disordered eating (ibid). In a meta-analysis of 57 studies and 203 706 participants, Dallacker *et al.* (2018) demonstrated significant associations between frequency of participation in family meals and measures of healthy and unhealthy diet and body mass index (BMI), independent of child age, country of residence, socioeconomic status, and whether the meals were eaten with one or more family members.[1] Verhage *et al.* (2018) reviewed the literature on family meals for infant and toddlers, specifically, and found that more frequent family meal participation at an early age was associated with a more nutrient-dense food intake, less fussy eating, and more food enjoyment among the youngest.[2]

Despite the consistent associations that have been demonstrated between family meal participation and child nutritional health, evidence of causality has not been strong.[1,5] In a recent paper based on data from the *Family Matters* study, Berge *et al.* (2023) report longitudinal associations between family meal *quantity* at mean age 7 years and a broad range of child health and well-being outcomes 18 months later.[3] They operationalized family meal quantity as number of times per week that most members of the family were sitting and eating a family meal together and demonstrate reduced obesity prevalence, better diet quality, less food fussiness and food responsiveness, and fewer emotional, peer relationship, and conduct problems 18 months later with increasing number of family meals per week.[3] They also assessed interpersonal and nutritional family meal *quality* and found that these measures predicted improved diet quality,

lower emotional problems, less food responsiveness, and fewer peer relationship problems among children 18 months later. Contrary to expectations, they found little evidence of synergy between meal quantity and quality on the health and well-being outcomes investigated, indicating independent associations with the selected outcomes.

Linear growth is an inherent part of nutritional health, and one gap in the family meal literature is the operationalization of nutritional health limited to measures of BMI, healthy diet, unhealthy diet and/or overall diet quality.[1] Beyond fetal development, the largest and fastest growth and development occur in infancy and toddlerhood.[6] Child growth is continuous, with accelerated growth during early childhood, followed by more stable growth during the preschool and school years.[7] Enough food, regular meals, and adequate diet quality is therefore fundamental to support healthy growth and development, especially during infancy and toddlerhood.[6,8–11] It is conceivable that linear growth may differ according to family meal quantity, especially if family meals are more nutritious and planned compared to meals eaten alone. Not including height as a relevant outcome in family meal research represents a missed opportunity for insights regarding family meal contribution to nutritional health.

Most studies to date on infants' and toddlers' family meal participation have assessed nutritional health in relation to frequency of specific meals such as family breakfast, family dinner, or family evening meal.[2,5] This approach does not cover the *overall* quantity of family meals, that is, total number of meals eaten with family per day or per week. Given the demonstrated independent associations between family meal quantity and child health and well-being outcomes, we wanted to assess associations over a larger range than single meals or dinner meals. The objective of the present study was therefore to examine a potential relationship of overall frequency of family meals at 12 months of age with attained height, weight, and BMI at 4 years of age using follow-up data on mothers and children participating in the Norwegian Fit for Delivery (NFFD) trial.

Method

This paper reports findings from a secondary analysis based on follow-up data on children born to mothers participating in the NFFD trial. We therefore start with a brief description of the main features of the original study for which the mothers were recruited during the index pregnancy. The NFFD trial was a randomized controlled effectiveness trial of a lifestyle intervention targeting dietary behavior and physical activity level during pregnancy.[12] The intervention aimed to limit gestational weight gain and provide health benefits for mother and child and consisted of dietary advice simplified to ten dietary recommendations addressing energy balance-related dietary behaviors in addition to access to biweekly exercise sessions throughout pregnancy.[12] The dietary component consisted of ten recommendations designed to increase awareness of food choices, with specific advice on portion sizes, regular meal patterns, limiting the consumption of snack foods, and increasing the intake of water, fruits, and vegetables.[13] Women were eligible for participation in the trial if they were nulliparous, carried a singleton baby, had a prepregnancy body mass index (BMI) $\geq$ 19 kg/m^2, and were literate in Norwegian or English.[14] After exclusions due to predefined criteria (miscarriage, twin gestations, low prepregnancy BMI, and planned relocation outside study area), a total of 591 women were included in the trial between 2009 and 2013 and participated in the trial at least until birth.[12] Participants completed questionnaires at inclusion in week 15 and 36 of pregnancy, and 6 and 12 months, 2 and 4 years postpartum for themselves and their child.

For the present analysis, we used data from the questionnaires that mothers completed on behalf of their child at 12 months and 4 years postpartum in the present analyses. Children for whom questionnaire data were provided at both time-points were included in the analyses. We treated the study sample as a cohort, but adjusted for randomization status in the models, that is, whether the mother was exposed to the NFFD lifestyle intervention or not during pregnancy. In addition, main findings are presented separately according to maternal randomization status.

