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EARLY POSTPARTUM PHYSICAL ACTIVITY AND PELVIC FLOOR SUPPORT AND SYMPTOMS ONE YEAR POSTPARTUM

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Abstract

Background—Risks of pelvic organ prolapse and urinary incontinence rise after the first vaginal delivery. During the early postpartum period, a time of active regeneration and healing of the pelvic floor, women may be particularly vulnerable to greater pelvic floor loading.

Objectives—This prospective cohort study aimed to determine whether objectively measured moderate-to-vigorous physical activity (MVPA) in the early postpartum period predicts pelvic floor support and symptoms 1 year following first vaginal birth.

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Conflicts of interest: Ingrid Nygaard received an honorarium from Elsevier during part of the time that this research was carried out. NONE of the other investigators report competing interests to disclose.

Study design—We enrolled nulliparous women in the third trimester, later excluding those delivered via cesarean or preterm. Participants wore triaxial wrist accelerometers at 2-3 and 5-6 weeks postpartum for 4 days. Primary outcomes, assessed 1 year postpartum, included 1) pelvic floor support on Pelvic Organ Prolapse Quantification examination, dichotomized as maximal vaginal descent < 0 cm (better support) versus ≥ 0 cm (worse support) and 2) pelvic floor symptom burden, considered positive with report of ≥ 1 bothersome symptom in ≥ 2 of 6 domains, assessed using the Epidemiology of Prolapse and Incontinence Questionnaire. The primary predictor was average daily MVPA. As we could not eliminate women with pelvic floor changes before pregnancy, we modeled prevalence, rather than risk, ratios (PR) for each outcome using modified Poisson regression.

Results—Of 825 participants eligible after delivery, 611 completed accelerometry and 1-year follow-up; 562 completed in-person visits and 609, questionnaires. Mean age was 28.9 years (SD 5.01). Mean (SD) MVPA was 57.3 (25.4) and 68.1 (28.9) minutes/day at 2-3 and 5-6 weeks, respectively. One year postpartum, 53/562 (9.4%) demonstrated worse vaginal support and 330/609 (54.2%) met criteria for pelvic floor symptom burden. 324 (53.1%), 284 (46.6%), 144 (23.6%), and 25 (4.1%) reported secondary outcomes of stress urinary incontinence, overactive bladder, anal incontinence, and constipation, respectively, and 264 (43.4%), 250 (41.0%) and 89 (14.6%) reported no, mild, or moderate to severe urinary incontinence, respectively.

The relationship between MVPA and outcomes was not linear. Based on plots, we grouped quintiles of MVPA into 3 categories: quintiles 1, 2 vs 3,4, vs 5. In final multivariable models, compared to women in MVPA quintiles 3 and 4, those in the lower 2 (PR 0.55 (95% CI 0.31, 1.00) and upper quintile (PR 0.70 (95% CI 0.35, 1.38)) trended towards lower prevalences of worse support. However, we observed the reverse for symptom burden: compared to women in quintiles 3, 4 those in the lower 2 (PR 1.20 (95% CI 1.02, 1.41) and upper quintile PR 1.34 (95% CI 1.11, 1.61) demonstrated higher prevalences of symptom burden.

MVPA did not predict any of the secondary outcomes. Presence of a delivery factor with potential to increase risk for levator muscle injury did not modify the effect of MVPA on outcomes.

Conclusion—Except for support, which was worse in women with moderately high levels of activity, early postpartum MVPA was either protective or had no effect on other parameters of pelvic floor health. Few women did substantial vigorous activity and thus these results do not apply to women doing strenuous exercise shortly after delivery.

Keywords

physical activity; pelvic floor disorder; postpartum; pelvic organ prolapse; urinary incontinence; accelerometry

INTRODUCTION

Up to 1 in 5 women undergoes surgery for pelvic organ prolapse (POP) or urinary incontinence (UI) in her lifetime.¹⁻³ The path to future end-stage POP for most women and UI for many women begins at the first vaginal delivery.^{4-14,15-17} While few young women require surgery, they do demonstrate a range of pelvic floor support and symptoms postpartum.¹⁸⁻³² Specific delivery events increase risk of traumatic levator ani muscle

defects and impaired vaginal support.^{19,33-38} Other than childbirth, modifiable non-obstetric risk factors for pelvic floor disorders (PFDs) pertinent to reproductive aged women include obesity, lifestyle factors, constipation, and physical activity.^{31,39-44}

Vaginal delivery is one of the larger soft tissue injuries most women sustain over their lives. However, while vaginal delivery increases the risk for end stage PFDs, it is not sufficient, in that most parous women don't have surgery for these conditions. Women experience different injury and recovery courses, both affected by their inherent regenerative capabilities and potentially by mechanical stressors placed on the pelvic floor. Women in the early postpartum period, a time of active regeneration and healing, may be particularly vulnerable to such stressors. It is possible that a high amount of moderate to vigorous physical activity (MVPA) during this recovery period may impair regeneration of damaged tissues.

The primary aims of this prospective cohort study are to determine whether MVPA, measured objectively using accelerometry, in the early postpartum period predicts pelvic floor support and symptom burden 1 year following first vaginal birth. We hypothesized that greater MVPA during this period will predict worse pelvic floor support and greater symptom burden one year postpartum. In planned secondary aims, we explored whether MVPA in the early postpartum period predicts urinary incontinence severity, stress urinary incontinence (SUI), overactive bladder (OAB), constipation or anal incontinence (AI) at one year postpartum. Finally, in a planned exploratory aim, we estimated whether the presence of a delivery variable that places women at higher risk for levator ani muscle (LAM) injury modifies the effect of MVPA on pelvic floor outcomes.

MATERIALS AND METHODS

Local institutional review boards approved this study. All participants completed an informed consent process.

Recruitment

Overall study methods are reported in more detail elsewhere⁴⁵ and summarized here. Research staff recruited women from 7 prenatal clinics in the Salt Lake Valley between 09/01/15 and 07/11/18. Participants were 18 years, English or Spanish speaking, nulliparous with a singleton gestation, 28 weeks gestation, planning vaginal delivery, not planning to move to a location precluding follow-up, and living within 60 miles of the research facility. Other exclusion criteria included medical conditions precluding physical activity, prior surgical treatment for POP or UI, and no email or telephone access. As our intent was to study women who underwent term vaginal delivery, after enrollment, women that delivered by cesarean or before 37 weeks gestation were excluded from further participation.

