Maternal Prepregnancy BMI and Risk of Cerebral Palsy in Offspring

Ingeborg Forthun, M.Econ,[a,b] Allen J Wilcox, MD, PhD,[c] Katrine Strandberg-Larsen, PhD,[d] Dag Moster, MD, PhD,[a,b,e] Ellen A Nohr, PhD,[f] Rolv Terje Lie, PhD,[a] Pål Surén, MD, PhD,[e] Mette C Tollånes, MD, PhD[a,e]

abstract

OBJECTIVES: To investigate the association between maternal pre-pregnancy BMI and risk of cerebral palsy (CP) in offspring.

METHODS: The study population consisted of 188 788 children in the Mothers and Babies in Norway and Denmark CP study, using data from 2 population-based, prospective birth cohorts: the Norwegian Mother and Child Cohort Study and the Danish National Birth Cohort. Prepregnancy BMI was classified as underweight (BMI <18.5), lower normal weight (BMI 18.5–22.9), upper normal weight (BMI 23.0–24.9), overweight (BMI 25.0–29.9), and obese (BMI ≥30). CP diagnoses were obtained from the national CP registries. Associations between maternal prepregnancy BMI and CP in offspring were investigated by using log-binomial regression models.

RESULTS: The 2 cohorts had 390 eligible cases of CP (2.1 per 1000 live-born children). Compared with mothers in the lower normal weight group, mothers in the upper normal group had a 40% excess risk of having a child with CP (relative risk [RR], 1.35; 95% confidence interval [CI], 1.03–1.78). Excess risk was 60% (RR, 1.56; 95% CI, 1.21–2.01) for overweight mothers and 60% (RR, 1.55; 95% CI 1.11–2.18) for obese mothers. The risk of CP increased ∼4% for each unit increase in BMI (RR, 1.04; 95% CI, 1.02–1.06). Estimates changed little with adjustment for mother's occupational status, age, and smoking habits.

CONCLUSIONS: Higher prepregnancy maternal BMI was associated with increased risk of CP in offspring.

[a]Department of Global Public Health and Primary Care, University of Bergen, Bergen, Norway; [b]Department of Pediatrics, Haukeland University Hospital, Bergen, Norway; [c]Epidemiology Branch, National Institute of Environmental Health Sciences, National Institutes of Health, Durham, North Carolina; [d]Section of Social Medicine, Department of Public Health, University of Copenhagen, Copenhagen, Denmark; [e]Norwegian Institute of Public Health, Oslo, Norway; and [f]Research Unit for Gynaecology and Obstetrics, Institute of Clinical Research, University of Southern Denmark, Odense, Denmark

Ms Forthun was responsible for the analysis and interpretation of data, and the drafting of the manuscript; Dr Wilcox participated in the analysis and interpretation of data and reviewed and revised the manuscript; Drs Lie and Moster provided advice regarding study design, participated in the interpretation of data, and reviewed and revised the manuscript; Drs Strandberg-Larsen, Nohr, and Surén participated in the interpretation of data and reviewed and revised the manuscript; Dr Tollånes proposed the study, participated in the analysis and interpretation of data, and reviewed and revised the manuscript; and all authors approved the final manuscript as submitted.

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Address correspondence to Ingeborg Forthun, M.Econ, Department of Global Public Health and Primary Care, University of Bergen, P.B. 7804, 5020 Bergen, Norway. E-mail: ingeborg.forthun@uib.no

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WHAT'S KNOWN ON THIS SUBJECT: Cerebral palsy (CP) is the most common physical disability in childhood, but little is known about its underlying causes. Several prenatal risk factors for CP have been identified including maternal infection, diseases, and nutritional deficiencies, suggesting that maternal factors may be important.

WHAT THIS STUDY ADDS: Our study suggests that the risk of CP in offspring increases with maternal prepregnancy BMI.