Family meal participation (exposure)

Family meal participation was operationalized as a family meal participation score denoting number of meal categories eaten with family at least 4 days per week at 12 months of age. Parents responded to the following question: *How often does the child eat the following meals with another family member, i.e., at the same time as at least one adult eats the same meal?*.[15] Responses were provided for breakfast, lunch, dinner, afternoon meal, and supper individually, and reported as "never/less than once per week," "1–3 times a week," "4–6 times a week," or "every day." The reliability of the family meal questions used has previously been assessed in test–retest analyses among 94 12-month-old children (45 male and 49 female children), carried out 1–2 weeks apart.[15] Spearman's r ranging from from 0.59 (between-meal snacks with parent) to 0.73 (lunch with parent) and Cohen's kappa ranging from 0.47 (between-meal snacks with parent) to 0.58 (breakfast with parent) were demonstrated.

In building the family meal participation score, we dichotomized child participation in each of the five family meal categories as seldom ($\leq$ 3 times/week = 0) or often ($\geq$ 4 times/week = 1) and constructed a summed score denoting number of meals eaten with family on a daily basis (0–5 family meals per day, equivalent to 0–35 family meals per week). Missing information on family meal participation for any meal category was replaced by zero (null-imputation), assuming that nonresponse was likely to represent irrelevant meal category or no meal participation by the child.

Anthropometric measures (outcome)

Child weight in kilograms (kg) and length in centimeters (cm), both recorded with one decimal at age 12 months, were objectively measured by a primary care health nurse and forwarded to the research team directly. Child height and weight at 4 years were self-reported by parents, but parents were asked to report the measurements as recorded in the child's formal health card in connection with the routine wellness exam at the child healthcare center at 4 years of age. For descriptive purposes we report anthropometric data for the child from birth until 4 years of age (Table 1). Information on weight, length, and head circumference at birth were collected from the child's medical birth record.

Demographics

We used background characteristics collected antenatally and at birth, 12 months, and 4 years postpartum. Education level was derived 12 months postpartum and mothers were given the

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Table 1. Demographic, socioeconomic and anthropometric measures according to family meal participation scoring† at 12 months of age ($n = 368$)

	Total $n = 368$		Family meal participation score 0–2 $n = 205$ (56%)		Family meal participation score 3–5 $n = 163$ (44%)		
Maternal and child characteristics	n	%	n	%	n	%	*P*-value‡
Maternal education (low) $n = 363$	102	28.1	61	30.5	41	25.2	0.378
Married or cohabiting $n = 363$	349	96.1	189	94.5	160	98.2	0.072
Income in lowest sample tertile (n = 361)	107	29.7	68	34.3	39	23.9	0.119
Maternal smoking during pregnancy $n = 363$	13	3.6	7	3.5	6	3.6	0.926
Belonging to the NFFD intervention group	183	50.3	103	51.2	80	49.1	0.681
Child sex - proportion of boys	197	53.5	106	51.7	91	55.8	0.431
Born small for gestational age (SGA) $n = 364$	39	10.7	27	13.4	12	7.4	0.063
Maternal age and anthropometry prepregnancy	Mean	SD	Mean	SD	Mean	SD	P-value
Maternal age $n = 364$	28.3	4.3	28.0	4.3	28.6	4.4	0.254
Maternal weight (kg) $n = 365$	67.3	12.3	67.1	12.3	67.5	12.4	0.776
Maternal height (cm) $n = 365$	168.8	6.2	**167.8**	**6.0**	**170.1**	**6.2**	**<0.001**
Maternal BMI (kg/m^2) $n = 365$	23.6	3.9	23.8	4.0	23.3	3.8	0.204
Paternal anthropometry prepregnancy							
Paternal weight (kg) $n = 365$	84.6	11.4	85.1	10.8	84.1	12.1	0.390
Paternal height (cm) $n = 342$	182.1	6.2	181.5	5.9	182.7	6.6	0.069
Paternal BMI (kg/m^2) $n = 365$	25.5	3.2	25.8	3.2	25.2	3.2	0.055
Child anthropometry at birth							
Weight (grams) $n = 364$	3442	505	3402	538	3492	459	0.092
Length (cm) $n = 352$	50.0	2.3	49.9	2.4	50.3	2.3	0.125
Head circumference (cm) $n = 361$	34.9	1.5	**34.8**	**1.5**	**35.1**	**1.6**	**0.049**
Ponderal Index $n = 339$	2.74	0.23	2.74	0.21	2.74	0.26	0.903
Child anthropometry at 12 months of age							
Weight (kg) $n = 322$	10.0	1.1	9.9	1.1	10.0	1.1	0.299
Height (cm) $n = 322$	77.1	2.7	**76.7**	**2.5**	**77.4**	**2.8**	**0.015**
Body mass index (BMI) $n = 322$	16.8	1.4	16.8	1.5	16.7	1.3	0.511
Child anthropometry at 4 years of age							
Weight (kg) $n = 350$	17.3	2.2	17.2	2.2	17.4	2.2	0.416
Height (cm) $n = 342$	105.6	4.3	**105.0**	**3.7**	**106.3**	**4.8**	**0.007**
Body mass index (BMI) $n = 342$	15.5	1.5	15.6	1.6	15.4	1.3	0.170