Outcome measures

The primary outcome measures were two dichotomous measures of pelvic floor health: 1) Pelvic floor support, assessed using the Pelvic Organ Prolapse Quantification (POP-Q) examination⁴⁶⁻⁴⁸, and categorized as maximal vaginal descent (the most distal point of C, Ba

or Bp) of < 0 cm (above the hymen; better support) versus 0 cm (at or below the hymen; worse support) and 2) Pelvic floor symptom burden, assessed using the Epidemiology of Prolapse and Incontinence Questionnaire (EPIQ)⁴⁹, and categorized as positive when a participant reported at least one symptom with bother > 0 on the visual analogue scale (VAS) in 2 domains.

We assessed the secondary outcomes of symptoms of SUI, OAB, and AI using the EPIQ and categorized each as positive when a participant reported 1 symptom with VAS > 0 in the pertinent domain. We categorized constipation as present with positive responses to both “Do you have < three bowel movements per week?” and “Do you have to strain > 25% of the time to have a bowel movement?” on the Defecation Distress Inventory.^{50,51} We compared MVPA by Incontinence Severity Index (ISI) categories of 0 (no UI), 1-2 (slight) and 3 (moderate to severe).^{52,53}

Primary predictor

Our a priori primary predictor, MVPA, was average daily minutes of MVPA based upon total accrual of MVPA, to best reflect all potential forces on the pelvic floor.

Study procedures

Pertinent to this analysis, during the third trimester and one year postpartum, trained research staff performed the POP-Q examination with participants in the lithotomy position, backs elevated to 45 degrees, and during maximal strain, except for vaginal length. At these timepoints and at 5-10 weeks postpartum, participants completed questionnaires in English or Spanish using RedCap, a web-based electronic data capture tool.⁵⁴ In addition to the study instruments noted above, others included demographic characteristics and medical history, the Rapid Assessment of Physical Activity questionnaire⁵⁵, and checklists of physical activity types modeled after the Bone Loading History Questionnaire.⁵⁶ We extracted delivery details from the electronic medical record.

To objectively measure physical activity, participants wore a GT9X triaxial accelerometer (Actigraph, Inc., Pensacola, FL) on the wrist at 2-3 and 5-6 weeks postpartum (operationalized as 12-25 days and 33-46 days postpartum, respectively). Details of the accelerometry protocol have been published.⁵⁷ To provide context for the accelerometer results, participants completed physical activity questionnaires after each wear period. For this analysis, we included women with valid (analyzable) data at either or both time frames. To be analyzable, participants must have worn the accelerometer within the correct time frame with adequate wear time. Consistent with prior studies, we required 4 days of wear, with 1 weekend day, and 10 and 8 hours of wear on weekdays and a weekend day, respectively, to consider the accelerometry data valid.^{58,59} As some recent studies require 16 hours of daily wear when wrist, rather than waist, accelerometry is used⁶⁰, we also calculated the proportion of participants that met this more stringent wear criterion and tested the effect of accelerometer wear time (16 hours/day versus 10 to <16 hours/day) in sensitivity analyses. We used GGIR V1.5, an R-package designed to process multi-day raw accelerometer data and applied quality control measures as per van Hees et al.^{61,62}

The GT9X accelerometer provides vector magnitude, in units of gravities, as a summary metric of acceleration from three axes. The Euclidean Norm Minus One (ENMO) metric subtracts the contribution of gravity (1 *g*) from vector magnitude, resulting in acceleration values that reflect human movement in mili-gravities (mgs).^{63,64,65} The greater movement intensity and activity duration, averaged over 5-second epochs, the greater the ENMO value. An ENMO intensity threshold of 100.6 mg corresponds to MVPA.^{64,66,67}

Based on work by others⁶⁸, we considered a woman to be at higher risk for LAM injury if one of the following risk factors were present: age ≥ 33 years, second stage of labor duration ≥ 150 minutes, birthweight > 4000 grams, forceps delivery or anal sphincter tear (3rd or 4th degree laceration).

Statistical methods

In this cohort study, we cannot remove prevalent cases occurring before pregnancy. Thus, as we could not estimate a risk ratio, we calculated prevalence ratios (PR) with 95% confidence intervals (CI) for each outcome using modified Poisson regression with variance correction by generalized estimating equations (GEE).^{69,70}

The adjustment variables in our multivariable analyses (provided in tables) were informed by directed acyclic graphs (DAG) completed prior to inspection of the data.^{71,72,73} Adjustment variables included symptoms and support during pregnancy which were categorized in the same way as at 1 year with 2 exceptions: For OAB, because most women would be categorized as positive during pregnancy, given the preponderance of nocturia and urinary frequency in pregnancy,⁷⁴ we adjusted for UUI. For the symptom burden outcome, we adjusted for the SUI, UUI or AI, demonstrated to increase subsequent risk of the same symptoms^{75-79,80-83}. Our primary predictor, average daily minutes of MVPA, reflects the mean of daily MVPA across the 2 time-points. This approach was supported by preliminary analyses, in which the predicted reliability of total MVPA between the 2 timepoints was moderately high (intraclass correlation=0.79), suggesting that both timepoints measure a single underlying construct. We conducted a planned sensitivity analysis, limiting the population to those with valid data at both timepoints, to assess whether MVPA at either timepoint independently predicted the primary outcomes. Finally, we conducted planned sensitivity analyses testing associations between outcomes and MVPA that occurred in at least 5-minute bouts, suggestive of sustained activity such as exercise.

Using SAS version 9.4, we checked models for model assumptions, multicollinearity, effects of sparseness, influential observations, and goodness of fit using standard regression diagnostics. For continuous variables, we used a graphical method of Hosmer and Lemeshow⁸⁴ and the quasi-information criterion (QIC) to check linearity of their relationship with each outcome on the log-prevalence scale. If not linear, we combined adjacent quintiles with similar coefficients. Thus, different outcomes have different cut-points for predictor variables. As a final step, we performed multiple imputation on missing values in the covariates using Stata version 16.^{85,86} To estimate prevalence ratios, we used modified Poisson regression rather than log-binomial models as the latter did not always converge, particularly in multivariable models.^{69,87}

We tested the primary outcomes, support and symptom burden, at the 5% significance level. For secondary outcomes, we adjusted the significance level based on the total number of secondary outcomes, degrees of freedom of the main exposure, and number of levels in the outcome of interest.