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Cerebral palsy (CP) is a group of disorders characterized by disturbances in motor function caused by a nonprogressive lesion of the fetal or infant brain, often accompanied by visual and hearing impairment, learning disabilities, or epilepsy.[1] CP affects around 2 per 1000 children and is the most common cause of physical disability in childhood.[2] CP may be divided into subtypes that differ in severity, type of motor impairment, and possibly etiology. Preterm birth and intrauterine growth restriction are strongly associated with CP, but it is not clear if they are causal factors or not.[3] Several other prenatal risk factors including maternal infection, diseases, and nutritional deficiencies have also been identified, indicating that maternal conditions may be important.[4,5]

The prevalence of overweight and obesity among pregnant women is increasing worldwide with adverse effects on maternal and child health.[6] Obese pregnant women (BMI >29.9) have increased risk of gestational diabetes, hypertension, and preeclampsia, and their offspring are at increased risk of preterm birth, macrosomia, complications during delivery, and perinatal death.[6–9] Maternal obesity is also associated with birth defects, in particular neural tube defects.[10] We used pooled data from 2 large prospective Nordic birth cohorts to investigate the association between BMI before pregnancy and risk of CP in offspring, both overall and for various subtypes of CP.

METHODS

Study Population

The study is based on data from the Mothers and Babies in Norway and Denmark (MOBAND CP) cohort of 211 010 births. MOBAND CP comprises harmonized data from 2 population-based, prospective birth cohorts: the Norwegian Mother and Child Cohort Study (MoBa)[11] and the Danish National Birth Cohort (DNBC).[12] In the DNBC, 100 417 pregnant women were recruited by their general practitioner nationwide at the first pregnancy visit in the period from 1996 to 2002. In MoBa, 112 509 pregnant women, in the period from 1999 to 2008, were recruited when invited to the first ultrasound examination of the fetus at around pregnancy week 17 to 18. The recruitment was nationwide and included 50 of 52 hospitals with maternity units. Information was collected at the same time during pregnancy in both cohorts, although in Denmark, telephone interviews were used whereas in Norway, information was collected by postal questionnaires. We used data from the first interview/questionnaire at around pregnancy week 17, with supplemental Danish data from the fourth interview 18 months after birth for selected variables. Data from the DNBC were linked to the Danish Medical Birth Registry,[13] and data from MoBa were linked to the Norwegian Medical Birth Registry.[14] We identified cases of CP by linkage to the Danish Cerebral Palsy Registry[15] and the Norwegian Cerebral Palsy Registry.[16] The Danish Cerebral Palsy Registry is regarded as complete for the birth cohort in the DNBC, whereas the Norwegian CP registry is not complete for MoBa. To identify the missing cases, the Norwegian cohort was linked to the Norwegian Patient Registry (NPR). The NPR comprises data from all hospitals and outpatient clinics, including all institutions that diagnose children with CP.[17] Diagnoses of CP in the registry were validated through medical record review by 2 pediatric neurologists.[18] The maximum follow-up time in the Norwegian cohort was 6 to 16 years, whereas in Denmark, the maximum follow-up time was 9 to 15 years. Only nonacquired cases were included in the study. Variables were harmonized through discussions and revisions by both Danish and Norwegian collaborators.

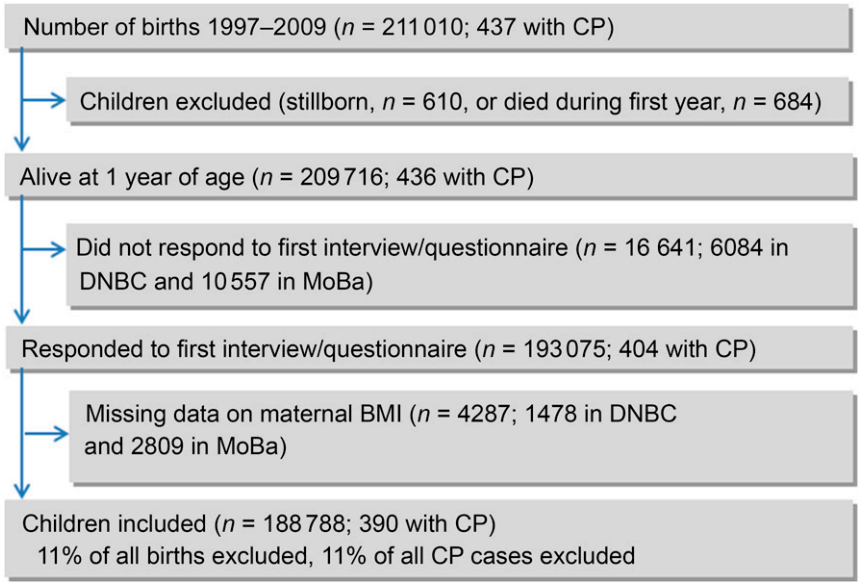

FIGURE 1
Selection of study sample.

