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No association between maternal exercise during pregnancy and the child's weight status at age 7 years; The MoBa Study

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Abstract

Introduction: Maternal lifestyle during pregnancy may affect the development of overweight and obesity in the child. We examined whether maternal exercise during pregnancy is associated with offspring overweight and obesity in childhood. A secondary aim was to examine whether the association is affected by the child's physical activity level.

Materials and methods: This study is based on data from the Norwegian Mother, Father and Child Cohort Study (MoBa), including 44 352 pregnancies and children (n=32 304 in week 17 and n=32 419 in week 30 in the final adjusted model). Maternal exercise during pregnancy was self-reported in gestational week 17 and 30. We conducted linear and logistic regression separately for girls and boys, and outcomes were the child's body mass index (BMI) and weight status (overweight/obese) at age 7 years. We further examined the additive joint association between maternal exercise during pregnancy and the child's leisure time physical activity on weight status at age 7 years.

Results: In total, 12.4% of the children were classified as overweight or obese, and 1.7% as obese. The results suggest no association between maternal exercise in both gestational week 17 and 30 and the weight status of the child at age 7 years. The association between maternal exercise and the child's weight status at age 7 years appears not to be affected by the child's physical activity level.

Conclusion: Maternal exercise level during pregnancy does not appear to be associated with the child's BMI or odds of being overweight or obese in childhood.

Keywords: Childhood overweight/obesity, BMI, exercise, pregnancy, MoBa, MBRN

Introduction

Childhood overweight and obesity are related to an adverse cardiometabolic risk profile, in addition to being a strong predictor for adult overweight and obesity (1-4). The World Health Organization (WHO) have reported that approximately 340 million children and adolescents were overweight or obese in 2016 (5). Childhood overweight and obesity is therefore a severe public health concern, and early prevention is important. Knowledge about risk factors is crucial to prevent the development of overweight and obesity in childhood. Previous research has demonstrated that the development of overweight and obesity in childhood may be affected by maternal lifestyle before and during pregnancy, with some of the established risk factors being maternal pre-pregnancy overweight and obesity, maternal smoking during pregnancy, maternal excessive weight gain during pregnancy and maternal gestational diabetes mellitus (6-8). Some studies have previously demonstrated a negative association between maternal exercise level during pregnancy and neonatal adiposity and birth weight (9, 10). However, the relationship between maternal exercise during pregnancy and the offspring's odds of developing overweight or obesity later in childhood is still unclear, and the evidence is limited and inconclusive (11-18). Three studies suggested that physical activity level during pregnancy is associated with lower probability for overweight in the child (13, 14, 17), whereas other studies examining the association between maternal physical activity during pregnancy and weight status of the offspring in childhood have demonstrated no relationship (11, 12, 15, 16, 18). In several of these studies the sample size was limited, and we therefore aimed to examine the association between maternal exercise during pregnancy and the child's weight status later in childhood in a large population-based, prospective cohort.

A well-known preventive factor for childhood overweight or obesity is the child's physical activity level (19), and a possible association between maternal exercise during pregnancy and the child's weight status may therefore depend on the child's physical activity level. A recent study demonstrated a positive association between maternal exercise during pregnancy and neuromotor development in the offspring at 1 month of age (20). These authors suggest that the improved neuromotor development may result in higher likelihood for the child to be physically active.

Some previous studies have suggested that early life factors influence later weight status differently in boys and girls (21-23). Furthermore, studies also suggest possible different influence of moderate-to-vigorous physical activity (MVPA) in childhood on the association between prenatal factors and risk of obesity and an unfavorable body composition (21, 24). One recent study examined MVPA and vigorous physical activity (VPA) as potential modifiers on the associations between maternal pre-pregnancy body mass index (BMI), birth weight and infant weight gain with body composition and BMI in 9-12-year-olds (21). The results demonstrated that MVPA and VPA attenuated the risk of unfavorable body composition in boys, but not in girls. These results may suggest that the early development of overweight differ between boys and girls, and thus highlight the need to stratify the analyses by sex in future research.

The purpose of this study was therefore to examine whether maternal exercise during pregnancy is associated with offspring overweight and obesity in childhood, separately for boys and girls. A secondary aim was to examine whether a possible relationship between maternal exercise during pregnancy and the child's weight status differ depending on the boys' or girls' physical activity level.

Methods

Study design and sample

This study is based on data derived from the Norwegian Mother, Father and Child Cohort Study (MoBa), conducted by the National Institute of Public Health (25). All women attending a routine ultrasound examination at 17-20 weeks of gestation at a Norwegian maternity unit (50 units out of 52 participated) between 1999 and 2008 were invited to participate. The women consented to participation in 41% of the pregnancies. The cohort now includes 114 500 children, 95 200 mothers and 75 200 fathers (25). The current study is based on version 10 of the quality-assured data files released for research in June 2017.

The current study included participants with available data on maternal age, maternal education, maternal exercise level, maternal smoking during pregnancy, maternal pre-pregnancy body height and weight, and the child's age, height and body weight at age 7 years in the final adjusted analyses (n=32 304 in week 17 and n=32 419 in week 30) (Figure 1). Baseline maternal characteristics in the participants lost to follow up and participants included in the analyses are provided in Supporting information S1.

The establishment of MoBa and initial data collection was based on a license from the Norwegian Data protection agency and the approval from The Regional Committee for Medical Research Ethics. The Norwegian Health Registry Act currently regulates the MoBa-cohort. The Regional Committee for Medical and Health Research Ethics (South-East) has approved the current study. All participating mothers and fathers have submitted written, informed consent.