† The family meal participation score denotes number of meal categories (breakfast, lunch, between-meal snack, dinner, and supper) eaten with family at least 4 days per week and may take values from 0 to 5.
‡ Independent *t*-test for continuous variables and Pearson's chi-squared test for categorical variables. Significant differences are indicated by bold text.

following response alternatives; < 7 years of primary education; 7–10 years of primary education; trade school or 1–2 years of high school; completed high school; < 4 years or ≥ 4 years of college/university. Educational level was dichotomized into low (not having attended college or university) or high education (having attended college or university). Maternal smoking was recoded into "never smoked," "smoked before, but quit during pregnancy," or "smoke." Maternal height was objectively measured at study inclusion in early pregnancy. Maternal prepregnancy weight was self-reported. Paternal height and weight were self-reported by the mother in the baseline questionnaire.

Dietary measures

At child age 4 years, mothers completed a diet questionnaire similar to the one responded to when the child was 12 months old.[15] The questionnaire included intake of various foods (48 items) and beverages (17 items), portion size of selected foods (8 items) and beverages (7 items), and questions about meal pattern (18 items). For the present study, the following 11 components were included as indicators of overall diet quality: fresh fruit (1 item), vegetables (2 items), fruit and vegetables combined (3 items), whole grain foods (6 items), total milk and

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yoghurt (8 items), fish total (3 items), meat total (4 items), tap water (1 item), sweetened beverages (7 items), sweets and salty snacks (3 items), and cake and desserts (5 items). All frequency questions (except for dinner items) had eight response alternatives ranging from "never/less than weekly" to "≥ five times/day." The frequency of intake was recoded as follows: "never/less than once per week"=0, "1–3 times/week"=0.3, "4–6 times/week"=0.7, "once/day"=1, "twice/day"=2, "three times/day"=3, "four times/day"=4, and "five times or more/day"=6. For foods normally eaten for dinner, in this case home-made and commercially produced fish and meat dishes, seven response alternatives were provided, ranging from never/less than once a month to three times a week. The frequency of intake of these foods was recoded into times per day as follows: never/less than once a month = 0, once a month = 0.03, twice a month = 0.07, three times a month = 0.1, once a week = 0.15, twice a week = 0.3, and three times a week = 0.4.

Statistical analyses

For descriptive purposes, we dichotomized family meal participation scoring at 12 months, with score cut-off ≤ 2 versus ≥ 3. The cut-off represents an arbitrary choice to facilitate comparison of maternal and child characteristics according to quantity of family meal participation. We compared maternal and child characteristics using independent sample's *t*-test for continuous variables and Pearson's chi-squared test for categorical variables. We modeled the association between family meal participation scoring (0–5) at 12 months with child height, weight, and body mass index (BMI) cross-sectionally at 12 months and longitudinally at 4 years in crude and adjusted linear regression models. All models were adjusted for maternal NFFD randomization status, maternal educational attainment, and child sex. We also fit models with additional adjustment for the corresponding maternal anthropometric measure, that is, maternal prepregnancy weight, height, or BMI, respectively. In the model of child height at 4 years we also included length at 12 months to get an estimate of potential difference in growth between the two time points according to number of daily family meals at 12 months.

Since approximately half of the mothers in the sample had participated in a lifestyle intervention targeting dietary behavior during pregnancy, we decided a priori to perform subgroup analyses stratified by maternal randomizations status. We also decided to check for potential moderating effects by maternal education level and child sex. We included the following interaction terms: *number of family meals *randomization*, *number of family meals*education*, and *number of family meals *child sex,* respectively. In the case of a significant interaction term, we reran analyses stratified by the respective moderating variable. P-values<0.05 were considered significant. No adjustments were made for multiple analyses.

Ethics approval and consent to participation

The NFFD trial was performed in accordance with the Declaration of Helsinki. The Norwegian Regional Committee for Medical Research Ethics South-East-C approved the trial and modifications (REK reference 2009/429). Signed, informed consent was obtained from all participants. The trial was registered in ClinicalTrials.gov ID NCT01001689.