Sample size

Sample size was based on calculations for logistic regression, as no power calculation formulae are available for modified generalized linear models designed to estimate the prevalence ratio. We considered women at the mean for daily average MVPA as “lower risk” and those at the mean plus one standard deviation as “higher risk”. We assumed a frequency of MVD of 15% in the lower-risk group⁴⁵ and that R^2 of MVPA regressed on other predictors is 0.5. Therefore, a sample size of 585 women at 1-year follow-up provides 90% power to detect a minimal odds ratio of 1.70 for women whose daily average MVPA is 1 standard deviation higher than other women whose value is at the mean.

RESULTS

Participant flow is summarized in Figure 1. Of 1078 women enrolled, 825 remained eligible after delivery, 739 had valid accelerometer data at 2-3 and/or 5-6 weeks postpartum and 611 of 825 (74.1%) completed 1-year follow-up. Of these, 562 of 825 eligible (68.8%) completed the pelvic floor support outcome assessment and 609 (73.8%) the symptom burden outcome assessment.

Participant characteristics are summarized in Table 1. Mean age of the sample at enrollment was 28.9 years (SD 5.01). There were no differences in age, ethnicity or insurance type between eligible women that agreed or that declined study participation. Of women still eligible after delivery, those that did not complete 1-year follow-up were younger (26.0 vs 28.8 years, $p < 0.001$), more likely to report Hispanic ethnicity (32.6% vs 17.8%, $p < 0.0001$), and less likely to have private insurance (61.2% vs 83.2%, $p < 0.0001$), have attended college (62.0% vs 88.3%, $p < 0.0001$) and be categorized as high-risk for LAM injury (18.5% vs 26.4%, $p = 0.03$) than participants that did complete 1-year follow-up.

All participants in this analysis met the wear time criteria described in Methods necessary for inclusion. Almost all also met more stringent wear time criteria of 16 hours/day for at least 3 weekdays and 1 weekend day: 531/537 (98.9%) at 2-3 weeks and 513/527 (97.3%) at 5-6 weeks. Mean (SD) wear times were 23.39 (1.50) hours and 23.13 (1.95) hours/day at each timepoint, respectively. Mean (SD) MVPA was 57.3 (25.4) and 68.1 (28.9) minutes/day at 2-3 and 5-6 weeks, respectively. Figure 2 demonstrates the shift to increasing MVPA between the two time-points. All women did at least some (>0 minutes) moderate and over 99% did at least some vigorous activity (>428.8 mg) at each time point. At 2-3 weeks, 376 (70.0%) and at 5-6 weeks, 402 (76.3%) did at least one 5-minute bout of MVPA. Only 23 (4.3%) at 2-3 weeks and 49 (9.3%) at 5-6 weeks did at least one 5-minute bout of vigorous activity. Table 2 summarizes activity types self-reported on checklists at each time point according to quintile of MVPA by accelerometry.

One year postpartum, 53 of 562 women (9.4%) demonstrated worse vaginal support. Mean (SD) points C (apex), Ba (anterior vagina) and Bp (posterior vagina) were -6.2 (1.09), -1.5 (0.77) and -2.1 (0.74) cm, respectively. About half, 330 of 609 (54.2%) met criteria for pelvic floor symptom burden; 119 (19.5%) reported no symptoms and 160 (26.2%) reported symptoms in only 1 domain. For secondary outcomes, 324 (53.1%) reported SUI, 284 (46.6%) OAB, 144 (23.6%) AI, and 25 (4.1%) constipation. Incontinence severity was mild in 250 (41.0%) and moderate to severe in 89 (14.6%), while 264 (43.3%) reported no UI.

As demonstrated by Figure 3, MVPA did not demonstrate a linear association with either primary outcome (or, not shown, with any secondary outcomes). Therefore we grouped quintiles of MVPA as noted in Methods. For the primary outcomes, we grouped MVPA into 3 categories: first and second quintiles combined, third and fourth quintiles combined, and fifth quintile.

In final multivariable models, compared to women in quintiles 1 and 2 for MVPA, those in quintiles 3 and 4 had a marginally significant higher prevalence of worse support (PR 1.80 (95% CI 1.00,3.26); $p=0.052$) and a lower prevalence of greater symptom burden (PR 0.83 (95% CI 0.71, 0.98); $p=0.03$) 1 year postpartum (Tables 3a and 3b), while those in quintile 5 demonstrated no significant difference in prevalence ratios for either primary outcome.

In final models, there were no statistical interactions between MVPA and higher-risk for LAM delivery variable on either primary outcome ($p=0.85$ for support and $p=0.31$ for symptom burden). There were also no statistical interactions between MVPA and age ($p=0.38$ for support and $p=0.16$ for symptom burden).

In multivariable sensitivity analyses, there were no significant associations between MVPA in 5-minute bouts and either worse support or symptom burden (Supplementary Tables 1a and 1b). In additional sensitivity analyses, MVPA at either timepoint did not independently predict either primary outcome (data not shown).

Given the primary findings, we explored variables that might explain the differences in the direction of effect for quintiles 3 and 4 versus quintile 5 of MVPA. As seen in Supplementary Table 2, there were some differences among the 3 groups but women in quintiles 3 and 4 did not report more pelvic loading activities, changes in activity pattern or factors that in theory might dissuade them from doing greater amounts of MVPA.

Final multivariable models revealed no statistically significant associations between MVPA and any of the secondary outcomes (data not shown).