Measurement methods

Exposure

Maternal exercise in pregnancy was self-reported in gestational week 17 and 30. The mothers reported weekly frequency of the following exercises: Brisk walking, running, bicycling, training in fitness centers, swimming, prenatal aerobic, low impact aerobics, high impact aerobics, dancing, skiing, ball games, horseback riding and other. Based on the frequency of these activities, we created a categorical variable previously described (26). The variable contains the following categories: “never”, “0–3 times a month”, “1–2 times a week” and ”≥3 times a week”. The questionnaire has previously been compared against accelerometer assessed physical activity and demonstrates acceptable validity for ranking the participants in exercise categories (27).

Outcome

The mothers reported their child’s height and weight at age 7 years. We calculated BMI by dividing weight by height squared (kg/m^2). Overweight (BMI corresponding to an adult BMI value of ≥25 kg/m^2) and obesity (BMI corresponding to an adult value of ≥30 kg/m^2) were defined according to the International Obesity Task Force (IOTF) criteria (28).

Covariates and child’s physical activity level

The mothers reported their highest completed educational level and pre-pregnancy weight and height via questionnaire in gestational week 17-20. We categorized maternal education into “secondary school”, “high school” and “college/university”.

We obtained data on parity and maternal smoking (yes/no) in pregnancy from the Medical Birth Registry of Norway (MBRN).

The children's sex was collected from MBRN, and age at follow-up is calculated based on birth date.

The mothers reported the number of times their 7-year-old child participated in MVPA outside of school hours in a usual week. The question has previously been compared with accelerometer assessed physical activity, and is considered useful for ranking children according to level of physical activity (29). For the joint association-analyses, we categorized the variables into 0–2 times/week, 3–4 times/week and ≥ 5 times/week.

Statistical analyses

Descriptive data are provided as number and percent for categorical variables, and average ± standard deviation for normally distributed continuous variables. We tested for differences between boys and girls using T-test on normally distributed continuous variables, Mann Whitney U test on ordinal variables, and chi-squared test on binary variables.

We conducted linear and logistic regression to examine the relationship between maternal exercise level during pregnancy and the child's weight status and BMI at age 7 years. We performed the analyses stratified by sex, because previous studies suggest that early life exposures may influence adiposity differently in boys and girls (21-24). We used mothers who never performed any exercise as the reference category in the logistic regression analyses. The outcome variable in the linear regression is the child's BMI, whereas the outcome variables in the logistic regression are binary variables for overweight and obesity. Results are reported as odds ratio/unstandardized regression coefficient and 95% confidence interval.

Potential confounders were selected based on drawing a directed acyclic graph (DAG) (DAG; Supporting information S2). We performed the analyses in three models. Model 1 is unadjusted, model 2 is adjusted for maternal age, maternal education and parity, while model 3 is, in addition to the covariates in model 2, adjusted for maternal smoking during pregnancy and maternal pre-pregnancy BMI. To improve the precision of the outcome due to the known changes in BMI with age, we also included child's age when body weight and height was measured in model 2 and model 3 when child's BMI was modelled as the outcome (for the outcome measures overweight and obesity, age is already accounted for by using the IOTF-criteria). We also performed two separate sensitivity analyses where we additionally adjusted for maternal pre-pregnancy exercise and excluded participants with multiple pregnancies (n=1124) in model 3. Maternal smoking, maternal pre-pregnancy BMI and maternal pre-pregnancy exercise level were included in the models to account for maternal health consciousness as a possible confounder.

We examined whether the association between maternal exercise during pregnancy and the child's weight status is dependent on childhood physical activity by evaluating the additive joint association between categories of maternal exercise and childhood physical activity on the odds of overweight/obesity in childhood. We used the highest category of maternal exercise (≥ 3 times per week) and childhood physical activity (≥ 5 times per week) as the reference category. The additive joint association analyses were performed in the final adjusted model (Model 3).

The statistical analyses were performed in Stata/SE version 16.0, and statistical significance was set at $p<0.05$.

Results

Descriptive characteristics of participants are provided in Table 1. Among the 44 352 participants, 12.4% (n=5480) of the children were classified as overweight and 1.7% (n=759) were classified as obese. The prevalence of overweight and obesity was higher and physical activity level lower in girls compared to boys. Overall, most of the mothers were highly educated with at least a college degree (71.8%) and the majority were non-smokers (91.6%).

Table 2 shows the results for the unadjusted and adjusted associations between maternal exercise in pregnancy week 17 and 30 and the BMI and odds ratio for overweight/obesity in boys at age 7 years. Unadjusted logistic regression analyses demonstrated lower odds for both overweight and obesity in boys whose mother exercised three times or more per week in week 17 and more than "never" in week 30. However, these results were not statistically significant after adjustments for possible confounders (Table 2). The sensitivity analyses additionally adjusting for maternal pre-pregnancy exercise, and excluding multiple pregnancies did not change the results (data not shown).

Table 3 shows the results for the associations between maternal exercise in pregnancy week 17 and 30 and the BMI and odds ratio for overweight/obesity in girls at age 7 years. Similar results were observed in the unadjusted analyses in girls, but were attenuated after adjusting for maternal educational level and parity. After further adjustment for maternal pre-pregnancy BMI and smoking during pregnancy, there was no association between maternal exercise during pregnancy and weight status or BMI in the 7-year-old girls (Table 3). Adding maternal pre-pregnancy exercise and excluding multiple pregnancies in the model (sensitivity analyses) did not change the results (data not shown).