In the study population of 211 010 births, we excluded all stillbirths, all children who died before 1 year of age (as these are not included in the CP registries), and those with missing information on maternal BMI (Fig 1).

Maternal Prepregnancy BMI

Maternal BMI (kg/m^2) was estimated from self-reported prepregnancy weight and height in the first interview/questionnaire and included either as a continuous or categorized variable in the models. BMI was categorized according to the World Health Organization's guidelines as underweight (BMI <18.5), lower normal weight (BMI 18.5–22.9), upper normal weight (BMI 23.0–24.9), overweight (BMI 25–29.9) and obese (BMI ≥30).[19]

CP

CP overall and the main subtypes of CP were used as outcomes in the analyses. Subtypes of CP were classified as spastic unilateral, spastic bilateral, dyskinetic, and ataxic according to the classification used by the Surveillance of Cerebral Palsy in Europe.[1]

Covariates

We assessed potential confounding by exploring the following covariates: maternal socioeconomic status, smoking, age, physical activity, and paternal BMI. Socioeconomic status was based on available information on occupational status given in the first interview/questionnaire around pregnancy week 17. Level of education is generally considered a more valid proxy of socioeconomic status than occupational status.[20] Information on years of completed education reported in the first questionnaire was available in the Norwegian cohort. In the Danish cohort, however, women were not asked about education until the interview conducted when the child was 18 months old, and only about 70% responded to this interview. Therefore, we used information on education from the Norwegian cohort only in the sensitivity analyses, whereas in the main analyses, socioeconomic status was based on occupational status. Women were classified as employed, unemployed, student, or receiving benefits or pension. Maternal smoking was based on number of cigarettes per day reported in the first interview/questionnaire, categorized as 0, 1 to 9, and ≥10 cigarettes per day, and thereby reflect the amount of smoking at the time of the interview/filling in the questionnaire. Maternal age was categorized as <20, 20 to 24, 25 to 29, 30 to 34, 35 to 39, and ≥40 years. Paternal BMI was reported by mothers in the first questionnaire in the Norwegian cohort (prepregnancy BMI) and in the fourth interview (18 months after birth) in the Danish cohort and was categorized in the same way as maternal BMI. Information on physical activity in the first part of pregnancy was retrieved from the first interview/questionnaire. Recreational physical activity included brisk walking, running/jogging/orienteering, bicycling, training studio/weight training, aerobics, dancing, skiing, ball sports, swimming, and riding. Being physically active was defined as taking part in physical activity at least once a week.

Factors that are associated with CP, but which may be consequences of the brain injury rather than causes of it (preterm birth and conditions of the newborn) were not adjusted for. In addition, we did not adjust for risk factors potentially on the causal pathway between prepregnancy BMI and CP (mediators), such as preeclampsia and diabetes, because this may result in "collider bias."[21]

Statistical Analyses

Differences in proportions between the cohorts were tested by using χ^2 tests. The prevalence of CP was calculated overall, within each group of BMI, and within deciles of BMI. We estimated crude relative risks (RR) of CP from log-binomial regression models with corresponding 95% confidence interval (CI). BMI was included either as a continuous (including 1 decimal) or categorized variable. In the subtype analyses, each subtype was coded as a binary outcome, with children not diagnosed with CP as controls. To account for possible dependency among births by the same mother, we used robust SEs that allowed for within-mother clustering. We investigated whether the effect of BMI and physical activity on the risk of CP differed between the Danish and Norwegian cohorts by including an interaction term in the models. Analyses were performed by using Intercooled Stata, version 12.1 (Stata Corp, College Station, TX).

