Adherence to the New Nordic Diet during pregnancy and subsequent maternal weight development – a study conducted in the Norwegian Mother and Child Cohort Study (MoBa)

Abstract:

The rising prevalence of overweight and obesity is a worldwide public health challenge. Pregnancy and beyond is a potentially important window for future weight gain in women. We investigated associations between maternal adherence to the New Nordic diet (NND) during pregnancy and maternal body mass index (BMI) trajectories from delivery to 8 years post-delivery. Data are from the Norwegian Mother and Child Cohort. Pregnant women from all of Norway were recruited between 1999-2008 and 55 056 are included in the present analysis. A previously constructed diet score, NND, was used to assess adherence to the diet. The score favors intake of Nordic fruits, root vegetables, cabbages, potatoes, oatmeal porridge, whole grains, wild fish, game, berries, milk and water. Linear spline multi-level models were used to estimate the association. We found that women with higher adherence to the NND pattern during pregnancy had on average lower post-partum BMI trajectories and slightly less weight gain up to 8 years post-delivery compared to the lower NND adherers. These associations remained after adjustment for physical activity, education, maternal age, smoking, and parity (mean diff at delivery (high v low adherers): -0.3kg/m2 95% CI -0.4 to -0.2; mean diff at 8 years: -0.5kg/m^2 95% CI: -0.6 to -0.4), and were not explained by differences in energy intake or by exclusive breastfeeding duration. Similar patterns of associations were seen with trajectories of overweight/obesity as the outcome. In conclusion, our findings suggest that the NND may have beneficial properties to long term weight regulation among women postpartum.

Key words: New Nordic Diet, Maternal weight trajectories, Overweight, Pregnancy

Introduction

Overweight and obesity are increasing in prevalence worldwide [1;2], and are associated with a range of adverse health outcomes [3-5]. The highest increase in obesity rates has been reported among young women [2]. A recent large population based study revealed that less than 1 in 100 obese persons managed to achieve and sustain normal weight [6]. Thus, maintaining normal weight is of high value and preferable to treating overweight and obesity [6;7]. One of the biological causes for female overweight is related to the natural increase in weight during pregnancy and its influence on future weight gain trajectory [8]. About 75% of women retain the extra weight they gain following pregnancy [9]. This extra adipose tissue may be difficult to lose later, and may adversely influence metabolism.

Increased body weight before entering new pregnancies, may also affect subsequent pregnancies. Prepregnant maternal obesity is associated with a range of adverse pregnancy and neonatal outcomes, such as increased risk of preeclampsia, gestational diabetes, offspring malformations, and later obesity in the child [10]. Both pre-pregnancy body mass index (BMI), excessive gestational weight gain and post-partum weight retention have been identified as risk factors for long-term maternal weight gain [11]. This highlights the importance of the pre-pregnancy- pregnancy-postpartum period in relation to the primary prevention of obesity [12].

Diet is important in the prevention of excessive weight gain during pregnancy and in prevention of obesity in general. Several intervention studies have explored the effectiveness of dietary modifications on gestational weight gain (GWG) and on short term weight retention, showing that it is possible to affect GWG with dietary changes during pregnancy [13]. Associations between dietary patterns during pregnancy and short-term weight development post-partum have also been investigated in longitudinal studies [11;14]. Von Ruesten et al. found that adherence to the Nordic food guidelines during pregnancy was associated with lower post-partum weight retention up to 6 months in the Norwegian Mother and Child cohort [14]. However, few have explored the association between dietary patterns in pregnancy and longer-term weight development of the mother [11].