The joint association analyses suggest that the odds of overweight and obesity by maternal exercise in pregnancy do not differ across the child's physical activity level (Figure 2). In girls with physical activity level 3-4 times per week, higher odds of overweight were observed in all categories of maternal exercise level in week 17 compared to the reference group. These associations indicate a relationship between a lower physical activity level and weight status in the child. In the least active girls (0-2 times/week) higher odds of childhood overweight/obesity were observed in the mothers exercising 1-2 times/week and equal to or less than 3 times/month in week 17, but not in the most active mothers. Higher odds of childhood overweight/obesity were also observed in the most active girls (≥ 5 times per week) when the mother's exercise level was 3 times or less per month in week 30.

Discussion

The results from this population-based pregnancy cohort study suggests no association between maternal exercise in gestational week 17 or 30 and the odds of the child being overweight or obese in childhood. Compared to the most active mothers, slightly higher odds of overweight and obesity in the mothers being less active in gestational week 17 was observed in the least active girls. Nevertheless, no consistent association between maternal exercise and childhood overweight or obesity was observed in any category of childhood physical activity in neither boys nor girls.

The results of this study are in accordance with the majority of previous research examining the association between maternal physical activity and subsequent weight status in the offspring (11, 12, 15, 16, 18). One recent study from the Danish National Birth Cohort investigated the association between maternal physical activity and infant weight at age 12 months, stratified by sex (16). They observed no relationship between physical activity level in gestational week 16 or 31 and infant weight at age 12 months. Furthermore, the results suggest no differences between boys and girls. A second study from the Danish National Birth Cohort indicates no clear relationship between maternal physical activity level during pregnancy and the child's BMI at age 7 years after adjustments for maternal smoking, pre-pregnancy BMI and socioeconomic status. The Danish National Birth Cohort has many similarities to the MoBa-study, including similar weaknesses and strengths. Both referred studies from this cohort have large sample sizes, and they were able to adjust for several potential confounding factors. A limitation is the self-reported, maternal physical activity level via telephone interviews (16, 18).

In contrast, two studies have suggested an association between maternal physical activity level during pregnancy and the child's body weight. However, one of the studies is limited by a very small sample size (17). A study by Mourtakos et al. (13) with a larger sample size observed a significant association between moderate levels of maternal physical activity level during pregnancy and a lower risk of overweight and obesity in the child at age 8 years. Their results remained significant after adjusting for various covariates, such as birth weight, maternal pre-pregnancy weight status and history of breastfeeding. This contrasts to our results and may be explained by the differences in the assessment of exercise/physical activity. The assessment of exercise in our study is based on weekly frequency, while the assessment in the study by Mourtakos et al. may be more precise since it is based on both frequency and duration (> 30 minutes) (13).

A few studies have examined the association between maternal exercise and offspring body composition using dual-energy X-ray absorptiometry (DXA) (11) and calibrated Harpenden calipers (14, 15). The results from these studies are conflicting, with one suggesting a negative association between maternal exercise during pregnancy and fat mass in the offspring (14), whereas two suggest no association (11, 15). Similar to our results, Clapp et al. (15) and Kong et al. (11) observed no significant associations between maternal physical activity during pregnancy and offspring adiposity at both age 1 year and 7-10 years. In contrast, another study by Clapp et al. (14) suggests that maternal exercise level during pregnancy reduces subcutaneous fat mass in the offspring at age 5 years. However, this study is limited by the small sample size.

Others suggest that the increased risk of obesity and unfavorable body composition in childhood and adolescence due to a rapid infant weight gain is attenuated by MVPA in boys, but not in girls (21, 24). To our knowledge, only one previous study has examined the interaction between maternal and offspring physical activity level with the child's weight status. Similar to our study, Mudd et al. 2015 (12) combined self-reported maternal exercise level and the child's physical activity level, whereas four categories were created when investigating the association with weight status in the child at age 3–9 years. The reference category was the group with active mother and active child. Maternal inactivity during pregnancy was associated with higher odds of obesity in the offspring across the child's activity level in unadjusted analyses, but no associations were observed after adjusting for covariates. Further research is needed to explore a possible association between maternal exercise in gestational week 17 and subsequent overweight/obesity in the least active girls.

We observed a negative association between maternal exercise levels more than «never» and weight status in the child after adjusting for maternal age, maternal educational level, and parity. However, further adjustments suggest that these associations were driven by maternal pre-pregnancy BMI and/or maternal smoking during pregnancy. Previous research has demonstrated associations between maternal smoking during pregnancy and maternal pre-pregnancy overweight/obesity with higher odds of overweight in later childhood (7, 30). Maternal smoking during pregnancy, maternal pre-pregnancy BMI and maternal pre-pregnancy exercise are indicators of maternal health consciousness, of which may further influence both the maternal exercise level during pregnancy and the child's weight status via shared lifestyle behaviors. Maternal health consciousness may thus act as a confounder on the association between maternal exercise during pregnancy and the child's weight status. For example, mothers who are health conscious are potentially more likely to be physically active during pregnancy and post-partum, and may thus pass on a more active lifestyle to their children. Alternatively, maternal BMI may be an intermediate on the relationship between maternal exercise and child's weight status. This should be further explored in future research with appropriate mediation analyses.

In contrast to most previous research on the association between maternal exercise in pregnancy and the child's weight status, we performed the analyses stratified by sex. Previous research has suggested that early life factors may influence the development of adiposity differently in boys and girls (21-24). However, our data indicates no difference between boys and girls related to the odds of developing overweight or obesity in mothers with either low or high maternal exercise level during pregnancy.