COMMENT

Principal findings

We had hypothesized that greater MVPA in the early postpartum, a period of active healing and regeneration of muscles, ligaments and nerves, would increase the prevalence of worse pelvic floor health one year postpartum. Instead, in this prospective cohort study, we found differential effects of early postpartum MVPA on the primary outcomes. Multivariable analyses of quintiles of MVPA demonstrated an inverted U-shaped pattern of prevalence

ratio for the support outcome and a shallow U-shaped pattern for the symptom burden outcome. Compared to women in the lowest two quintiles of MVPA (representing 8.9 to 52.8 minutes/day), those in quintiles 3 and 4 (52.9 to 81.9 minutes/day) had nearly 200% of the prevalence of worse support (though with marginal significance, with $p=0.051$) and a 20% lower prevalence of worse symptom burden, while those in the highest quintile (81.9-158.7 minutes/day) demonstrated no significant difference in either outcome. The presence or absence of a high-risk delivery variable did not change the effect of MVPA on either primary outcome. Additionally, MVPA had no significant effect on any of the secondary outcomes.

There are several possible explanations for these findings. First, pelvic floor support tends to be poorly correlated with non-bulge pelvic floor symptoms⁸⁸ and thus, physical activity may be deleterious in terms of support for some women but not in terms of symptoms, even in the face of acute healing postpartum. Indeed, in a recent report, women that reported exercising 3 times/week at 6 weeks postpartum were not at increased risk of vaginal bulge symptoms compared to non-exercisers.⁸⁹ Second, even 2-3 weeks postpartum might be too late to fully test the effect, as substantial wound healing may have already occurred by this point. Third, the amount and intensity of activity may not have been high enough to have an effect. Consistent with other literature on postpartum women, few women engaged in vigorous activity, such as fast running (which would produce ENMO values the vigorous intensity cutpoint of 428.8 mg). However, given that even elite athletes are unlikely to resume their full volume of pre-pregnancy activities in the first 2-4 weeks postpartum,^{90,91} if our testing interval was too late after delivery to see an effect, this would have little clinical relevance.

The finding, that compared to the least active women, the most active women do not have an increased prevalence of worse support while those moderately active do, was surprising as one might anticipate a dose-response type of effect. Yet, further exploration of pelvic loading activities and other characteristics did not explain differences in outcomes between women in the 3 MVPA groups. Women in quintile 5 may differ from those in quintiles 3 and 4 in some factor that we were not able to measure that influences both ability to be more active and protection against worse support.

To quantify how strong an uncontrolled variable would have to be, in order to overturn our results, we calculated E-values for confounding^{92,93} and E-values for selection bias related to drop-outs.⁹⁴ The E-value for confounding is the strength of association that an uncontrolled confounder must have with both early MVPA and the outcome in order to completely explain away our findings. For example, the E-value for confounding for the effects of MVPA quintiles 3 and 4 vs 1 and 2 on worse support is 3.0, and for symptom burden, 1.67. The E-value for selection bias related to drop-outs (that is, the bias that arises when a risk ratio in a population differs from that risk ratio in the subset of the population available for analysis⁹⁵) addresses the strength of the association that an uncontrolled factor must have with both drop-out and the outcome, at each level of MVPA, in order to completely explain away our findings.^{94,95} The E-value for selection bias for the effects of MVPA quintiles 3 and 4 vs 1 and 2 on worse support at 1 year postpartum is 2.02; and for symptom burden, 1.41. Thus an uncontrolled factor would have to have considerable

strength to overturn our finding for worse support, but only moderate strength to overturn it for worse symptom burden.

Strengths

Our 1-year follow-up rate was similar to or higher than other published studies that followed women between late pregnancy and 1 year postpartum, with rates from 37% to 77% with the exception of Chen who reported 100% adherence between 3rd trimester and 1-year postpartum.^{22,23,44,68,96,97} We objectively measured physical activity and adherence was high. We assessed total MVPA to better represent total loads on the pelvic floor, but also found no differences in sensitivity analyses of 5-minute bouts of MVPA, which might be more reflective of sustained exercise. By enrolling women during pregnancy, we were able to include pelvic floor symptoms and objectively measured support before delivery in our multivariable models. Consistent with studies of prevention strategies, our a priori analysis plan did not include adjusting for downstream events that occurred after the prevention period (early postpartum).

Weaknesses

While women that enrolled in the study were similar to those eligible who declined participation, there were key differences between participants that completed both accelerometry and 1-year follow-up versus those that did not. Those factors would have to have considerable strength to cause enough selection bias to overturn our finding for worse support, but only moderate strength to overturn our finding for symptom burden. In addition, our results may not be generalizable to other populations, including multiparas or other racial and ethnic groups. At 5-6 weeks postpartum, only about one-third of women in the highest quintile of MVPA reported doing strenuous exercise (Table 2) and thus, our results are not applicable to those competitively active women who seek guidance on resuming high-duration, high-impact and strenuous activity in the very early postpartum. However, the vast majority of women are not highly active or elite athletes and rather need guidance on whether common activities, such as jogging, cycling, swimming, or heavy housework or gardening after vaginal childbirth are safe in terms of pelvic floor health.

While the EPIQ provides thresholds validated for predicting women at high risk of being diagnosed with POP, SUI, OAB and AI, we used symptoms from the EPIQ as outcome measures to investigate experiences of young, postpartum women rather than urogynecologic conditions in middle-aged and older women. Indeed, studying selected pelvic floor symptoms extracted from validated condition-specific questionnaires is common.⁹⁸⁻¹⁰¹ However, this approach and in particular our use of a non-validated measure of symptom burden, chosen as no single measure appropriate for our population exists, are limitations of this study.

Though the step output differs between wrist-and waist-worn accelerometers worn during daily life, the correlations between the two are good to high in adults and in postpartum women.¹⁰²⁻¹⁰⁵ Because compliance is better with accelerometers worn on the wrist compared to the waist or hip, wrist-worn devices are now preferentially used in large population-based studies.¹⁰⁶ Accelerometry is likely to under-measure some loads on the

pelvic floor. Body acceleration correlates highly with intra-abdominal pressure for dynamic activities, such as running, walking and jumping, but poorly for loading activities with little body movement, such as heavy lifting.¹⁰⁷ However, most participants reported no heavy lifting types of activities at either time-point and so it is likely that accelerometry in our population captured most activities.