Written informed consent was obtained from all participating mothers in MoBa and DNBC at the time of enrollment, and licenses from the national data protecting agencies were obtained. Linkage of MoBa with the National CP registry of Norway and the NPR was additionally approved by Regional Committees for Medical and Health Research Ethics South-East, Norway (2012/1738). The DNBC has been approved by the Danish Committee on Biomedical Research Ethics (case no. [KF] 01-471/94).

RESULTS

Among the 188 788 children included in the total study cohort, we identified 390 with CP (2.1 per 1000 children): 177 cases from DNBC (2.0 per 1000 children) and 213 cases from MoBa (2.2 per 1000 children) (P = .5). About 21% of the children had mothers who were overweight, and 9% had mothers who were obese before pregnancy (Table 1). In both cohorts, obese women were more likely to be unemployed or receive benefits or pension and to smoke during pregnancy, and were less likely to be physically active than normal weight women (Table 1). The proportion of obese fathers increased with increasing maternal BMI. Overall, Danish women were more likely to smoke or receive benefits

or pensions than Norwegian women (Supplemental Table 4).

The prevalence of CP increased steadily with maternal BMI, ranging from 1.4 per 1000 children in the first decile (BMI, 13.2–19.4) to 2.5 per 1000 children in the 10th decile (BMI, 29.4–64.4). This increase was seen within each cohort separately (Fig 2). The prevalences of CP were statistically significantly different between the cohorts in only the 10th decile (1.6 per 1000 children in DNBC and 3.3 per 1000 children in MoBa (P = .02). We therefore pooled the 2 cohorts for the main analyses.

When considering BMI as a continuous variable, the risk of CP increased by ~4% for each unit increase in BMI (RR, 1.04; 95% CI,

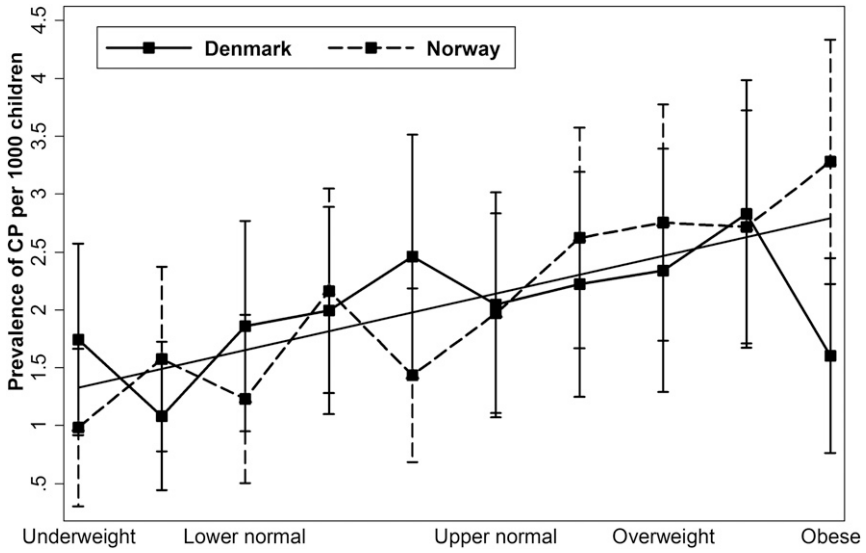

FIGURE 2
Prevalence of CP per 1000 children by deciles of BMI and cohort (the solid black line is the linear prediction in the pooled cohort).