Strengths and limitations

One major strength of this study is the large sample size allowing us to perform additive joint analyses in several categories of the mother and child's physical activity level. Another important strength of the MoBa-study is the prospective design and comprehensive data collection, of which participants are followed from pregnancy and into childhood. Hence, the cohort includes information about many early life factors, and we were therefore able to adjust for several potential confounding factors, including factors that are related to maternal health consciousness that appears to confound the relationship between maternal exercise during pregnancy and subsequent weight status of the child. One limitation is that we were not able to additionally adjust for healthy/unhealthy maternal diet, however including diet in the model would likely not have influenced the conclusions of this study. The covariates parity, the child's sex and maternal age are collected from MBRN, which is likely to reduce the risk of measurement error.

Some limitations should be considered when interpreting the results from this study. A significant limitation is the self-reported data for maternal exercise level during pregnancy. Self-reported physical activity relies on recall and can potentially lead to bias from misreporting and misclassification (31). We can therefore not exclude the possibility of measurement bias due to intentional and/or accidental misreporting of the participant's exercise level. Furthermore, both self- and proxy-report of physical activity level can be particularly challenging in children, due to their intermittent physical activity pattern (31, 32). The questions used for measuring maternal exercise level in week 17 in MoBa are validity tested, and demonstrate acceptable validity in categorizing participants according to exercise level (27). Furthermore, the external validity of our results may be limited due to the response rate (41%) in MoBa (25) and differential loss to follow-up (Supporting information, S1). Especially women with low socioeconomic status may be underrepresented among MoBa-participants compared to the general population (33, 34). Additionally, lost to follow-up analyses demonstrated relatively small but significant differences between the participants included in the analyses and lost-to follow-up for several maternal factors age (Supporting information 1).

The use of BMI as a measure of adiposity is considered a limitation due to its inability to differentiate between fat mass and fat free mass, as well as its inability to directly measure body fat (35). BMI as a measure of overweight and obesity in children has demonstrated good specificity, but low sensitivity, and can result in imprecise measurement of adiposity (28, 35, 36). However, BMI correlates with cardiovascular risk factors and adiposity in adulthood, and may therefore provide useful information if used thoughtfully (35). Furthermore, the cutoff points used to distinguish between normal weight, overweight and obesity is essential for the validity of BMI (35). This study has used the IOTF-criteria to categorize the children according to weight status, which is internationally recognized and suitable for international comparisons of overweight and obesity (28). Nevertheless, future research should preferably include both maternal device-measured physical activity and precise measurements of body composition in the offspring before firm conclusions can be made.

Perspective

Childhood overweight and obesity is a severe public health concern, and knowledge about risk factors is crucial to prevent the development of overweight and obesity in childhood. Maternal lifestyle before and during pregnancy have shown to affect the development of overweight and obesity in the child (6-8). However, the relationship between maternal exercise during pregnancy and the child's odds of developing overweight or obesity later in childhood is still unclear (11-18). The results of this study suggest that maternal exercise level during pregnancy is not associated with the child’s weight status in childhood, and the associations do not appear to differ by sex. Furthermore, the associations are similar across the child’s physical activity level. Hence, although physical activity during pregnancy may have many important health benefits for both the mother and the child, it does not appear to be an important factor to curb childhood obesity.

Abbreviations

MoBa: Norwegian Mother, Father and Child Cohort Study; BMI: Body Mass Index; B: Unstandardized regression coefficient; OR: Odds ratio; WHO: World Health Organization; MVPA: Moderate-to-vigorous physical activity; MBRN: Medical Birth Registry of Norway; IOTF: International Obesity Task Force; SD: Standard Deviation; 95% CI: 95% Confidence Interval; DXA: Dual-energy X-ray absorptiometry

Ethics approval and consent to participate

The establishment of MoBa and initial data collection was based on a license from the Norwegian Data protection agency and the approval from The Regional Committee for Medical Research Ethics. The Regional Committee for Medical and Health Research Ethics (South-East) has approved the current study. All participating mothers and fathers have submitted written, informed consent.

Consent for publication

Not applicable.

Data availability statement

The consent given by the participants does not open for storage of data on an individual level in repositories or journals. Researchers who want access to data sets for replication should submit an application to datatilgang@fhi.no. Access to data sets requires approval from the Regional committees for medical and health research ethics in Norway and a formal contract with MoBa.

Conflict of interest

The authors declare that they have no competing interests.

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Authors' contributions

All authors conceptualized the specific research question. SMA and GPB analyzed the data and drafted the manuscript. UE has revised the work critically. All authors have approved the submitted version and agreed to be personally accountable.

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Table 1. Descriptive characteristics of study participants (n=44 352). Data are provided for the total and stratified by sex. Continuous variables are stated as average ± standard deviation. Categorical variables are stated as n (%). P-value demonstrates difference between boys and girls.