The concept of the New Nordic Diet (NND) was reported in 2009 as a potentially sustainable regional alternative to the Mediterranean diet [15]. Documentation of its dietary composition and nutritional qualities was further developed by Mitril et al. [16]. The NND is characterized by foods that can be produced within the Nordic countries such as whole grains, potatoes, milk, fruits, berries, root vegetables, cabbages, wild game and fish [15;16]. We previously showed that higher adherence to this dietary pattern was associated with healthier macronutrient distribution and higher nutrient density in a cohort of pregnant women [17]. Health effects of Nordic Diets are increasingly being investigated in the Nordic countries [18-21]. In intervention trials, increasing adherence to aspects of healthy Nordic diets has been shown to be beneficial with respect to weight loss [18;20], satiety [21], and weight regain after weight loss [21]. Furthermore, in observational studies increased adherence to aspects of a Nordic diet has been inversely associated with abdominal obesity [22;23], body fat percentage [22], risk of excessive gestational weight gain in normal weight women [17] , and inflammatory markers associated with obesity [24]. The association between adherence to a Nordic diet during pregnancy and long term weight trajectories has however not been investigated. Thus, the current study aimed to investigate associations between maternal adherence to the NND during pregnancy and maternal BMI trajectories up to 96 months post-delivery.

Materials and methods

<u>Participants and data sources:</u>

We used linked data from the Norwegian Mother and Child Cohort Study (MoBa) [25] and the Medical Birth Registry of Norway (MBRN) [26]. The MoBa cohort is a prospective population-based pregnancy cohort study conducted by the Norwegian Institute of Public Health [27-29]. Participants were recruited from all over Norway from 1999-2008. The women consented to participation in 40.6% of the pregnancies. At the time of this report, the cohort includes 114.500 children and 95.200 mothers. MBRN was established in 1967 and is based on compulsory notification of all live- and still-births from 16 weeks of gestation (12 weeks from 2001) in Norway [26].

-INCLUDE "FIGURE 1 Flow chart of sample selection" here.

Figure 1 describes how we arrived at the number of participants to be included in the analyses. In total 102 265 unique pregnancies were identified from the MoBa-study and of these 101 811 had data from the MBRN. We only included women carrying a single foetus and only the first pregnancy if a mother participated with more than one pregnancy in the MoBa cohort. We excluded pregnancies resulting in perinatal deaths, and women who emigrated before birth. We also excluded those who had not completed the food frequency questionnaire (FFQ) in mid-pregnancy, and those with extreme energy intakes defined as <

4,500 KJ or more than 20,000 KJ (30). Of 71 648 eligible pregnancies, the ones who did not have data for calculation of BMI on any occasion (n=6571) and those with missing data on one or more covariable (n=10 021) were excluded. The final analysis sample comprised of 55056 pregnancies.

Written informed consent was obtained from each MoBa participant upon recruitment. The study was approved by The Regional Committee for Medical Research Ethics in South-Eastern Norway (reference S-97045 and S-95113). Follow-up is conducted by questionnaires at regular intervals. The present study is based on version 7 of the data files from the MoBa study made available in 2014. Data from seven different postal questionnaires were used. In questionnaire 1 (Q1) completed around gestational week 17, women provided information about lifestyle and socioeconomic factors. Questionnaire 2 (Q2) completed around gestational week 22, contained a validated FFQ. Further data on maternal weight were collected from follow-up questionnaires.

Outcome

Height and pre-pregnant weight were self-reported and collected around week 17 of pregnancy. Six additional self-reported weight measures were included in the analyses: at delivery (before giving birth), and at 6, 18, 36, 60 and 96 months post-delivery. Body mass index (BMI) (weight (kg)/height (m^2)) was calculated at each time point and used as the main outcome. We standardized height, weight and BMI using z-scores and only included values within +/- 4 SD in the analyses. From this standardization 296 out 231290 BMI observations of were removed, in total 0.1%. Since weight and BMI were not normally distributed, these variables were log-transformed before the z-scores were computed. If a mother became pregnant again, she was censored at the point of this subsequent pregnancy.

The New Nordic Diet score

The exposure of interest in the present study was degree of adherence to the New Nordic Diet (NND) as measured by a previously constructed diet score [(17)].