TABLE 1 Maternal Characteristics by Prepregnancy BMI

Prepregnancy BMI	<18.5 (n = 6914)	18.5–22.9 (n = 88 696)	23.0–24.9 (n = 36 451)	25–29.9 (n = 39 674)	≥30 (n = 17 053)	Total (n = 188 788)
Maternal occupational status, n (%)						
Employed	4807 (69.5)	69 797 (78.7)	29 251 (80.3)	31 346 (79.0)	12 818 (75.2)	148 019 (78.4)
Unemployed	745 (10.8)	5778 (6.5)	2415 (6.6)	3202 (8.1)	1814 (10.6)	13 954 (7.4)
Student	1074 (15.5)	11 334 (12.8)	3996 (11.0)	4051 (10.2)	1672 (9.8)	22 127 (11.7)
Receiving benefits or pensions	204 (3.0)	945 (1.1)	416 (1.1)	636 (1.6)	508 (3.0)	2709 (1.4)
Missing data	84 (1.2)	842 (1.0)	373 (1.0)	439 (1.1)	241 (1.4)	1979 (1.1)
Maternal age (y), n (%)						
<20	181 (2.6)	739 (0.8)	226 (0.6)	230 (0.6)	110 (0.7)	1486 (0.8)
20–24	1050 (15.2)	7813 (8.8)	3157 (8.7)	3774 (9.5)	1890 (11.1)	17 684 (9.4)
25–29	2627 (38.0)	31 467 (35.5)	12 713 (34.9)	13 966 (35.2)	6039 (35.4)	66 812 (35.4)
30–34	2208 (31.9)	34 429 (38.8)	14 171 (38.9)	14 977 (37.8)	6203 (36.4)	71 988 (38.1)
35–39	762 (11.0)	12 683 (14.3)	5516 (15.1)	5933 (15.0)	2489 (14.6)	27 383 (14.5)
≥40	86 (1.2)	1565 (1.8)	668 (1.8)	794 (2.0)	322 (1.9)	3435 (1.8)
Maternal smoking (cigarettes per day), n (%)						
0	5393 (78.0)	78 307 (88.3)	32 346 (88.7)	34 637 (87.3)	14 513 (85.1)	165 196 (87.5)
1–9	878 (12.7)	6476 (7.3)	2534 (7.0)	2930 (7.4)	1419 (8.3)	14 273 (7.5)
≥10	611 (8.8)	3519 (4.0)	1402 (3.9)	1913 (4.8)	1049 (6.2)	8494 (4.5)
Missing data	32 (0.5)	394 (0.4)	169 (0.5)	194 (0.5)	72 (0.4)	861 (0.5)
Paternal BMI[a], n (%)						
<18.5	38 (0.6)	219 (0.3)	73 (0.2)	89 (0.2)	48 (0.3)	467 (0.3)
18.5–22.9	1487 (21.5)	16 315 (18.4)	5478 (15.0)	5146 (13.0)	1903 (11.2)	30 329 (16.1)
23.0–24.9	1628 (23.6)	22 961 (25.9)	8783 (24.1)	8014 (20.2)	2627 (15.4)	44 013 (23.3)
25–29.9	1966 (28.4)	29 692 (33.5)	13 876 (38.1)	15 974 (40.3)	6374 (37.4)	67 882 (36.0)
≥30	295 (4.3)	3993 (4.5)	2462 (6.8)	4081 (10.3)	3228 (18.9)	14 059 (7.5)
Missing data	1500 (21.7)	15 516 (17.5)	5779 (15.9)	6370 (16.1)	2873 (16.9)	32 038 (17.0)
Maternal physical activity[b], n (%)						
No	4073 (58.9)	45 190 (51.0)	19 257 (52.8)	22 329 (56.3)	10 458 (61.3)	101 307 (53.7)
Yes	2736 (39.6)	42 123 (47.5)	16 520 (45.3)	16 560 (41.7)	6189 (36.3)	84 128 (44.6)
Missing data	105 (1.5)	1383 (1.6)	674 (1.9)	785 (2.0)	406 (2.4)	3353 (1.8)

[a] Paternal BMI reported by the mother in the first questionnaire in pregnancy week 17 in MoBa and in the interview that took place 6 mo after birth in DNBC.
[b] Physical activity defined as doing recreational physical activity at least once a week in the first part of pregnancy.

TABLE 2 Prevalence and RR of CP by Prepregnancy BMI

Maternal BMI	Total Study Sample, *n* (%)	With CP, *n* (per 1000 Children)	RR (95% CI)	
			Crude	Adjusted[a]
Per unit BMI increase	—	—	1.04 (1.02–1.06)	1.04 (1.02–1.06)
<18.5	6914 (3.7)	11 (1.6)	0.96 (0.52–1.77)	0.91 (0.50–1.67)
18.5–22.9	88 696 (47.0)	147 (1.7)	1.00 (Ref)	1.00 (Ref)
23.0–24.9	36 451 (19.3)	83 (2.3)	1.37 (1.05–1.80)	1.35 (1.03–1.78)
25.0–29.9	39 674 (21.0)	103 (2.6)	1.57 (1.22–2.02)	1.56 (1.21–2.01)
≥30	17 053 (9.0)	46 (2.7)	1.63 (1.17–2.27)	1.55 (1.11–2.18)

Total study sample in adjusted analysis, *n* = 185 985; 386 with CP. Ref, reference category. —, not applicable.
[a] Adjusted for maternal occupational status, smoking in the first part of pregnancy and age.