Variables	**Total (n = 44 352)**	**Boys (n = 22 924)**	**Girls (n = 21 428)**	**P-value**
Maternal factors				
Age (y)	30.63 ± 4.38	30.58 ± 4.40	30.68 ± 4.35	***0.02***
Pre-pregnancy BMI (kg/m^2)	23.89 ± 4.06	23.85 ± 4.05	23.93 ± 4.07	***0.04***
Highest completed education				*0.90*
Secondary school	545 (1.3)	295 (1.4)	250 (1.2)	
High school	11 348 (26.9)	5837 (26.8)	5511 (27.0)	
College/university	30 294 (71.8)	15 654 (71.9)	14 640 (71.8)	
Smoking during pregnancy				*1.17*
Yes	3105 (8.4)	1645 (8.6)	1460 (8.2)	
No	33 855 (91.6)	17 499 (91.4)	16 356 (91.8)	
Parity				*0.20*
0	20 530 (46.3)	10 684 (46.6)	9846 (46.0)	
1	15 697 (35.4)	8064 (35.2)	7633 (35.6)	
2	6406 (14.4)	3293 (14.4)	3113 (14.5)	
3	1336 (3.0)	695 (3.0)	641 (3.0)	
≥ 4	383 (0.9)	188 (0.8)	195 (0.9)	
Exercise in pregnancy wk. 17				*0.39*
Never	5959 (14.4)	3106 (14.5)	2853 (14.2)	
1-3 times/month	8829 (21.3)	4494 (21.0)	4335 (21.6)	
1-2 times/wk.	13 375 (32.2)	6910 (32.2)	6465 (32.3)	
≥ 3 times/wk.	13 319 (32.1)	6938 (35.4)	6381 (31.9)	
Exercise in pregnancy wk. 30				*0.18*
Never	11 657 (27.9)	5971 (27.6)	5686 (28.2)	
1-3 times/month	8456 (20.2)	4344 (20.1)	4112 (20.4)	
1-2 times/wk.	12 040 (28.8)	6302 (29.1)	5738 (28.4)	
≥ 3 times/wk.	9658 (23.1)	5006 (23.2)	4652 (23.0)	
Child factors at age 7 years				
Age (y)	7.12 ± 0.17	7.12 ± 0.17	7.12 ± 0.17	*0.88*
BMI (kg/m^2)	15.81 ± 1.80	15.79 ± 1.72	15.83 ± 1.89	***0.04***
Underweight/normal weight	38 872 (87.6)	20 529 (89.6)	18 343 (85.6)	***< 0.001***
Overweight	5480 (12.4)	2395 (10.5)	3085 (14.4)	***< 0.001***
Obese	759 (1.7)	322 (1.4)	437 (2.0)	***< 0.001***
Physical activity after school				***< 0.001***
0-2 times/wk.	12 227 (28.7)	5244 (24.0)	6983 (33.6)	
3-4 times/wk.	14 667 (34.4)	7151 (32.7)	7516 (36.1)	
≥ 5 times/wk.	15 755 (36.9)	9455 (43.3)	6300 (30.3)	

SD, Standard Deviation; BMI, Body Mass Index

Table 2. The relationship between maternal exercise level during pregnancy and the child's weight status at age 7 years (boys).

	Model 1 ***(n = 21 448 [wk. 17])*** ***(n = 21 623 [wk. 30])***			***Model 2*** ***(n = 20 490 [wk. 17])*** ***(n = 20 556 [wk. 30])***			***Model 3*** ***(n = 16755 [wk. 17])*** ***(n = 16808 [wk. 30])***		
Maternal exercise wk. 17	**overweight OR (95 % CI)**	**obesity OR (95 % CI)**	**BMI B (95 % CI)**	**overweight OR (95 % CI)**	**obesity OR (95 % CI)**	**BMI B (95 % CI)**	**overweight OR (95 % CI)**	**obesity OR (95 % CI)**	**BMI B (95 % CI)**
Never	1.0	1.0	Ref.	1.0	1.0	Ref.	1.0	1.0	Ref.
1-3 times/mo.	0.93 (0.81–1.08)	0.82 (0.58–1.18)	-0.03 (-0.11 to 0.05)	0.99 (0.85–1.15)	0.92 (0.63–1.33)	0.0004 (-0.08 to 0.08)	1.07 (0.90–1.26)	0.96 (0.64-1.44)	0.009 (-0.07 to 0.10)
1-2 times/wk.	0.88 (0.77-1.01)	0.74 (0.53–1.04)	-0.08* (-0.15 to -0.007)	0.96 (0.83–1.10)	0.86 (0.60–1.21)	-0.03 (-0.11 to 0.04)	1.07 (0.90–1.25)	0.94 (0.63–1.38)	0.008 (-0.07 to 0.09)
≥3 times/wk.	0.83** (0.72-0.95)	0.64* (0.46–0.91)	-0.13** (-0.20 to -0.06)	0.92 (0.80–1.07)	0.76 (0.53–1.10)	-0.07 (-0.14 to 0.009)	1.10 (0.93–1.29)	0.92 (0.61-1.38)	0.028 (-0.05 to 0.11)
Maternal exercise wk. 30	**overweight OR (95 % CI)**	**obesity OR (95 % CI)**	**BMI B (95 % CI)**	**overweight OR (95 % CI)**	**obesity OR (95 % CI)**	**BMI B (95 % CI)**	**overweight OR (95 % CI)**	**obesity OR (95 % CI)**	**BMI B (95 % CI)**
Never	1.0	1.0	Ref.	1.0	1.0	Ref.	1.0	1.0	Ref.
1-3 times/mo.	0.83** (0.73–0.94)	0.65** (0.46–0.90)	-0.04 (-0.11 to 0.02)	0.88* (0.77–1.0)	0.70* (0.50–0.98)	-0.008 (-0.08 to 0.06)	0.93 (0.80–1.07)	0.79 (0.55-1.14)	0.03 (-0.05 to 0.08)
1-2 times/wk.	0.80** (0.72–0.90)	0.64** (0.48–0.86)	-0.10** (-0.16 to -0.04)	0.88* (0.78–0.99)	0.72* (0.53–0.98)	-0.05 (-0.11 to 0.01)	0.98 (0.86–1.12)	0.76 (0.53-1.08)	0.01 (-0.05 to 0.08)
≥3 times/wk.	0.77** (0.68–0.87)	0.55** (0.39–0.76)	-0.15** (-0.22 to -0.09)	0.87* (0.77–0.99)	0.64* (0.45–0.90)	-0.07* (-0.14 to -0.006)	1.05 (0.91–1.21)	0.72 (0.48–1.09)	0.07 (-0.01 to 0.14)