The rationale for, and the construction of the NND score has been thoroughly described elsewhere [(17)]. In short, the score is built from 10 subscales capturing different identities of the NND:

(1) Meal pattern (frequency of eating breakfast, lunch, dinner and evening meal), (2) Nordic fruits (frequency of eating pears, apples, plums, and strawberries), (3) root vegetables

(frequency of eating carrots, rutabaga and onions), (4) cabbages (frequency of eating kale, cauliflower, broccoli and Brussels sprouts), (5) potatoes (frequency of eating potatoes relative to rice and pasta), (6) whole grain breads (consumption of whole grain breads relative to refined breads), (7) oatmeal porridge (frequency of eating oatmeal porridge), (8) foods from the wild countryside (frequency of eating native berries, game, wild fish and seafood), (9) milk (consumption of unsweetened milk relative to fruit juice), and (10) water (consumption of water relative to all kinds of sweetened beverages).

Each subscale was constructed from one or more relevant FFQ items in the questionnaire completed by mothers around week 22. The FFQ included 255 items, covering diet during the first half of pregnancy. The frequency of consumption was given per day, per week and/or per month, depending on the food item. Predefined portion sizes were applied to bread and drinks [31]. Single missing values in the FFQ were addressed by assuming that any missing value in the FFQ was likely to reflect no intake and therefore assigned '0'[32]. Each subscale was dichotomized with the sample-specific median as cut-off. Participants were assigned a score of '1' in any given subscale if they had frequency of intake above the median. The diet score ranged from 0-10 points with higher participant score reflecting higher adherence to the NND. Participants were categorized as having 'low' (0-3 points), 'medium' (4-5 points) or 'high' (6-10 points) NND adherence. This was done in line with previous analyses with NND adherence as the exposure, where diet quality of the respective adherence categories is presented. In short, high NND adherence yields higher intakes of energy, nutrients and higher nutrient density, as well as higher intakes of fruits, vegetables, milk, wholegrain bread, fish, meat and desserts, while lower intakes of sweetened beverages, sweets and snacks [17]. Similar methods of constructing diet scores for assessing diet-disease associations have been widely reported in epidemiological studies, especially diet scores reflecting adherence to the Mediterranean diet [33].

Potential confounders & mediators

Eight covariates were selected for their known association with maternal weight gain; maternal age, parity, maternal educational level, pre-pregnant smoking, pre-pregnant physical activity level, maternal energy intake, offspring birth weight and duration of exclusive breastfeeding. From the MBRN, we obtained information on the women's age at delivery, parity and offspring birth weight. The first MoBa questionnaire provided data on maternal height, pre-pregnant weight, maternal education, pre-pregnant smoking, and pre-pregnant physical activity. Energy intake was extracted from calculations based on the MoBa FFQ answered around week 22 of pregnancy. The MoBa follow-up questionnaires at 6 and 18 months post-delivery provided data on exclusive breastfeeding duration. Detailed information about the measurement of these covariates is provided in the supplementary material.

Statistical analysis

Means (SDs), medians (IQRs) and proportions were used to describe the women included in the analyses and to compare with women who were eligible but had missing data on the exposure and/or at least one covariable.

Linear spline multi-level models with a random intercept and random slopes were used to estimate the association between NND adherence and the post-partum trajectory of maternal BMI (kg/m^2). A visualisation of the overall mean trajectory and individual trajectories suggested that knots at 6 and 18 months most closely captured the shape of the trajectory (see figure S1 in the online supplementary material). To check the robustness of our findings to this choice, we also did a sensitivity analysis using knots at 6 months and 3 years postpartum. The NND score was modelled as approximate tertiles (described above) so that non-linear associations could be explored. Using quartiles or quintiles would cause the model to have many more parameters and be very complex, tertiles were therefore used. The NND exposure was allowed to affect the intercept and all 3 slopes. Thus, the measures of association were the difference in maternal BMI at birth (in kg/m^2) and the differences in BMI velocities (kg/m^2 per year) from birth to 6 months, 6 to 18 months and 18 months to 8 years post-partum, comparing each of the medium and high NND adherence tertiles against the low NND tertiles.

Three sets of analytical models were considered: a crude model (unadjusted), a model adjusted for potential confounders (model a) and a model adjusting for both potential confounders and exclusive breastfeeding duration (model b). All covariables were also allowed to affect the intercept and slopes. Model (a) adjusted for maternal age (years), parity (nulliparous, multiparous), offspring birthweight (g), pre-pregnancy maternal smoking (none, occasional, daily), years in education of the mother (<13 years, 13-16 years, and ≥17 years), pre-pregnancy physical activity levels (regular, irregular, light, none) and energy intake (quintiles). Model (b) included the variables in model (a) and duration of exclusive breast feeding. Maternal age, offspring birthweight and breastfeeding were modelled as continuous variables, all others were modelled as categorical variables.