Results

A total of 368 of the 591 mothers (62%) who participated in the NFFD trial during pregnancy provided data on behalf of their child both at both 12 months and 4 years of age. In Table 1, parental and child characteristics are described according to family meal scoring at child age 12 months (family meal participation score ≤ 2, 56% versus ≥3, 44%). There were no significant differences in maternal education level, income level, smoking status, proportion of boys, or original randomization status according to level of family meal scoring at 12 months of age. Children with higher family meal scoring had, however, slightly larger head circumference at birth (35.1 versus 34.8 cm, $p = 0.049$) and were taller at 12 months (77.4 versus 76.7 cm, $p = 0.015$) and 4 years of age (106.3 versus 105.0 cm, $p = 0.007$). They had also taller mothers (170.1 versus 167.8, $p < 0.001$). The correlation between birthweight and weight at 12 months and 4 years was $r = 0.412$ and $r = 0.321$, respectively. The correlation between weight at 12 months and 4 years was $r = 0.704$. The correlation between birth length and length at 12 months and 4 years was $r = 0.497$ and $r = 0.277$, respectively. The correlation between length at 12 months and height at 4 years was $r = 0.584$.

Table 2 describes dietary characteristics at 4 years of age according to family meal scoring at 12 months. At 4 years, children with higher participation in family meals at 12 months had more frequent intake of fresh fruit (2.1 versus 1.8 times/day, $p = 0.043$) and fish (0.9 versus 0.6 times/day, $p < 0.001$), but also more frequent intake of sweets & salty snacks (2.3 versus 2.0 times per day, $p = 0.029$) than children with less frequent participation in family meals (Table 2). Frequency of eating breakfast, lunch, between-meal snack, dinner, or supper with family at 4 years correlated strongly with family meal participation scoring at 12 months, with the highest correlation being for family breakfast ($r = 0.789$) and lowest for between-meal snack ($r = 0.651$). The proportion of children participating in specific family meals at 4 years did not differ between high and low family meal scoring at 12 months did not differ at 4 years according to family meal scoring at 12 months, except for a suggestion of more frequent family supper at 4 years with higher family participation at 12 months (Table 2).

Cross-sectional associations between family meals and anthropometric measures

There was a cross-sectional association between family meal participation at 12 months of age and child length in crude model ($B = 0.207$, 95% CI 0.028, 0.367, $p = 0.022$) and the model adjusted for maternal randomization status, maternal educational attainment, and child sex. ($B = 0.198$, 95% CI 0.028, 0.367, $p = 0.022$). The estimates denote increase in child length for each increase in family meal scoring at 12 months (Table 3). When maternal height was included as a covariate in the model, the association attenuated and was no longer significant ($B = 0.142$, 95% CI −0.035, 0.319, $p = 0.116$). No cross-sectional association was observed for family meal frequency in relation to weight or BMI at 12 months (Table 3).

Longitudinal associations between family meal participation and anthropometric measures

A longitudinal association between family meal participation at 12 months of age and child height at 4 years was observed in crude

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Table 2. Dietary characteristics at 4 years of age according family meal participation scoring† at 12 months of age ($n = 368$)

Proportion of children eating main meals with family daily† at 4 years of age	Total $n = 368$		0-2 family meals/day at 12 months $n = 205$		3-5 family meals/day at 12 months $n = 163$		
	n	%	n	%	n	%	P-value‡
Breakfast ($n = 355$)	228	64.2	120	61.2	108	67.9	0.190
Lunch ($n = 355$)	33	9.3	17	8.7	16	10.1	0.654
Between-meal snack ($n = 355$)	49	13.8	23	11.7	26	16.4	0.210
Dinner ($n = 355$)	338	95.2	188	95.9	150	94.3	0.488
Supper ($n = 355$)	213	60.0	109	55.6	104	65.2	0.061
Child dietary characteristics at 4 years of age, frequency per day	Mean	SD	Mean	SD	Mean	SD	P-value
Fresh fruit $n = 364$	1.91	1.51	**1.77**	**1.46**	**2.09**	**1.55**	**0.043**
Vegetables total $n = 364$	1.38	1.41	1.26	1.35	1.53	1.48	0.070
Fruits and vegetables total $n = 359$	4.72	3.15	4.46	3.20	5.05	3.05	0.076
Wholegrain bread including cereal and porridge $n = 363$	3.46	2.21	3.41	2.21	3.53	2.22	0.616
Plain drinking water $n = 366$	4.60	1.61	4.46	1.59	4.78	1.63	0.059
Milk and yoghurt total $n = 364$	3.24	2.68	3.13	2.43	3.39	2.97	0.357
Meat total (including spreads) $n = 359$	1.32	0.99	1.27	0.96	1.38	1.02	0.292
Fish total (including spreads) $n = 359$	0.70	0.73	**0.56**	**0.45**	**0.89**	**0.94**	**<0.001**
Sweetened beverages total $n = 365$	0.75	1.20	0.70	1.00	0.81	1.42	0.369
Sweets and salty snacks $n = 358$	2.11	1.28	1.98	1.18	2.28	1.37	0.029
Cakes and desserts $n = 358$	2.29	1.72	2.15	1.59	2.47	1.86	0.081

† The family meal participation score denotes number of meal categories (breakfast, lunch, between-meal snack, dinner, and supper) eaten with family at least 4 days per week and may take values from 0 to 5.
‡ Independent *t*-test for continuous variables and Pearson's chi-squared test for categorical variables. Significant differences are indicated by bold text.