* $p < 0.05$, ** $p < 0.01$

OR, Odds ratio; B, Unstandardized regression coefficient; CI, Confidence Interval

Model 1: Unadjusted model. Model 2: Adjusted for maternal age, education and parity. Model 3: Adjusted for maternal age, education, parity, maternal smoking during pregnancy and maternal pre-pregnancy BMI. Model 2 and model 3 are additionally adjusted for child's age when child's BMI are modelled the outcome. The dependent variable in linear regression is the child's BMI, and dependent variable in logistic regression is a binary variable for overweight (BMI corresponding to an adult BMI value of ≥25 kg/m^2) or obesity (BMI corresponding to an adult BMI value of ≥30 kg/m^2) in the child.

Table 3. The relationship between maternal exercise level during pregnancy and the child's weight status at age 7 years (girls).

	Model 1 ***(n = 20 034 [wk. 17])*** ***(n = 20 188 [wk. 30])***			***Model 2*** ***(n = 19 157 [wk. 17])*** ***(n = 19 220 [wk. 30])***			***Model 3*** ***(n = 15549 [wk. 17])*** ***(n = 15611 [wk. 30])***		
Maternal exercise wk. 17	**overweight OR (95 % CI)**	**obesity OR (95 % CI)**	**BMI B (95 % CI)**	**overweight OR (95 % CI)**	**obesity OR (95 % CI)**	**BMI B (95 % CI)**	**overweight OR (95 % CI)**	**obesity OR (95 % CI)**	**BMI B (95 % CI)**
Never	1.0	1.0	Ref.	1.0	1.0	Ref.	1.0	1.0	Ref.
1-3 times/mo.	0.93 (0.82-1.06)	0.60** (0.44–0.81)	-0.06 (-0.15 to 0.03)	0.97 (0.85-1.10)	0.62** (0.45–0.86)	-0.04 (-0.13 to 0.05)	1.04 (0.90–1.21)	0.73 (0.51–1.06)	0.02 (-0.07 to 0.12)
1-2 times/wk.	0.81** (0.72–0.91)	0.67** (0.51–0.88)	-0.15** (-0.24 to –0.07)	0.86* (0.76–0.97)	0.76 (0.57–1.02)	-0.11* (-0.19 to -0.02)	1.00 (0.87–1.15)	0.97 (0.70–1.34)	0.001 (-0.09 to 0.09)
≥3 times/wk.	0.73** (0.64–0.82)	0.58** (0.44–0.77)	-0.22** (-0.30 to -0.14)	0.80** (0.71–0.91)	0.71* (0.53–0.96)	-0.14** (-0.23 to -0.06)	0.98 (0.84–1.13)	0.93 (0.66–1.31)	0.03 (-0.07 to 0.12)
Maternal exercise wk. 30	**overweight OR (95 % CI)**	**obesity OR (95 % CI)**	**BMI B (95 % CI)**	**overweight OR (95 % CI)**	**obesity OR (95 % CI)**	**BMI B (95 % CI)**	**overweight OR (95 % CI)**	**obesity OR (95 % CI)**	**BMI B (95 % CI)**
Never	1.0	1.0	Ref.	1.0	1.0	Ref.	1.0	1.0	Ref.
1-3 times/mo.	0.84** (0.76–0.94)	0.66** (0.50–0.87)	-0.1** (-0.18 to -0.03)	0.87* (0.78–0.98)	0.72* (0.54–0.96)	-0.07 (-0.15 to 0.002)	0.92 (0.80–1.04)	0.81 (0.59–1.12)	-0.01 (-0.09 to 0.07)
1-2 times/wk.	0.79** (0.71–0.88)	0.60** (0.46–0.77)	-0.18** (-0.24 to -0.11)	0.84** (0.76–0.94)	0.68** (0.52–0.89)	-0.13** (-0.20 to -0.06)	0.94 (0.82–1.06)	0.82 (0.60–1.10)	-0.04 (-0.11 to 0.04)
≥3 times/wk.	0.71** (0.63–0.79)	0.57** (0.43–0.75)	-0.26** (-0.34 to -0.19)	0.76** (0.68–0.86)	0.67** (0.50–0.90)	-0.20** (-0.28 to -0.13)	0.95 (0.83–1.09)	0.99 (0.71–1.37)	0.006 (-0.08 to 0.09)