1.02–1.06). Mothers with upper normal BMI had a 40% excess risk of having a child with CP (RR, 1.35; 95% CI, 1.03–1.78) compared with women in the lower normal BMI group (Table 2). Excess risks were ~60% for both overweight and obese mothers (RR, 1.56; 95% CI, 1.21–2.01 and RR, 1.55; 95% CI, 1.11–2.18, respectively). Adjusting for maternal occupational status, smoking habits in the first part of pregnancy and maternal age at birth hardly affected the results (Table 2). Among obese women, a difference was observed between the cohorts. Although no significant excess risk of having a child with CP was observed among obese Danish women (RR, 0.78; 95% CI, 0.42–1.48), in Norway, obesity was associated with a 130% excess risk (RR, 2.32; 95% CI, 1.53–3.50) (*P* = .008) (Supplemental Table 5).

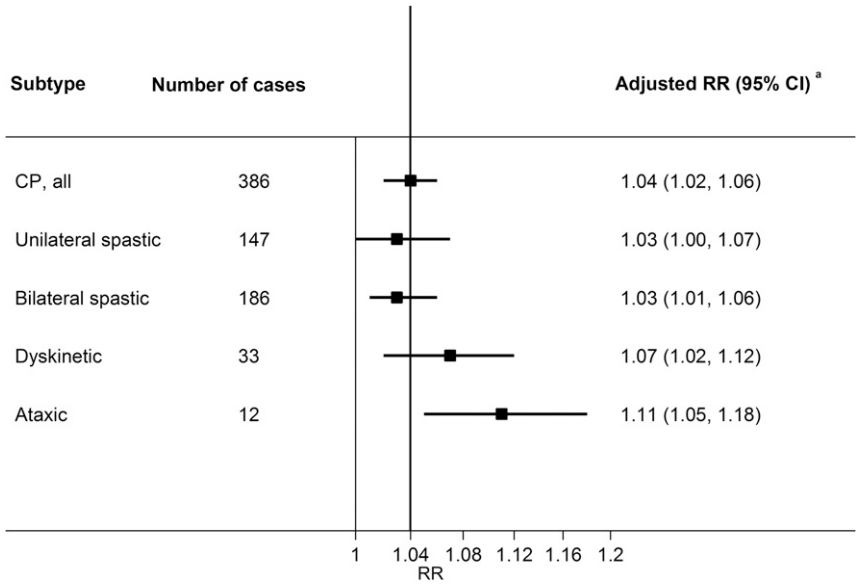

FIGURE 3
Adjusted RR of CP subtypes by maternal prepregnancy BMI. [a]Adjusted for maternal occupational status, smoking in the first part of pregnancy, and age. Total study sample in adjusted analysis for unilateral CP: *n* = 185 746, 147 cases; total study sample in adjusted analysis for bilateral CP: *n* = 185 785, 186 cases; total study sample in adjusted analysis for dyskinetic CP: *n* = 185 632, 33 cases; and total study sample in adjusted analysis for ataxic CP: *n* = 185 611; 12 cases.

With regard to CP subtypes, we observed an increasing risk with increasing BMI for all subtypes (Fig 3). The risks of unilateral and bilateral spastic CP increased by ~3% (RR, 1.03; 95% CI, 1.00–1.07 and RR, 1.03; 95% CI, 1.01–1.06, respectively). Stronger but more imprecise associations were found for dyskinetic CP (RR, 1.07; 95% CI, 1.02–1.12) and ataxic CP (RR, 1.11; 95% CI, 1.05–1.18).