Table 3. Crude and adjusted associations between family meal participation scoring† (0–5) at 12 months of age and anthropometric measures at 12 months and 4 years of age, respectively. Regression coefficient β with 95% CI

	Crude model			Adjusted model ‡			Additional adjustment for the corresponding maternal variable		
12 months	***β***	**95% CI**	***p*-value**	***β***	**95% CI**	***p*-value**	***β***	**95% CI**	***p*-value**
Child weight	0.053	−0.022, 0.129	0.166	0.050	−0.021, 0.120	0.167	0.050	−0.024, 0.123	0.186
Child height	**0.207**	**0.026, 0.389**	**0.026**	**0.198**	**0.028, 0.367**	**0.022**	0.142	−0.035, 0.319	0.116
Child BMI	−0.003	−0.097, 0.091	0.951	−0.005	−0.98, 0.87	0.912	0.004	−0.088, 0.097	0.924
4 years									
Child weight	0.059	−0.076, 0.195	0.391	0.050	−0.084, 0.184	0.462	0.070	−0.060, 0.200	0.291
Child height	**0.282**	**-0.008, 0.556**	**0.044**	**0.283**	**0.011, 0.555**	**0.042**	0.160	−0.103, 0.422	0.232
Child BMI	−0.039	−0.129, 0.050	0.388	−0.044	−0.134, 0.045	0.333	−0.028	−0.116, 0.060	0.532

† The family meal participation score denotes number of meal categories (breakfast, lunch, between-meal snack, dinner, and supper) eaten with family at least 4 days per week and may take values from 0 to 5.
‡ Associations adjusted for NFFD randomization status, maternal education level, and child sex. Additional adjustment for maternal prepregnancy weight, height, or BMI, respectively, in the right column. Significant associations are indicated by bold text.

($B = 0.282$, 95% CI 0.008, 0.556, $p = 0.044$) and adjusted models ($B = 0.283$, 95% CI 0.011, 0.555, $p = 0.042$) (Table 3). When maternal height was included as a covariate in the model, the association attenuated and was no longer significant ($B = 0.160$, 95% CI −0.103, 0.422, $p = 0.232$). We also included child length at 12 months as a covariate in a separate model to assess potential difference in growth between 12 months and 4 years according to frequency of family meals. The association between family meal participation and growth was not significant ($B = 0.130$, 95% CI −0.119, 0.379, $p = 0.304$). Including maternal height as a covariate

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Table 4. Adjusted associations between family meal participation scoring† (0–5) at 12 months of age and child anthropometric measures at 4 years. Analyses stratified by maternal NFFD randomization status. Regression coefficient β with 95% CI*

	Adjusted model confined to children of NFFD control mothers‡ ($n = 163$)			Adjusted model confined to children of NFFD intervention mothers‡ ($n = 175$)		
12 months	**β**	**95% CI**	***p*-value**	**β**	**95% CI**	***p*-value**
Child weight	0.089	−0.015, 0.193	0.093	0.014	−0.082, 0.111	0.769
Child height	**0.351**	**0.111, 0.592**	**0.004**	0.057	−0.183, 0.297	0.640
Child BMI	−0.006	−0.142, 0.130	0.930	−0.004	−0.131, 0.124	0.957
4 years						
Child weight	**0.199**	**0.009, 0.389**	**0.041**	−0.090	−0.278, 0.098	0.345
Child height	**0.379**	**0.004, 0.779**	**0.048**	0.183	−0.217, 0.583	0.369
Child BMI	0.055	−0.068, 0.177	0.379	**−0.144**	**-0.275, -0.014**	**0.030**

Significant associations are indicated by bold text.
*Significant interaction term only for the association for child weight (p = 0.030) and BMI (p = 0.035).
† The family meal participation score denotes number of meal categories (breakfast, lunch, between-meal snack, dinner, and supper) eaten with family at least 4 days per week and may take values from 0 to 5.
‡ Associations adjusted for maternal education level and child sex.