We used selected concepts and tools of modern causal analytic methods in executing and interpreting our analyses, such as directed acyclic graphs and E-values. In theory, a randomized masked trial, preferably stratifying women with and without levator ani muscle injuries, would provide the highest quality evidence about the effect of MVPA on the pelvic floor, but this approach has both ethical and logistical obstacles. If one hypothesizes, as we did, that higher MVPA during this vulnerable period increases the risk of pelvic floor problems, it would be unethical to randomize women to this group. However, logistical concerns are great as well. It is not possible to mask participants randomized to MVPA vs limited activity to their assigned group. Adherence to physical activity intervention and retention in trials is poor in healthy, inactive postpartum women.¹⁰⁸

We based our sample size calculation on the prediction that 15% of the population would demonstrate worse pelvic floor support 1 year postpartum but the proportion that did so was one-third lower. Thus, this study may have been underpowered to explore all comparisons for the support outcome.

Meaning of the study

Our results provide objective data about pelvic floor health that in general support the most recent ACOG guidelines on postpartum PA, which state, “In the absence of medical or surgical complications, rapid resumption of (physical) activities has not been found to result in adverse effects”.¹⁰⁹ With the exception of support, which was worse in women with moderately high activity levels in our population, MVPA was either protective or had no effect on other parameters of pelvic floor health.

Unanswered questions

Further research is needed to understand why moderate amounts of MVPA affect support and symptom burden differently in postpartum women. Larger populations are necessary to test whether the effects of MVPA in the early postpartum period differ in women with an objectively measured levator ani injury, pre-existing worse support, pre-existing high levels of fitness, or other factors.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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CONDENSATION: Early postpartum moderate to vigorous physical activity had variable effects on pelvic floor support and symptoms at one year postpartum.

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AJOG AT A GLANCE

Why was this study conducted?

- Risks of pelvic organ prolapse and urinary incontinence rise after the first vaginal delivery.
- The early postpartum period, a time of active regeneration and healing of the pelvic floor, may be particularly vulnerable to high volumes of pelvic floor loading.
- We aimed to determine whether objectively measured moderate-to-vigorous physical activity (MVPA) in the early postpartum period predicts pelvic floor support and symptom burden (bothersome symptoms in at least 2 domains) 1 year following first vaginal birth.

What are the key findings?

- Early postpartum MVPA had differential effects on support and symptoms.
- Women with a moderately high amount of physical activity trended toward higher prevalence of worse support but lower prevalence of symptom burden compared to both least active and most active women.

What does this study add to what is already known?

- These results provide objective data about the effect of early postpartum physical activity on pelvic floor health amongst primiparous women delivered vaginally.
- Further research is needed to understand the differential effect of moderate amounts of MVPA on support versus symptom burden in postpartum women.