Paternal obesity has previously been found to be an independent risk factor for autism spectrum disorders (ASDs) within the Norwegian cohort.[22] Paternal BMI was not associated with CP in offspring (Table 3), nor did adjustment for paternal BMI affect the results when using maternal prepregnancy BMI as a continuous predictor (RR, 1.05; 95% CI, 1.03–1.07). Similarly, the prevalence of CP was not affected by mothers' level of physical activity (Table 3). Adjusting for physical activity did not affect the association between continuous prepregnancy BMI and CP (RR, 1.04; 95% CI, 1.02–1.06).

As a sensitivity analyses, we performed all analyses adjusting for education instead of employment status in the Norwegian cohort. Results were similar (upper normal weight RR, 1.64; 95% CI, 1.11–2.42; overweight RR, 1.90; 95% CI, 1.32–2.74; and obese RR, 2.64; 95% CI, 1.71–4.06).

DISCUSSION

We found an increasing risk of CP in offspring with increasing maternal prepregnancy BMI. Compared with women in the lower normal BMI group, women in the upper normal BMI group had a 40% excess risk, and women in the overweight and obese groups each had a 60% excess risk of CP in their offspring. Continuously increased risks with increasing BMI were found for all individual CP subtypes.

TABLE 3 Prevalence and RR of CP by Prepregnancy Paternal BMI and Physical Activity

Paternal BMI	Total Study Sample, *n* (%)	With CP *n* (per 1000 Children)	RR (95% CI)	
			Crude	Adjusted[a]
Per unit BMI increase	—	—	1.01 (0.97–1.04)	0.99 (0.96–1.03)
<18.5	467 (0.3)	2 (4.3)	2.55 (0.62–10.43)	2.41 (0.60–9.89)
18.5–22.9	30 329 (19.4)	51 (1.7)	1.00 (Ref)	1.00 (Ref)
23.0–24.9	44 013 (28.1)	86 (2.0)	1.16 (0.82–1.64)	1.14 (0.81–1.61)
25.0–29.9	67 882 (43.3)	129 (1.9)	1.13 (0.82–1.56)	1.04 (0.75–1.45)
≥30	14 059 (9.0)	27 (1.9)	1.14 (0.72–1.82)	0.97 (0.60–1.56)
Physical activity				
<1 times per week	101 307 (54.6)	227 (2.2)	1.00 (Ref)	1.00 (Ref)
≥1 times per week	84 128 (45.4)	156 (1.9)	0.83 (0.67–1.02)	0.89 (0.72–1.10)

Total study sample in adjusted analysis for paternal BMI, *n* = 154 160; 291 with CP. Total study sample in adjusted analysis for physical activity, *n* = 182 849; 379 with CP. Ref, reference category. —, not applicable.

[a] Adjusted for maternal occupational status, smoking in the first part of pregnancy, age, and BMI.

Our findings are in agreement with recently published studies on maternal obesity and risk of CP,[23,24] but demonstrate an association across the entire BMI scale less explored in previous studies. In a Swedish case-control study, Ahlin et al[25] found a 7% increased odds of CP for every 1 unit increase in maternal BMI (odds ratio, 1.07; 95% CI, 1.03–1.12) for babies born at term, but the authors did not state when BMI was measured. An increased risk was found for all subtypes, but the estimates were only statistically significant for all spastic and unilateral spastic CP. In contrast, a case-control study from Australia including 587 cases and 1154 controls found no association between maternal BMI at the beginning of pregnancy and odds of CP.[26] The information on maternal BMI was based on self-report at recruitment when the children were between 5 and 18 years old. Recall bias as well as bias in recruitment may have contributed to the null finding.

The major strengths of this study are the prospective design, the large sample of cases, and the possibility of investigating CP subtypes. By combining 2 of the world's largest birth cohorts, we are able to examine a prospective sample of exceptional size, not affected by maternal recall bias. Both pregnancy cohorts were linked to national CP registries where all diagnoses have been validated by neuropediatricians.