Table 5. Associations between family meal participation scoring† (0–5) at 12 months of age and child anthropometric measures at 4 years, adjusted for corresponding maternal variables (maternal height, prepregnancy weight, and BMI, respectively). Analyses stratified by maternal NFFD randomization status. Regression coefficient β with 95% CI*

	Maternal adjustments confined to the control group‡ ($n = 163$)			Maternal adjustments confined to the intervention group‡ ($n = 175$)		
12 months	**β**	**95% CI**	***p*-value**	**β**	**95% CI**	***p*-value**
Child weight	0.067	−0.043, 0.177	0.232	0.028	−0.072, 0.128	0.584
Child height	0.259	−0.002, 0.520	0.052	0.030	−0.213, 0.274	0.806
Child BMI	−0.013	−0.146, 0.121	0.854	−0.009	−0.120, 0.139	0.886
4 years						
Child weight	**0.196**	**0.012, 0.380**	**0.037**	−0.062	−0.246, 0.122	0.509
Child height	0.251	−0.116, 0.619	0.179	0.076	−0.303, 0.455	0.693
Child BMI	0.064	−0.054, 0.182	0.288	−0.124	−0.254, 0.006	0.062

Significant associations are indicated by bold text.
*Significant interaction term only for the association for child weight (p = 0.030) and BMI (p = 0.035).
† The family meal participation score denotes number of meal categories (breakfast, lunch, between-meal snack, dinner, and supper) eaten with family at least 4 days per week and may take values from 0 to 5.
‡ Associations adjusted for maternal education level and child sex in addition to maternal education level and child sex.

in the growth model attenuated the association ($B = 0.093$, 95% CI −0.156, 0.342, $p = 0.463$).

No association was observed between family meal participation at 12 months and child weight or BMI at 4 years in the main analyses (Table 3).

Subgroup analyses

We found significant interactions by maternal randomization status on the association between family meal participation and child weight (interaction term $p = 0.030$) and BMI (interaction term $p = 0.035$) at 4 years. No interaction by maternal educational attainment or child sex on the associations between family meal participation and anthropometric measures were observed.

It should be noted that there was no significant difference in child weight, height, or BMI at 4 years of age according to maternal randomization status (data not shown). Nor was there any difference in maternal height or pre pregnancy BMI according to NFFD randomization status. When the models were rerun stratified by maternal randomization status, an association between family meal participation at 12 months and child BMI at 4 years was observed confined to children born to intervention mothers (B = −0.144, 95% CI −0.275, −0.014, $p = 0.030$), with no such association observed among children born to control mothers ($B = 0.055$, 95% CI −0.068, 0.177, $p = 0.379$) (Table 4). The association observed among children born to intervention mothers attenuated and was no longer significant when maternal prepregnancy BMI was included as a covariate in the model (B = −0.124, 95% CI −0.254, 0.006, $p = 0.062$) (Table 5).

In stratified models the association between family meal participation at 12 months and child height at 4 years was stronger for children born to mothers in the control group compared to children born to mothers in the intervention group ($B = 0.379$, 95% CI 0.004, 0.779, $p = 0.048$ versus $B = 0.183$, 95% CI −0.217,

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0.583, $p = 0.369$) (Table 4). When maternal height was included in the stratified models the association attenuated in both groups ($B = 0.251$, 95% CI −0.116, 0.619, $p = 0.179$ in the control group versus $B = 0.076$, 95% CI −0.303, 0.455, $p = 0.693$ in the intervention group) (Table 5). As there was no significant interaction by maternal randomization status regarding association between family meal participation and child height, this finding should be interpreted with caution.

Comparison of characteristics between participants included and those lost to follow-up

Data regarding family meal participation at 12 months of age was available for 408 children. At 4 years of age, only 368 of the parents completed the questionnaire, meaning that 40 children (9.8%) were lost to follow-up. To assess potential differences between those retained and those lost to follow-up, we compared background information for the sample analyzed in the present study with those only providing data at 12 months. There were no significant differences between children included in the present analyses and those lost to follow-up at 4 years regarding maternal age, educational attainment, family income, prevalence of smoking, proportion of boys, or proportion belonging to the intervention group (data not shown). Nor was there any difference in frequency of family meal participation at 12 months of age.

Discussion

We found evidence that family meal participation at 12 months of age was positively associated with attained height both cross-sectionally at 12 months and 3 years later. The observed associations attenuated when maternal height was included in the models. For children born to mothers exposed to the NFFD lifestyle intervention during pregnancy, more frequent family meal participation at 12 months of age was associated with lower BMI at 4 years of age. This association attenuated when maternal prepregnancy BMI was included in the model. Since the observed associations between family meal participation at 12 months and anthropometry 3 years later were attenuated and no longer significant when maternal anthropometric measures were included in the respective models, we do not have evidence that family meal participation per se influences child growth and energy balance within this time frame.