We also fitted a linear spline model with no explanatory variables to describe the post-partum trajectory of BMI for the so-called average woman in the cohort and a set of models including NND score with adjustment for each potential confounder in turn to understand the confounding structure of the NND score. And finally, as a secondary analysis we examined the association between NND score and trajectories of overweight or obesity using mixed logit models.

All statistical analyses were conducted in Stata (v14) and plots of the marginal means in each NND category were produced using R (v3.3.3).

Results

Sample description

Table 1 describes the analysis sample along with a comparison versus those who were eligible but not included in the analyses due to missing data. With respect to those included in the analysis sample, the median age at delivery was 30 years. The median BMI was 28.6 kg/m^2 at delivery and 24 kg/m^2 8 years post-delivery, and at 8 years 39.6% of the mothers were classified as overweight/obese. The median NND score was 5.0. Seventy percent had received a higher education, 46% had one or more than one previous children and 73% were non-smokers pre-pregnancy. Fifty percent reported regular physical activity before getting pregnant and 28.7% reported that they exclusively breastfed the child 4 months postpartum. Those excluded due to missing data had on average slightly higher BMI, less years of education, higher energy intake and were more likely to be multiparous, less active, and not having initiated breastfeeding.

Association between maternal NND score and covariables.

Table 2 shows the associations between the covariables and the NND adherence tertiles. All potential confounders were unevenly distributed according to NND adherence. Participants with higher adherence to the NND were on average older and more physically active and had higher energy intakes. Those with higher NND adherence were also more likely to have received more years of education, be multiparous and non-smokers, and exclusively breastfeed for more than 4 months. Babies born to mothers in the highest NND tertile were also more likely to be heavier.

Postpartum BMI trajectories and its association with maternal NND adherence

The post-partum BMI trajectory for the so-called average woman in the cohort was characterised by a loss of approximately 5 kg/m^2 over the first 6 months followed by a gradual gain of 0.01 kg/m^2 per year up to 18 months and slightly elevated gains of 0.1 kg/m^2 per year up to 8 years (full results available on request).

Table 3 shows the association between maternal NND adherence during pregnancy and maternal BMI at birth and changes in BMI in intervals up to 8 years postpartum. These results are visualised in figure 2 which plots the marginal mean trajectory of BMI at birth, 6 months, 18 months and 8 years postpartum for each NND category. In the unadjusted model there was a strong linear relationship between NND adherence and BMI at birth, with lower BMI among higher NND adherers. On average, women in the highest NND adherence tertile had a BMI 0.6 kg/m^2 lower at birth compared to those in the lowest tertile. This association was attenuated by approximately a half to -0.32 kg/m^2 after adjustment for confounders (model a) and attenuated further to -0.25 kg/m^2 after adjustment for exclusive breastfeeding duration (model b) but the evidence was still strong.

There was some evidence that the highest adherers to NND had faster weight loss in the first 6 months following birth and lower weight gain thereafter to 8 years, although these associations were small as shown by the parallel slopes in figure 2. After adjustment for confounders, only the slopes from 6 to 18 months and 18 months to 8 years postpartum in the highest adherers showed any evidence of a difference from the lowest adherers, but again, the strength of association was small - a difference of only -0.04 kg/m^2 per year and -0.02 kg/m^2 per year for the 6-18 months and 18 months - 8 year interval respectively.

Separate plots of the predicted mean post-partum BMI trajectory for each category of NND adherence adjusted for each confounder one at a time are given in the online supplementary material (Figure S2). The covariables that most attenuated the relationship between NND and post-partum BMI were maternal education and breastfeeding duration, although each only [(14)] attenuated the association to a small extent. As expected given the positive association between energy intake and NND, adjusting for energy intake slightly intensified the association.