The Danish and Norwegian birth cohorts were planned in close collaboration and have many similarities in design and type of information collected. Even so, there are some important differences in how the information was obtained and in the format and content of the questions. This can lead to loss of information when harmonizing variables and reduce the ability to control for confounding in the analyses. There was a self-selection of healthier women into both cohorts.[11,27] This could result in effect estimates that differ from those in the source population, to the degree that such selection depends both on prepregnancy BMI and CP risk. It is reassuring, however, that other well-established exposure–outcome associations have not been found to be affected in either the Danish or Norwegian cohort, even though self-selection can affect prevalence estimates in the cohorts.[28,29] Another possible limitation is that BMI is self-reported. Maternal BMI has not been validated in MoBa, but a previous study validating self-reported BMI in DNBC found a slight but consistent and increasing underreporting of weight across the entire BMI scale when compared with weight reported in antenatal care.[30] This could result in an underestimation of the adverse effect of overweight and obesity on CP. However, the same study found agreement with regard to BMI categories between maternal self-reported data in DNBC and data recorded by general practitioners in antenatal care in 91% of cases.[30]

We excluded all stillborn and infant deaths in the analyses. Children born with CP probably have a higher risk of dying in their first year of life, before they have a chance of being diagnosed. Because maternal obesity also increases the risk of infant death,[8] it is possible that the exclusion of early deaths biases our estimates toward the null.

As far as we know, no previous studies on maternal BMI and risk of CP in offspring have taken paternal BMI into account. We found no association between paternal BMI and risk of CP, and paternal BMI did not attenuate the effect of maternal BMI on risk of CP. This suggests that the observed association is not due to genetic factors related to overweight, but could be due to a direct harmful effect of maternal overweight through the intrauterine environment. Maternal obesity increases the risk of pregnancy complications, including preeclampsia, gestational diabetes, and cesarean delivery, all of which are associated with CP.[4,5] Infants of obese mothers are more often macrosomic, increasing the risk of a difficult labor and, consequently, birth injury. It is well known that the

risk of CP is increased in children who are small for their gestational age, but the risk is also elevated in children who are born large for their gestational age.[31]

Previous studies have found an increased risk of congenital abnormalities with high BMI (BMI > 30), in particular neural tube defects. It has been suggested that adiposity might impair folate status, reducing the amount of folate available to the fetus (low folate being a well-established risk factor for neural tube defects).[10] We are not aware of any studies linking maternal intake of folate and risk of CP in offspring. Folic acid supplements have been associated with a lower risk of other neurodevelopmental disorders, such as ASDs[32] and language delay,[33] although the association with ASDs was not replicated in a recent study within the Danish birth cohort.[34]

Another biologically plausible hypothesis linking BMI and CP is through the effects of inflammation. Intrauterine infection and inflammation are established risk factors for CP.[35] Obesity is a chronic low-grade inflammatory condition,[36] but it is not clear whether maternal obesity-induced inflammation might have adverse effects on the developing human brain. However, a study in offspring of rats fed a high-fat diet during pregnancy found increased inflammation within the brain at birth.[37]

For obese women (BMI ≥30), there was a difference between the cohorts; offspring of obese Danish women had no excess risk of CP, whereas offspring of obese Norwegian women did. We explored various possible explanations for this difference, without success. If, because of cultural differences, Danish obese mothers were more physically active and generally healthier than Norwegian obese mothers, then that could possibly explain the contradictory difference in results. However, there was no evidence of a stronger selection of healthier obese women into the Danish cohort. The rates of stillbirth and infant death are similar among the obese in the DNBC as among the obese in the Danish population.[8,30] Obstetric care is very similar in Norway and Denmark. We could not find any important differences in the rate of complications among overweight women in the 2 cohorts. In addition, a higher proportion of obese women in the Norwegian cohort were physically active compared with obese women in the Danish cohort. The apparent difference may be because of unmeasured differences between the 2 cohorts, or random variation.

CONCLUSIONS

We found a continuously increasing risk of CP with increasing maternal prepregnancy BMI. The risk was significantly elevated both for women in the upper normal weight, overweight, and obese groups compared with normal weight women. Although we cannot draw any conclusions about the underlying mechanisms for this association, the clinical implications may become all the more important if prepregnancy BMI continues to increase.

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ABBREVIATIONS

ASD: autism spectrum disorder
CI: confidence interval
CP: cerebral palsy
DNBC: Danish National Birth Cohort
MoBa: Norwegian Mother and Child Cohort Study
MOBAND: Mothers and Babies in Norway and Denmark
NPR: Norwegian Patient Registery
RR: relative risk

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