Adult height is primarily established during the first growth period in early childhood when nutritional requirements are greater than at any subsequent time.[6] Although genetic factors are important determinants of height, only diet provides the resources necessary for attaining the individual's genetic potential.[6,16] Specific nutrients, such as protein, vitamin D, and calcium are fundamental to child growth, but the whole spectrum of nutrients from a variety of foods have roles to play in the complex processes of linear growth. A study of geographic differences in stature among young men from 45 countries of European origin demonstrated that nutrition level explained most of the differences in adult height, particularly the consumption of high-quality proteins from milk, pork, fish, and wheat.[16]

We have previously demonstrated cross-sectional associations between family meal participation at 12 months of age and frequency of intake of fruit, vegetables, and milk.[17] When diet was reassessed at 4 years of age in the present analysis, children with more frequent family meals at 12 months had a sustained higher frequency of intake of fresh fruit and fish compared to children with less frequent family meal participation at 12 months. Fruit, vegetables, milk, and fish are markers of a nutrient-dense diet with the potential to influence growth, metabolic health, and possibly energy balance.[18]

Taller mothers would be expected to have taller children regardless of other determinants of child height. The fact that family meal frequency in the present study was associated with child stature mainly through its association with maternal height is interesting. It is tempting to speculate that family meal routines may be associated with nutritional health and biological capital and transmitted across generations. We do not, however, have evidence in the dataset to support such speculations.

In models stratified by NFFD randomization status, the association between family meal participation at 12 months and child height at 4 years was only significant among children born to control mothers, and no longer significant after controlling for maternal height. Given that there was no formal interaction with maternal randomization status in this model, the difference in effect size according to previous intervention exposure could be due to chance and should be interpreted with caution.

The fact that the associations between quantity of family meal participation at 12 months and BMI at 4 years of age differed by previous maternal exposure to an intervention targeting dietary behavior and exercise during pregnancy is interesting. More frequent family meal participation at 12 months was predictive of lower BMI at 4 years only among children born to mothers in the NFFD intervention group. The association was attenuated when maternal prepregnancy BMI was included in the model, but the estimates were still indicative of an inverse association with child BMI that was not seen in the control group. This finding could imply sustained impact of the dietary intervention on family meal nutritional quality and/or energy balance-related behaviors. As one of the aims of the NFFD study was to limit gestational weight gain, intervention mothers may have adopted and sustained energy balance-related dietary behaviors and meal preparation habits that could be protective of excess weight gain for the child. We have previously shown that mothers in the NFFD intervention group improved dietary behavior during pregnancy relative to mothers in the control group, with higher consumption of water relative to sweetened beverages, more frequent fruit and vegetable consumption, less frequent consumption of sugar-dense foods, more often choosing small portion sizes of unhealthy foods, less frequent overeating and more often checking food labels than women in the control group.[19] The fact that maternal prepregnancy BMI partly explained the association between family meal participation and child BMI indicate that at least in this sample, frequent family meals and including the infant in family meals were more common among slimmer mothers. Berge *et al.* 2023 also found an independent association between family meal quantity at 7 years and lower risk of obesity 18 months later,[3] adjusted for obesity at baseline, but not for maternal or parental BMI.

Strengths and limitations

To our knowledge this is the first study to investigate associations between early-life family meal participation and growth measures 3 years later. Previous publications investigating family meal frequency in relation to health have mostly used weight status or BMI as nutritional outcomes.[1,4,20] Given that weight status primary reflects energy balance over time rather than the degree to which broader nutritional needs have been met, not including height as an inherent measure of nutritional health could be a missed

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opportunity in establishing nutritional contributions of family meal regularity. Longitudinal associations between family meal participation and anthropometric outcomes have previously mostly been investigated among older children and adolescents.[3,21,22]. We were also able to demonstrate associations over a broader range of early family meal participation than have been shown in previous studies.[1]

Family meal definitions and operationalization of family meal measures vary between studies. Horning *et al.* (2016) found few differences regarding associations with nutritional and psychological outcomes when they examined associations among nine family meal dinner frequency measures and various child weight, dietary and psychosocial outcomes.[23] They noticed, however, that family meal definitions that remained significant and inversely associated with BMI z-score included a specification of "sitting and eating together." This aligns fairly well with definition used in the question parents responded to by child age 12 months in the present study, namely *How often does the child eat the following meals with another family member, i.e., at the same time as at least one adult eats the same meal?*

Data on child weight and length at birth and 12 months of age were collected from official hospital records and from the child's healthcare records, respectively. Maternal prepregnancy weight was self-reported and hence less reliable than height that was objectively measured in the study. Child weight and height at 4 years were reported by one of the parents in the web-based questionnaire, but the measures requested were measured at the healthcare center and registered by the healthcare nurse in the child's ambulant health card which should increase the confidence in these self-reported measurements.