Sensitivity analysis

The results were broadly similar to the main analyses in models that used different knot points at 6 month and 3 years (see Table S1 and figure S3 in the online supplementary material). Likewise, excluding the preterm births from the analysis sample did not alter the general findings (see Table S2 and figure S4 in the online supplementary material).

Secondary analysis: NND score and trajectories of overweight or obesity

Due to non-convergence problems with estimation it was only possible to fit a model with a single knot at 6 months in the secondary analysis of overweight/ obese trajectories. Differences between NND tertiles in the proportion overweight or obese participants were not present at birth where the prevalence was, as expected high (~70%) but emerged at 6 months postpartum and widened slightly through to 8 years (see figure S5 in online supplementary material). The overall patterns were thus similar to those for BMI from 6 months.

Discussion

Our study showed that women with higher adherence to the New Nordic dietary pattern during pregnancy had on average lower post-partum BMI trajectories and slightly less weight gain up to 96 months post-delivery. These associations were independent of a range of confounders, and were not explained by differences in energy intake or mediated by exclusive breastfeeding duration. Similar patterns of associations were seen with trajectories of overweight as the outcome.

Our results extend Von Ruesten et al.'s findings in the same cohort, which reported that higher adherence to the Nordic food-based dietary guidelines was associated with lower maternal weight retention at six months postpartum [(14)]. Few studies [(11;14)] have investigated diet in pregnancy in relation to long-term maternal weight development. Kirkegaard et al. found that healthy dietary behaviours during pregnancy in the Danish National birth cohort was associated with lower weight gain seven years later [(11)]. Three distinct dietary patterns were described in this Danish cohort; a Western dietary pattern high in fat dairy and red meat, a health-conscious dietary pattern with high consumption of fruits and vegetables, and an intermediate dietary pattern comprising women with intakes of foods from the other two dietary patterns in a balanced way [(34)]. Women with the intermediate dietary pattern in the Danish cohort has previously been described as the ones with the most varied diet [(34)], and seems to have a diet quality that resembles that of the women with high NND adherence in our sample [17;34]. Women with health-conscious and intermediate during pregnancy had gained less weight seven years later than women consuming a Western diet [34]. Interestingly, both Von Ruesten et al. and Knudsen et al. adjusted for pre-pregnancy BMI in their analysis. Kramer et al. (2016) recommend not adjusting for earlier measures of the outcome when the exposure also affects the outcome at the earlier age [35]. In an expository analysis, they show how such an adjustment results in a systematic underestimate of the effect of the exposure, in our case the NND score, since it appears twice on the right-hand side of the regression equation [35]. In line with this, we decided not to adjust for maternal pre-pregnancy BMI because it could be considered an over- adjustment. However, to enable a comparison with these two studies, we estimated an additional model with adjustment for pre-pregnancy BMI – see results in online supplementary material (figure S6, table S3 and S4). For a woman of average stature in our dataset, this equated to a difference between high and low NND adherers of -0.1 kg at 6 months and -0.6 kg at 8 years post-partum. These associations are of similar magnitude to those described by Kirkegaard et al. and Von Ruesten et al. [11;14]. Without adjusting for pre-pregnancy BMI, these differences equated to -1.04 kg and -1.48 kg at 6 month and 8 years, respectively. Similar over-adjustment arguments apply when considering controlling for gestational weight gain. Nonetheless, we did a sensitivity analysis adjusting for gestational weight gain (figure S7, table S5) and it did not influence the associations we report in this paper.

A few observational studies in non-pregnant populations have assessed cross-sectional associations between adherence to various Nordic diets and measures of weight or adiposity. The National FINRISK Study found that higher adherence to the National Finnish Dietary guidelines was associated with lower body fat in normal weight women and less abdominal fat in men [22]. In the same population, higher adherence to the Baltic Sea Diet was associated with lower abdominal obesity in men. A similar trend was observed in women, although not significant [24].