* $p < 0.05$, ** $p < 0.01$

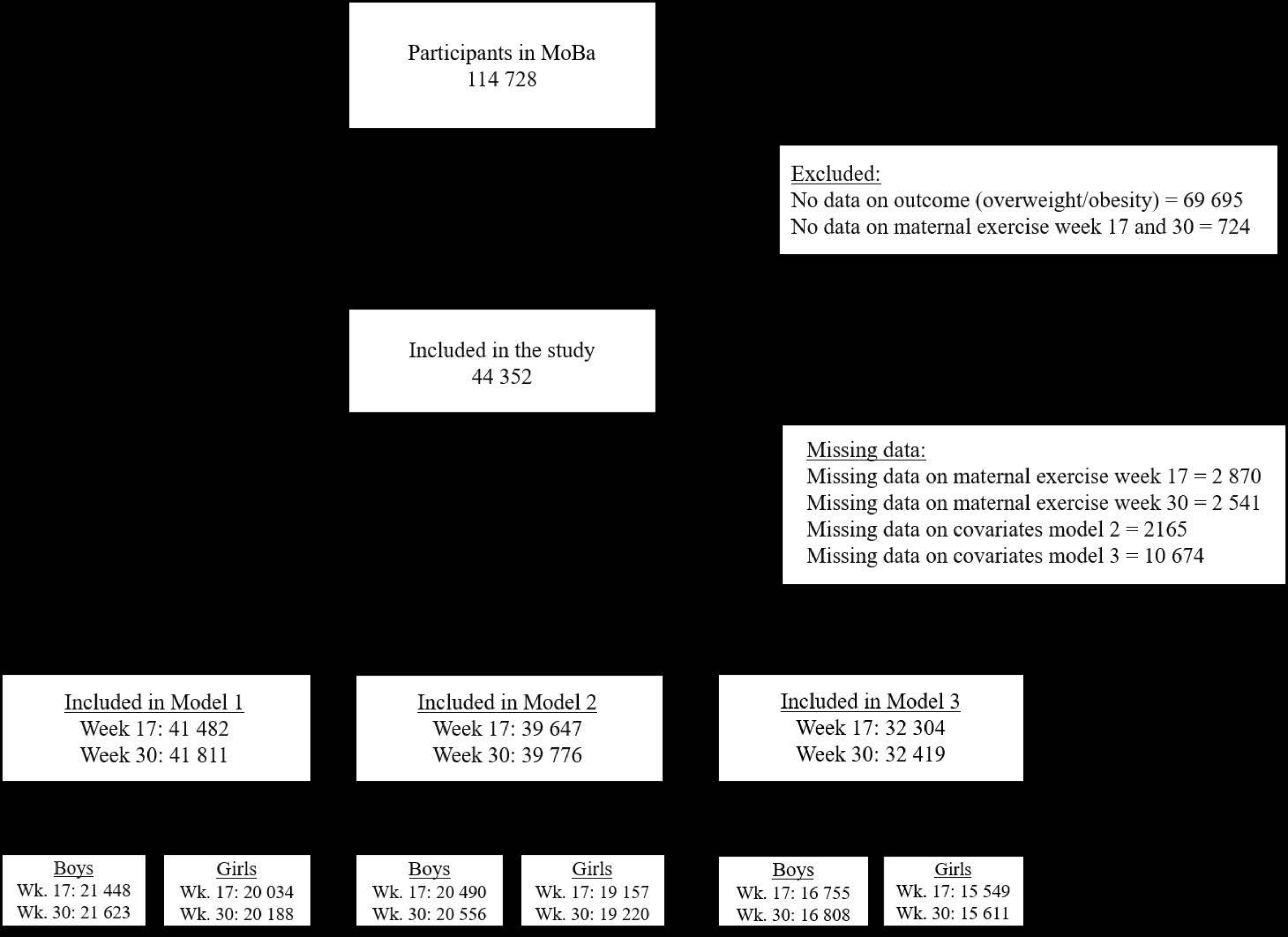
OR, Odds ratio; B, Unstandardized regression coefficient; CI, Confidence Interval

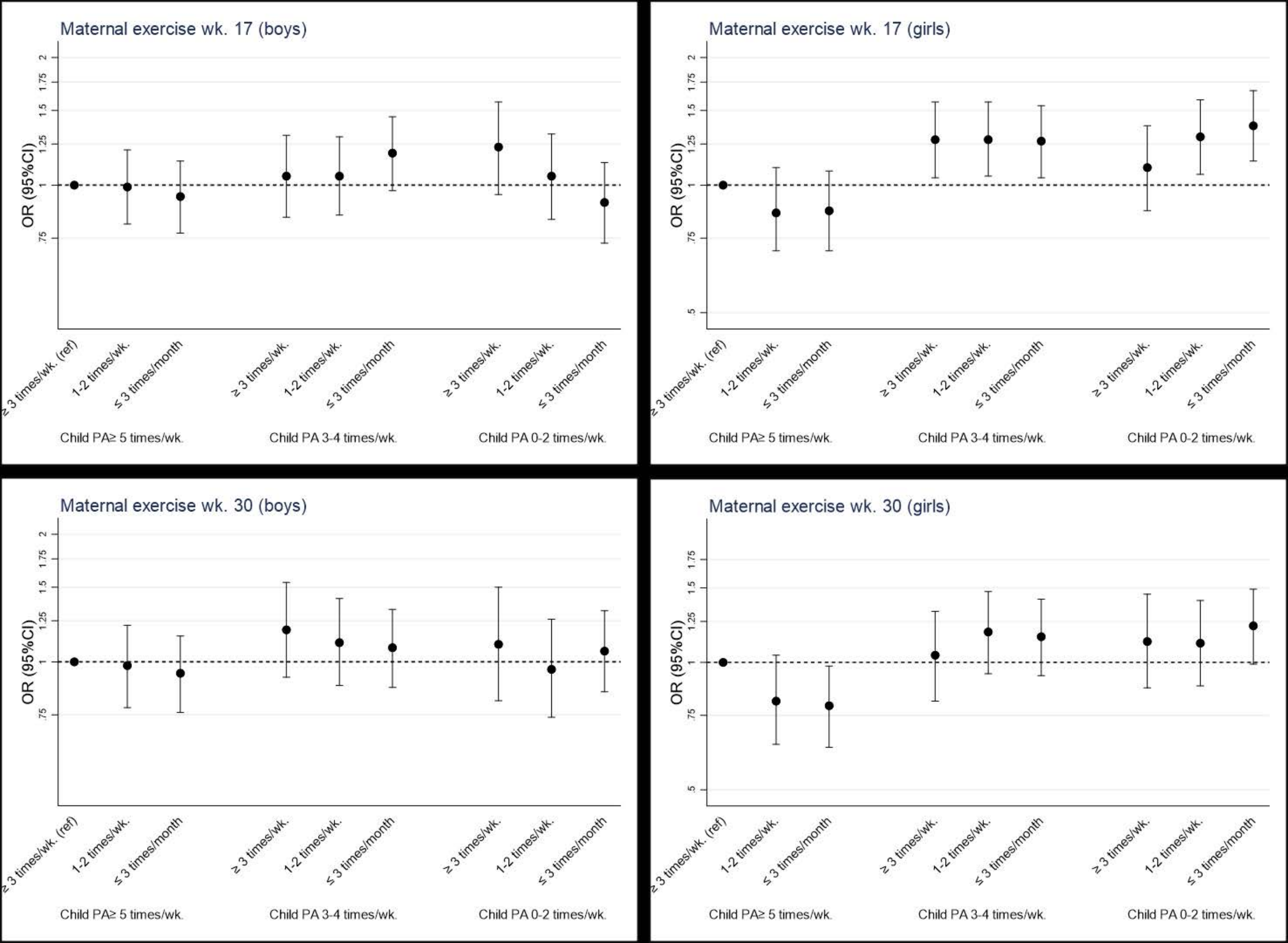
Model 1: Unadjusted model. Model 2: Adjusted for maternal age, education and parity. Model 3: Adjusted for maternal age, education, parity, maternal smoking during pregnancy and maternal pre-pregnancy BMI. Model 2 and model 3 are additionally adjusted for child's age when child's BMI are modelled the outcome. The dependent variable in linear regression is the child's BMI, and dependent variable in logistic regression is a binary variable for overweight (BMI corresponding to an adult BMI value of ≥25 kg/m^2) or obesity (BMI corresponding to an adult BMI value of ≥30 kg/m^2) in the child.