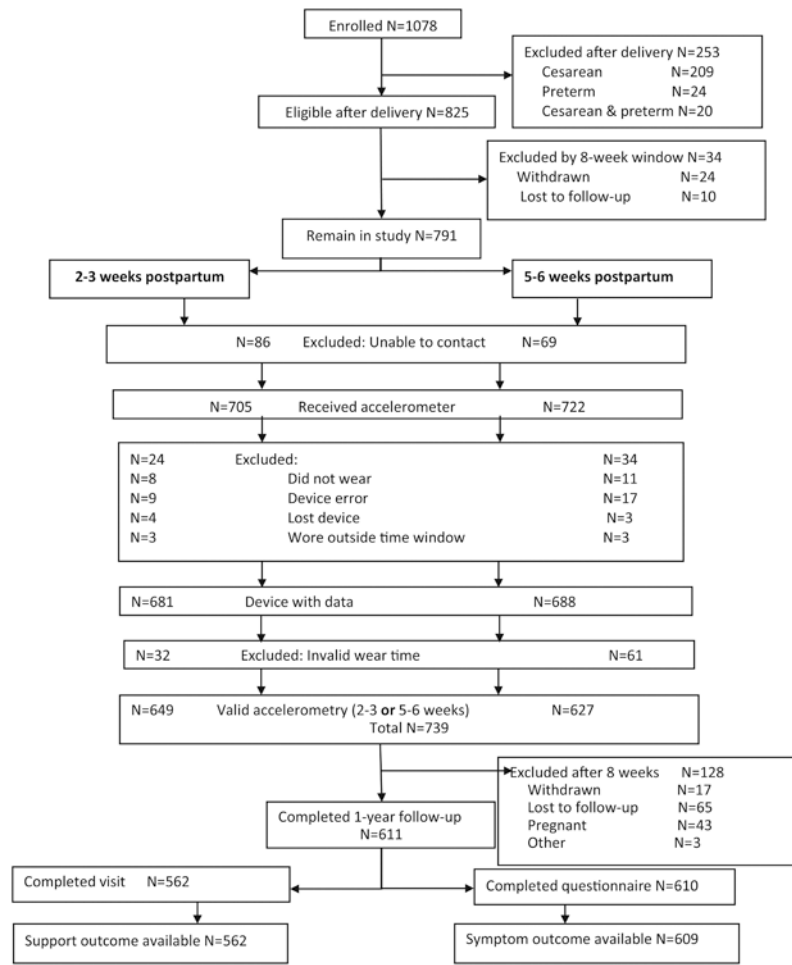


Fig. 1.
Participant flow

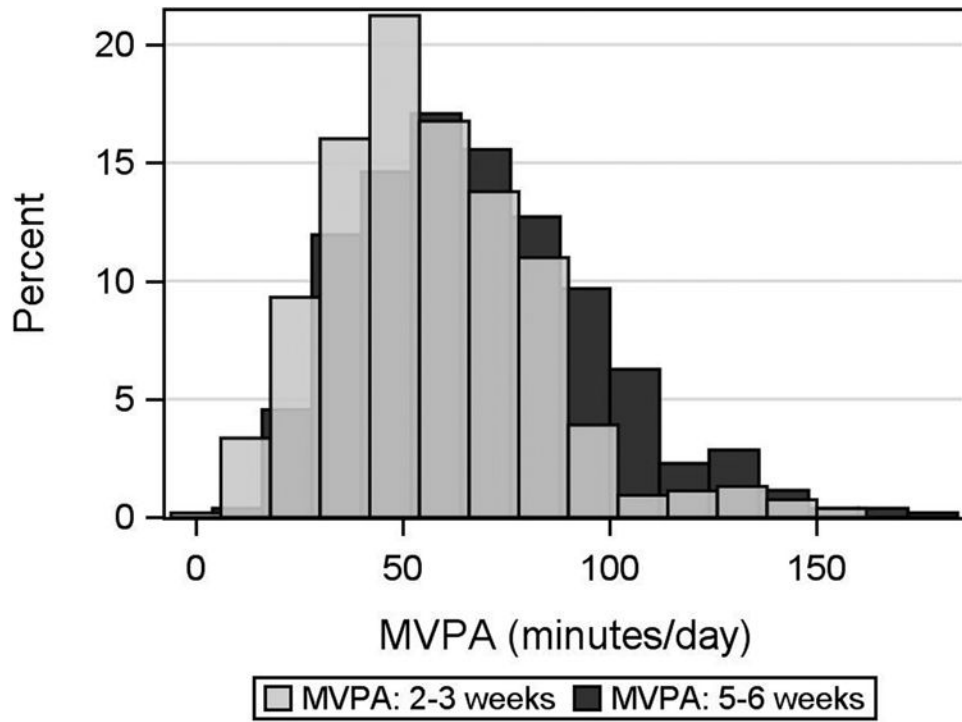


Fig. 2. Moderate to Vigorous Physical Activity (MVPA) at 2-3 weeks and 5-6 weeks postpartum

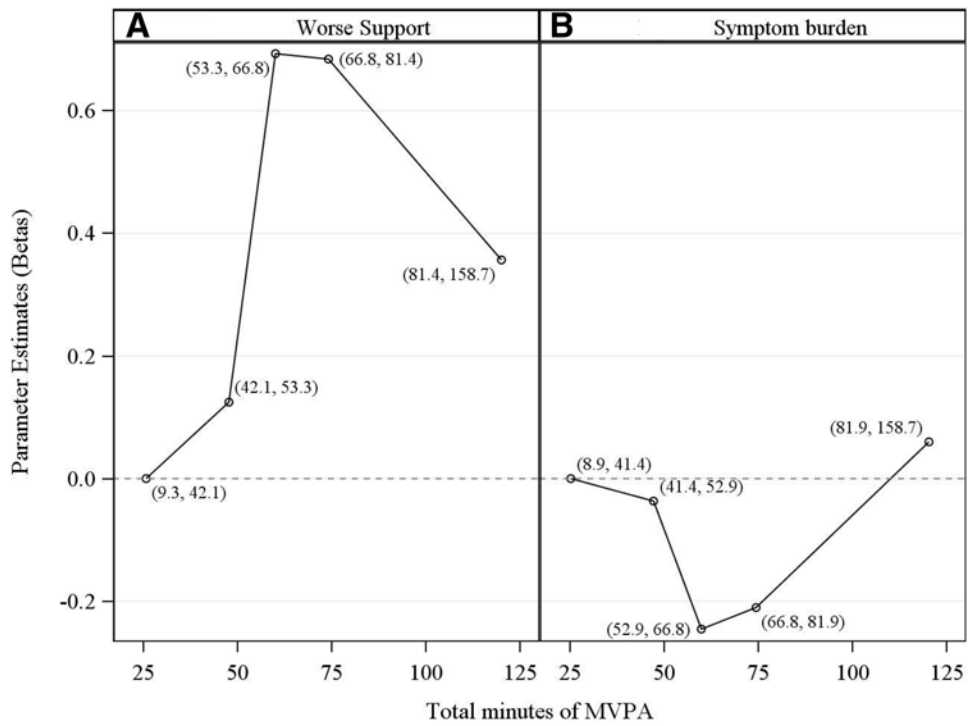


Fig. 3. Figures demonstrate plots of relationships between each primary outcome and MVPA. On the y-axis is displayed the log of the prevalence ratio for each quintile versus the reference quintile (1st). The log of the prevalence ratio is the parameter estimate beta from an unadjusted modified Poisson regression. The x-axis displays total minutes of MVPA averaged over the two early postpartum time-points at which these data were collected. Open circles represent betas plotted at the mid-point of each quintile. The range for each quintile, in minutes, is shown next to each mid-point.

Table 1.

Participant Characteristics

| Characteristic | Missing* | N=611 |
|---|-----------------|--------------------|
| Age at enrollment, years; mean (SD) | 1 | 28.9 (5.0) |
| Gestational age at enrollment, weeks; mean (SD) | 4 | 33.7 (2.5) |
| Ethnicity | 0 | |
| Hispanic | | 104 (17.0%) |
| Non-Hispanic | | 507 (83.0%) |
| Race | 0 | |
| Caucasian/White | | 562 (92.0%) |
| Other/do not wish to identify | | 49 (8.0%) |
| Education | 2 | |
| High school or less | | 66 (10.8%) |
| Some college/completed college | | 362 (59.4%) |
| Graduate or professional degree | | 181 (29.7%) |
| Work status | 2 | |
| Working full-time (≥ 30 hours per week) | | 408 (67.0%) |
| Working part-time (< 30 hours per week) | | 67 (11.0%) |
| Other (student, homemaker, disabled) | | 134 (22.0%) |
| Heavy lifting or heavy work in 3 rd trimester | 3 | 197 (32.2%) |
| Smoking in 3 rd trimester | 5 | 7 (1.2%) |
| Diabetes, preexisting or gestational | 1 | 26 (4.3%) |
| Hypertension, preexisting or gestational | 1 | 9 (1.5%) |
| Family history of pelvic organ prolapse or urinary incontinence | 39 | 214 (37.4%) |
| Maximal vaginal descent ≥ 0 cm at 3 rd trimester | 0 | 19 (3.1%) |
| SUI at 3 rd trimester | 3 | 299 (49.2%) |
| UUI at 3 rd trimester | 4 | 53 (8.7%) |
| AI at 3 rd trimester | 4 | 152 (25.0%) |
| AT DELIVERY | | |
| Mode of delivery | 0 | |
| Normal spontaneous vaginal delivery | | 550 (90.0%) |
| Vacuum assisted delivery | | 13 (2.1) |
| Forceps assisted delivery | | 47 (7.7%) |
| Anal sphincter laceration | 4 | 23 (3.8%) |
| Epidural anesthesia | 0 | 487 (79.7%) |
| Labor augmentation or induction | 2 | 379 (62.0%) |
| Duration of 2 nd stage of labor, minutes; median (IQR) | 154 | 83.0 (48.0, 142.0) |
| Birth weight, grams; mean (SD) | 11 | 3318.4 (396.3) |
| Presence of high-risk delivery variable | 0 | 163 (26.7%) |
| AT 5-10 WEEKS POSTPARTUM** | | |