Possible explanations for the more beneficial weight development with higher NND adherence could be a higher satiety potential of the diet, favourable gut microbial profile [36] due to the diet composition, and a healthier regulation of hunger and satiety [21]. The NND is characterized by high intakes of whole grain, vegetables and fruits, and low intake of sugar and sugar-sweetened beverages, all of which have been found to be associated with reduced long-term weight gain [37;38]. A healthy Nordic diet in the NORDIET study was associated with high satiation [20]. In the FINRISK study, high consumption of fruit and low consumption of sugar were the most important contributors to low body fat in women [22]. High intake of vegetables and rye [22] as well as other cereals [23] contributed most to the prevention of abdominal obesity in men. These benefits might partly be explained by the high content of fibre and for women, low content of sugar in the Finnish diets [23]. Animal models suggest that ingestion of carbohydrates high in fibre might regulate appetite and energy homeostasis through a number of mechanisms by which colonic short chain fatty acids are one of the modulators [39]. High adherence to the NND in our dataset also implied higher consumption of milk and higher consumption of milk relative to fruit juice [17]. In several prospective studies fruit juices [37;40] as opposed to milk [37;41;42] are reported to be positively associated with weight gain. Furthermore, in the present study women with high as compared to low NND adherence had a lower intake of sugar-sweetened beverages, which has consistently been linked to weight gain [37;43].

Strengths to this study are the large population included, the robust dietary data from validated food frequency questionnaires, birth outcomes from the MBRN, and the statistical methods that maximises the sample size by including all women with at least one measure of BMI and are unbiased under the assumption that the data are missing at random. Further our sensitivity analyses showed that the results were robust to the way the form of the trajectory was modelled.

There are several limitations. Although we adjusted for a range of confounders, residual or unmeasured confounding is likely. Random measurement error from misreporting of diet would lead to misclassification of NND adherence and may have biased the associations towards the null. However, the results could also be biased in the other direction through response bias of self-reported diet, weight and height among less healthy and more overweight groups. In addition, other aspects of life may have influenced the participants' weight trajectories during the eight-year time-span that were not accounted for in this study. For example, we only adjusted for pre-pregnancy physical activity at one time-point, this is unlikely to fully capture an individual's activity during pregnancy and beyond. The participation rate of around 40% in the MoBa study could be a concern regarding generalizability. MoBa participants have been shown to be older, more often cohabiting, highly educated, non-immigrant, non-smoking, and parous compared with the general pregnant population in Norway [28]. Nilsen et al. (2009) previously documented biased prevalence data for some pregnancy conditions in the MoBa cohort, but documented in the paper unbiased diet-outcome associations [28]. This documented self-selection could imply a healthier study sample with potentially less variation in postpartum weight development as well as less variation in diet than in the background population. The way we have internally constructed the NND score, could make it difficult to reproduce findings in other cohorts, because the cut-offs for scoring are sample-specific. Lastly, NND adherence was assessed in mid-pregnancy in this study, but most likely reflects longer-term preconception diet as well, as dietary patterns tend to track [44]. Future studies should include prospective dietary information assessed before pregnancy to reveal potential time-associated vulnerability during adolescence, preconception, pregnancy or postpartum regarding the association between diet quality and long-term weight development.

In conclusion, our findings suggest that the New Nordic Diet may have beneficial properties to long term weight regulation among women postpartum. In order to understand whether it is a useful target for public health intervention, further research is needed to understand the correlates of this dietary pattern and the mechanisms that may underlie the associations reported here.

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Authorship: ERH, EB and NCØ conceived the project and designed the present study; ALB was involved in the development and calculations of the MoBa food frequency questionnaire; ERH, MS and NCØ prepared the dataset, AKW designed and performed all statistical analyses and drafted the results. MS and NCØ drafted the rest of the manuscript. All authors read and approved the final version.