Figure legends

Figure 1: Flow chart of study participants

Figure 2: Joint association of the child's physical activity level and maternal exercise level during pregnancy in week 17 and 30 with the child's odds of overweight/obesity at age 7 years in boys (n=15 998 [week 17]; n=16 052 [week 30]) and girls (n=15 114[week 17]; 15 166 [week 30]).


Participants in MoBa
114 728
Excluded:
No data on outcome (overweight/obesity) = 69 695
No data on maternal exercise week 17 and 30 = 724
Included in the study
44 352
Missing data:
Missing data on maternal exercise week 17 = 2 870
Missing data on maternal exercise week 30 = 2 541
Missing data on covariates model 2 = 2165
Missing data on covariates model 3 = 10 674
Included in Model 1
Week 17: 41 482
Week 30: 41 811
Included in Model 2
Week 17: 39 647
Week 30: 39 776
Included in Model 3
Week 17: 32 304
Week 30: 32 419
Boys
Wk. 17: 21 448
Wk. 30: 21 623
Girls
Wk. 17: 20 034
Wk. 30: 20 188
Boys
Wk. 17: 20 490
Wk. 30: 20 556
Girls
Wk. 17: 19 157
Wk. 30: 19 220
Boys
Wk. 17: 16 755
Wk. 30: 16 808
Girls
Wk. 17: 15 549
Wk. 30: 15 611



Maternal exercise wk. 17 (boys)
OR (95%CI)
2
1.75
1.5
1.25
1
.75
≥ 3 times/wk. (ref)
1-2 times/wk.
≤ 3 times/month
≥ 3 times/wk.
1-2 times/wk.
≤ 3 times/month
≥ 3 times/wk.
1-2 times/wk.
≤ 3 times/month
Child PA≥ 5 times/wk.
Child PA 3-4 times/wk.
Child PA 0-2 times/wk.
Maternal exercise wk. 17 (girls)
OR (95%CI)
2
1.75
1.5
1.25
1
.75
.5
≥ 3 times/wk. (ref)
1-2 times/wk.
≤ 3 times/month
≥ 3 times/wk.
1-2 times/wk.
≤ 3 times/month
≥ 3 times/wk.
1-2 times/wk.
≤ 3 times/month
Child PA≥ 5 times/wk.
Child PA 3-4 times/wk.
Child PA 0-2 times/wk.
Maternal exercise wk. 30 (boys)
OR (95%CI)
2
1.75
1.5
1.25
1
.75
≥ 3 times/wk. (ref)
1-2 times/wk.
≤ 3 times/month
≥ 3 times/wk.
1-2 times/wk.
≤ 3 times/month
≥ 3 times/wk.
1-2 times/wk.
≤ 3 times/month
Child PA≥ 5 times/wk.
Child PA 3-4 times/wk.
Child PA 0-2 times/wk.
Maternal exercise wk. 30 (girls)
OR (95%CI)
1.75
1.5
1.25
1
.75
.5
≥ 3 times/wk. (ref)
1-2 times/wk.
≤ 3 times/month
≥ 3 times/wk.
1-2 times/wk.
≤ 3 times/month
≥ 3 times/wk.
1-2 times/wk.
≤ 3 times/month
Child PA≥ 5 times/wk.
Child PA 3-4 times/wk.
Child PA 0-2 times/wk.