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| Characteristic | Missing* | N=611 |
|--|----------|--------------|
| Body mass index, kg/m ² ; mean (SD) | 17 | 26.2 (4.9) |
| Work status | 28 | |
| Working full-time (≥ 30 hours per week) | | 52 (8.9%) |
| Working part-time (< 30 hours per week) | | 43 (7.4%) |
| Other | | 488 (83.7%) |
| Heavy lifting (other than baby) or heavy work in past 7 days | 29 | 158 (27.2%) |
| Performs pelvic floor muscles exercises, n (%) IF YES: | 28 | 296 (50.8%) |
| IF YES: | | |
| More than once a day/every day | | 85 (28.9%) |
| Less than daily but more than weekly | | 185 (62.9%) |
| Less than weekly | | 24 (8.2%) |
| Currently breastfeeding | 29 | 521 (89.5%) |
| UTI since delivery | 29 | 27 (4.6%) |
| Hormonal contraception | 28 | 290 (47.5%) |
| Chronic cough** | 28 | 8 (1.4%) |
| AT 1 YEAR POSTPARTUM** | | |
| Body mass index, kg/m ² ; mean (SD) | 49 | 24.84 (5.62) |
| Heavy lifting (other than baby) or heavy work in past 7 days | 3 | 267 (43.9%) |
| Work status | 2 | |
| Working full-time (≥ 30 hours per week) | | 308 (50.6%) |
| Working part-time (< 30 hours per week) | | 127 (20.9%) |
| Other | | 174 (28.6%) |
| Performs pelvic floor muscles exercises, n (%) IF YES: | 5 | 174 (28.7%) |
| IF YES: | | |
| More than once a day/every day | | 31 (17.8%) |
| Less than daily but more than weekly | | 106 (60.9%) |
| Less than weekly | | 37 (21.3%) |
| Currently breastfeeding | 2 | 278 (45.7%) |
| Chronic cough | 4 | 13 (2.1%) |

* Percentages reflect the denominators with complete data for each variable. Family history of prolapse or urinary incontinence was added to the initial questionnaire after enrollment began, and one of the participating hospitals did not record duration of 2nd stage of labor, accounting for larger number of missing responses for these variables.

** 28 women did not complete the 5-10 week questionnaire. 49 women completed only the 1-year questionnaire and not the examination.

Table 2.

Types of self-reported activities according to quintile of average daily minutes of Moderate to Vigorous Physical Activity (MVPA) at each time point *

| Time | MVPA Quintile (minutes per day) | Activity that does not involve bouncing, jumping, straining or heavy lifting | Activity that involves some bouncing or easy running and or greater effort | Activity that involves hard running or straining | Activity that involves heavy lifting or work | Lifting weights at the gym |
|-----------|---------------------------------|--|--|--|--|----------------------------|
| 2-3 weeks | 4.8 - 35.5 | 67 (17.2) | 6 (7.1) | 1 (5.9) | 6 (8.6) | 1 (5.6) |
| | 35.5 – 48.4 | 77 (19.8) | 11 (13.1) | 1 (5.9) | 13 (18.6) | 4 (22.2) |
| | 48.4 - 60.5 | 88 (22.6) | 24 (28.6) | 2 (11.8) | 17 (24.3) | 2 (11.1) |
| | 60.5 - 77.5 | 74 (19) | 22 (26.2) | 6 (35.3) | 16 (22.9) | 3 (16.7) |
| | 77.5 - 153.1 | 83 (21.3) | 21 (25) | 7 (41.2) | 18 (25.7) | 8 (44.4) |
| 5-6 weeks | 11.2 - 42.3 | 61 (16.1) | 25 (13.4) | 7 (9.1) | 21 (15) | 6 (10.9) |
| | 42.3 - 58.6 | 71 (18.7) | 31 (16.6) | 12 (15.6) | 26 (18.6) | 10 (18.2) |
| | 58.6 - 72.5 | 84 (22.2) | 43 (23) | 12 (15.6) | 22 (15.7) | 7 (12.7) |
| | 72.5 - 90.5 | 82 (21.6) | 40 (21.4) | 20 (26) | 35 (25) | 13 (23.6) |
| | 90.5 - 177.1 | 81 (21.4) | 48 (25.7) | 26 (33.8) | 36 (25.7) | 19 (34.5) |

* The population for this analysis includes participants with both valid accelerometry and completed physical activity questionnaires at each time-point (537 at 2-3 weeks postpartum and 527 at 5-6 weeks postpartum). Quintiles are shown for average daily minutes of MVPA according to wrist accelerometry at each time-point. Participants reported activity types performed for at least 10 minutes in the last 7 days, according to the modified Bone Loading Questionnaire. Participants could report more than one, or no, types of activities. Column percentages reflect the proportion of women that reported each activity type according to their objectively measured quintile of MVPA. Some column counts do not add up to 100% due to missing responses in some individual activity questions.

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Table 3a.