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Table 1 Description of study sample and comparison with those eligible but not included in the analysis due to missing data

		Included in analysis (observed)		Others from eligible the MoBa cohort		
		N	**Median (IQR) or n (%)**	**N**	**Median (IQR) or n (%)**	**P**
Maternal exposure & outcomes						
NND score		55056	5.0 (3.0, 6.0)	16592	5.0 (3.0, 6.0)	<0.001
BMI at birth	kg/m^2	53075	28.6 (26.1, 31.6)	7377	28.9 (26.4, 32.0)	<0.001
BMI at 6 months	kg/m^2	53498	23.5 (21.3, 26.5)	7384	23.9 (21.5, 26.9)	<0.001
BMI at 18 months	kg/m^2	37600	23.4 (21.3, 26.4)	6186	23.7 (21.5, 26.8)	<0.001
BMI at 3 years	kg/m^2	28396	23.6 (21.5, 26.6)	4684	23.9 (21.6, 27.1)	<0.001
BMI at 5 years	kg/m^2	16457	23.7 (21.6, 26.6)	2913	24.0 (21.7, 27.0)	0.003
BMI at 8 years	kg/m^2	11437	24.0 (21.9, 27.0)	1982	24.2 (22.0, 27.3)	0.037
Overweight at birth	>25 kg/m^2	53075	45248 (85.3%)	7377	45248 (86.7%)	0.001
Overweight at 6 months	>25 kg/m^2	53498	19156 (35.8%)	7384	19156 (38.9%)	<0.001
Overweight at 18 months	>25 kg/m^2	37600	13223 (35.2%)	6186	13223 (37.1%)	0.003
Overweight at 3 years	>25 kg/m^2	28396	10301 (36.3%)	4684	10301 (39.7%)	<0.001
Overweight at 5 years	>25 kg/m^2	16457	5975 (36.3%)	2913	5975 (38.9%)	0.008
Overweight at 8 years	>25 kg/m^2	11437	4531 (39.6%)	1982	4531 (42.8%)	0.007
Covariables						
Age	years	55056	30.0 (27.0, 33.0)	16592	30.0 (26.0, 33.0)	<0.001
BMI before pregnancy	kg/m^2	55056	23.1 (21.1, 25.8)	14814	23.2 (21.1, 26.2)	<0.001
	≤12y		16088 (29.2%)		6244 (41.4%)	
Education (n, %)	13 to 16 years	55056	24088 (43.8%)	15070	5669 (37.6%)	<0.001
	≥17 years		14880 (27.0)		3157 (21.0%)	
Parity (n, %)	≥1	55056	25305 (46.0%)	16592	25305 (52.2%)	<0.001
Smoked before pregnancy (n, %)	No		39950 (72.6%)		10490 (65.7%)	
	Occasionally	55056	5626 (10.2%)	15963	1784 (11.2%)	<0.001
	Daily		9480 (17.2%)		3689 (23.1%)	
Activity before pregnancy	None		3177 (5.8%)		1175 (8.3%)	
	Light	55056	7683 (14.0%)	13115	2031 (14.4%)	<0.001
	Irregular		16200 (29.4%)		4020 (28.5%)	
	Regular		27996 (50.9%)		6861 (48.7%)	
Energy intake	Kj	55056	9329 (7894, 11099)	16592	9446 (7849, 11355)	<0.001
Offspring birthweight	kg	55056	3600 (3270, 3932)	16559	3595 (3260, 3940)	0.049
Exclusive breast feeding duration	Not intiated		7271 (13.2%)		790 (15.2%)	
	1 month		3264 (5.9%)		317 (6.1%)	
	2 months		4900 (8.9%)		560 (10.8%)	
	3 months	56028	14902 (27.1%)	4227	1450 (27.9%)	<0.001
	4 months		15781 (28.7%)		1280 (24.6%)	
	5 months		7952 (14.4%)		716 (13.8%)	
	6 months		986 (1.8%)		86 (1.7%)	

IQR: Interquartile range

Table 2. Associations between each potential confounder/ mediator and NND score.