There are, however, also limitations in the present analyses. Participation in family meals may entail a range of exposures. The definition of family meal participation as eating with at least one adult eating the same meal, groups together eating occasions with large variance in multiple dimensions. Participation in family meals entails a range of exposures other than being fed and nourished. A meal eaten with family may also consist of any combination of foods and beverages and is no guaranty for overall diet quality. Variance in nutritional quality of the family meals among participants in this sample is likely to bias true associations between healthy and nutritious meals and growth and weight measures toward the null, as is variance in other dimensions of family meals that may impact nutritional health, such as parental role modeling, repeated exposure to new foods and positive meal atmosphere that may foster food acceptance and healthy food preferences.

The fact that we were able to identify both dietary differences and height difference according to degree of family meal participation support that our findings are valid. A more precise assessment of differences in energy and nutritional intake at 4 years according to early-life family meal participation might have shed light on potential nutritional mediators of the relationship between early family meal participation and height, but since the food frequency questions did not cover the whole diet, detailed nutritional information was not obtainable from the dataset. It should also be mentioned that for two of the indicators of overall diet quality at 4 years, that is, "fish total" and "meat total," only seven response alternatives were provided in the questionnaire, ranging from never/less than once a month to three times a week. This was a mistake that limited the possible range of intake for these food items which may have led to an underestimation of true frequency of intake.

We did not include information on child day care in the analyses. At 12 months, 85 children (23%) attended kindergarten. Being away from family for one or more meals would implicate lower likelihood of being categorized in the higher range of family meal participation. Since day care meals are likely to resemble family meals in many ways, number of meal settings for the child may be underreported in the presented findings because of the way we operationalized family meal participation. This is, however, likely to have influenced our findings toward lower ability to detect true differences in nutrition-related health measures related to family meal participation or number of structured meal settings for the child.

There is an obvious correlation between meal frequency in general and participation in family meals. The observed associations with anthropometric measures could be related to a regular and planned food intake rather than the specific aspect of eating together with others. Children exposed to fewer or more irregular meals may not cover nutritional needs to the same extent as with more frequent and planned meals. Frequency of family meal participation was, however, assessed by detailed frequency questions for each meal type, and it was clearly specified that these questions concerned meals eaten together with at least one other family member.

Residual and unmeasured confounding by factors associated with early family meal participation and causally related to anthropometric measures cannot be ruled out. Indicators of socioeconomic position such as maternal education and family income did not differ significantly according to family meal participation at 12 months of age, nor did the proportion of mothers reporting smoking during pregnancy. We adjusted for maternal education in the models, but residual confounding by socioeconomic factors cannot be ruled out. There may also be other parental characteristics related to family meal routines and structure that education and income do not capture.

Family meal frequency may be a proxy for unmeasured determinants of child health, such as parental health literacy, positive health behaviors and family cohesion. There could also be unmeasured characteristics related to the child that associates with family meal participation, such as food fussiness, food neophobia, lack of self-feeding skills, or other factors that could influence both family meal participation, diet quality and anthropometry, and thus have the potential to confound associations.[24]

Half of the mothers of children in the present analysis had been exposed to the NFFD lifestyle intervention targeting dietary behavior during pregnancy. This means that findings confined to the control group should be more generalizable to the background population. But even mother-child dyads from the control group are likely to differ from the background population by being composed of mothers willing to be recruited for a lifestyle intervention. Mothers of the children in the present analysis were mostly white, European, and highly educated.[12] It is conceivable that a wider representation of the background population might entail larger variability in both family meal frequency and child weight, height, and BMI. Even though education level did not differ according to family meal participation in the present sample of relatively highly educated mothers, this could be different in a more representative sample.

In conclusion, we found a positive association between family meal participation at 12 months and attained height at 4 years that was partly explained by a similar association between child family meal participation and maternal height. We also found an inverse association between family meal participation at 12 months of age

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and BMI at 4 years among children born to mothers exposed to a lifestyle intervention during pregnancy, possibly indicating a sustained impact of this intervention on energy balance-related family meal practices. Our findings add to the body of research on associations between family meal participation and nutritional health and address the knowledge gap regarding associations of early family meal participation with longitudinal measures of growth. More research with larger datasets and richer information on potential confounders are required to strengthen the evidence base for the nutritional health potential of early participation in family meals.

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Author contributions. ERH, LRS, and NCØ initiated and designed the present study. ERH performed the statistical analyses. ERH drafted the first version of the manuscript. All authors gave substantial input to the manuscript. All authors contributed to, read, and approved the final version of this manuscript.

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Competing interests. None.

Ethical standards. The NFFD trial that provided secondary data for the present paper was performed in accordance with the Declaration of Helsinki. The Norwegian Regional Committee for Medical Research Ethics South-East-C approved the trial and modifications (REK reference 2009/429). Signed, informed consent was obtained from all participants. The trial was registered in ClinicalTrials.gov ID NCT01001689.

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