		NND group			
		Tertile 1 (lowest)	Tertile 2 (middle)	Tertile 3 (highest)	p-value*
Age (mean)	years	29.2	30	30.8	<0.001†
Education (n, %)	≤12y	5157 (35.2%)	5948 (29.9%)	5363 (25.0%)	
	13 to 16 years	6191 (42.2%)	8668 (43.6%)	9604 (44.7%)	<0.001
	≥17 years	3307 (22.6%)	5277 (26.5%)	6513 (30.3%)	
Parity (n, %)	0	8709 (54.3%)	11010 (55.4%)	10478 (48.8%)	
	≥1	5946 (40.6%)	8883 (44.7%)	11002 (51.2%)	<0.001
Smoked before pregnancy (n, %)	No	9909 (67.6%)	14322 (72%)	16392 (76.3%)	
	Occasionally	1473 (10.1%)	2051 (10.3%	2196 (10.2%)	<0.001
	Daily	3273 (22.3%)	3520 (17.7%)	2892 (13.5%)	
Activity before pregnancy (n, %)	None	1492 (10.2%)	1134 (5.7%)	641 (3.0%)	
	Light	2750 (18.8%)	2899 (14.6%)	2178 (10.1%)	<0.001
	Irregular	4499 (30.7%)	5994 (30.1%)	5975 (27.8%)	
	Regular	5914 (40.4%)	9866 (49.6%)	12686 (59.1%)	
Energy intake (mean)	kj	8978	9530	10280	<0.001†
Offspring birthweight (mean)	kg	3563	3584	3609	<0.001†
Exclusive breast feeding duration (mean)	0 months	2347 (16.0%)	2667 (13.4%)	2413 (11.2%)	
	1 month	1088 (7.4%)	1197 (6.0%)	1027 (4.8%)	
	2 months	1541 (10.5%)	1790 (9.0%)	1652 (7.7%)	
	3 months	4039 (27.6%)	5485 (27.6%)	5637 (26.2%)	
	4 months	3744 (25.6%)	5643 (28.4%)	6656 (31%)	<0.001
	5 months	1663 (11.4%)	2778 (14.0%)	3661 (17.0%)	
	6 months	233 (1.6%)	333 (1.7%)	434 (2.0%)	

NND: New Nordic Diet. *Chi-squared test unless indicated

† F-test

Table 3. Associations between NND and post-partum BMI*

		Crude		Model (a)		Model (b)	
		β (95% CI)	p	β (95% CI)	p	β (95% CI)	p
At birth ($kg.m^2$)	NND lowest tertile	Ref		Ref		Ref	
	NND middle tertile	-0.29 (-0.38, -0.20)	<0.001	-0.13 (-0.22, -0.04)	0.003	-0.01 (-0.18, -0.01)	0.033
	NND highest tertile	-0.63 (-0.72, -0.54)	<0.001	-0.32 (-0.41, -0.22)	<0.001	-0.25 (-0.34, -0.16)	<0.001
0 to 6m ($kg.m^2$ per year)	NND lowest tertile	Ref		Ref		Ref	
	NND middle tertile	-0.10 (-0.18, -0.01)	0.026	-0.10 (-0.18, -0.01)	0.024	-0.07 (-0.15, 0.02)	0.12
	NND highest tertile	-0.10 (-0.18, -0.02)	0.019	-0.10 (-0.19, 0.01)	0.023	-0.04 (-0.13, 0.04)	0.32
6 to 18m ($kg.m^2$ per year)	NND lowest tertile	Ref		Ref		Ref	
	NND middle tertile	-0.01 (-0.06, 0.03)	0.5	-0.00 (-0.05, 0.04)	0.8	-0.02 (-0.06, 0.03)	0.47
	NND highest tertile	-0.05 (-0.10, -0.01)	0.011	-0.02 (-0.07, 0.02)	0.33	-0.04 (-0.09, 0.00)	0.051
18 to 96m ($kg.m^2$ per year)	NND lowest tertile	Ref		Ref		Ref	
	NND middle tertile	-0.01 (-0.02, 0.01)	0.27	-0.01 (-0.02, 0.01)	0.37	-0.01 (-0.02, 0.01)	0.30
	NND highest tertile	-0.02 (-0.04, -0.01)	0.002	-0.02 (-0.03, -0.01)	0.006	-0.02 (-0.04, -0.01)	0.003

NND: New Nordic Diet, BMI: Body Mass Index
*From the main analysis using knots at 6 and 18m & complete cases (N=55056)
Model a: adjusted for maternal age, parity, education, pre-pregnant smoking, physical activity, energy intake and offspring birthweight
Model b: model a + exclusive breast feeding duration.