Univariate and final multivariable models summarizing prevalence of worse support at 1 year postpartum

| | Univariate PR (95% CI) | P | Multivariable PR (95% CI)* | P |
|--|---------------------------|-------|-------------------------------|--------|
| MVPA postpartum | | | | |
| Q (Quintiles) 3,4 vs Q1, 2 (reference) | 1.87 (1.03, 3.4) | 0.041 | 1.80 (1.00, 3.26) | 0.052 |
| Q5 vs Q1, 2 (reference) | 1.34 (0.62, 2.88) | 0.456 | 1.26 (0.58, 2.72) | 0.554 |
| Q 5 vs Q 3, 4 (reference) | 0.72 (0.36, 1.42) | 0.343 | 0.70 (0.35, 1.38) | 0.304 |
| Age, 30.4 (age quintiles 4,5) vs <30.4 (age quintiles 1,2,3) | 2.12 (1.26, 3.56) | 0.005 | 2.18 (1.30, 3.66) | 0.003 |
| High-risk delivery factor (yes vs no) | 1.43 (0.86, 2.39) | 0.173 | 1.02 (0.65, 1.59) | 0.933 |
| Ethnicity (Hispanic vs non-Hispanic) [#] | 0.78 (0.36, 1.67) | 0.518 | 1.00 (0.48, 2.08) | 1.000 |
| Support in 3 rd trimester (worse vs better ^{**}) [#] | 4.09 (2.03, 8.24) | <.001 | 3.37 (1.80, 6.29) | <0.001 |
| Education (professional vs college or less) [#] | 1.36 (0.8, 2.29) | 0.257 | 0.77 (0.42, 1.42) | 0.406 |
| Chronic cough at 5-10 weeks postpartum (yes vs no) ^{***} | 1.3 (0.2, 8.29) | 0.780 | N/A | N/A |
| Breastfeeding at 5-10 weeks postpartum (yes vs no) [#] | 5 (0.71, 35.35) | 0.107 | 3.55 (0.51, 24.79) | 0.202 |
| Body mass index (BMI) at 5-10 weeks postpartum [#] | | | | |
| 25- <30 vs < 25 kg/m ² | 0.77 (0.44, 1.35) | 0.364 | 0.89 (0.50, 1.58) | 0.692 |
| 30 vs < 25 kg/m ² | 0.34 (0.12, 0.94) | 0.037 | 0.38 (0.14, 1.08) | 0.070 |

* Final model (n=562) includes multiple imputation on missing values. Prior to imputation, n=533. There were no statistically significant differences in MVPA category according to the frequency of missing responses for any variable.

** Worse=maximal vaginal descent ≥ 0 cm; Better = maximal vaginal descent < 0 cm.

*** Omitted from multivariable model due to small cell counts

[#]The multivariable model based on the directed acyclic graph designed to test the total effect of MVPA on worse support is also appropriate to test the total effect of age and high-risk delivery factor on worse support, but reflects direct or 'partial' effects for the other variables after MVPA, a downstream intermediate variable, has been adjusted. The total effects of these variables include indirect effects that may be mediated via MVPA. Therefore, guided by separate DAGs to determine adjustment factors for the other variables in the above model, we created additional models designed to test the total effect of each of the other variables after adjustment. The total effects of these other variables are as follows: Ethnicity: PR 0.96 (95% CI 0.45, 2.03), p=0.91 (adjusted for age, high-risk delivery factor, antenatal support, education, breastfeeding at 5-10 weeks postpartum, BMI at 5-10 weeks postpartum). Antenatal support: PR 3.81 (95% CI 1.99, 7.33), p<0.0001 (adjusted for age, high-risk delivery factor, ethnicity, education, breastfeeding at 5-10 weeks postpartum, BMI at 5-10 weeks postpartum). Education: PR 0.83 (95% CI 0.46, 1.51), p=0.55 (adjusted for age, high-risk delivery factor, antenatal support, ethnicity, breastfeeding at 5-10 weeks postpartum, BMI at 5-10 weeks postpartum). Breastfeeding at 5-10 weeks postpartum: PR 3.4 (95% CI 0.48, 23.91), p=0.22 (adjusted for age, high-risk delivery factor, antenatal support, ethnicity, education, BMI at 5-10 weeks postpartum). BMI at 5-10 weeks postpartum: PR 0.76 (95% CI 0.37, 1.59), p=0.47 for 25- <30 vs < 25 kg/m², and PR 0.26 (95% CI 0.07, 0.95), p=0.04 for 30 vs < 25 kg/m² (adjusted for age, high-risk delivery factor, antenatal support, ethnicity, breastfeeding at 5-10 weeks postpartum, education, pre-pregnancy BMI).

Table 3b.

Univariate and final multivariable models summarizing prevalence of symptom burden outcome at 1 year postpartum

| | Univariate PR (95% CI) | P | Multivariable PR (95% CI)* | P |
|--|------------------------|-------|----------------------------|--------|
| MVPA postpartum | | | | |
| Q (Quintiles) 3,4 vs Q1,2 (reference) | 0.81 (0.68, 0.96) | 0.017 | 0.83 (0.71, 0.98) | 0.028 |
| Q5 vs Q1,2 (reference) | 1.08 (0.91, 1.29) | 0.382 | 1.12 (0.94, 1.32) | 0.202 |
| Q 5 vs Q 3, 4 (reference) | 1.33 (1.10, 1.62) | 0.003 | 1.34 (1.11, 1.61) | 0.002 |
| Age, ≥30.4 (age quintiles 4,5) vs <30.4 (age quintiles 1,2,3) | 1.03 (0.96, 1.1) | 0.468 | 1.00 (0.98, 1.01) | 0.686 |
| High-risk delivery factor (yes vs no) | 1.19 (1.03, 1.37) | 0.021 | 1.21 (1.03, 1.42) | 0.019 |
| Ethnicity (Hispanic vs non-Hispanic) [#] | 0.77 (0.61, 0.97) | 0.026 | 0.80 (0.65, 0.99) | 0.042 |
| SUI, UUI or AI in 3 rd trimester (present vs absent) ^{**} , [#] | 1.93 (1.61, 2.33) | <.001 | 1.92 (1.60, 2.30) | <0.001 |
| Education (professional vs college or less) [#] | 0.95 (0.81, 1.12) | 0.565 | 0.90 (0.76, 1.07) | 0.222 |
| Chronic cough at 5-10 weeks postpartum (yes vs no) ^{***} | 0.52 (0.16, 1.69) | 0.277 | N/A | N/A |
| Breastfeeding at 5-10 weeks postpartum (yes vs no) [#] | 1.04 (0.81, 1.34) | 0.754 | 0.96 (0.75, 1.23) | 0.754 |
| Body mass index (BMI) at 5-10 weeks postpartum [#] | | | | |
| 25- <30 vs < 25 | 1.05 (0.89, 1.24) | 0.540 | 1.02 (0.87, 1.20) | 0.827 |
| 30 vs < 25 | 1.05 (0.86, 1.28) | 0.629 | 1.04 (0.87, 1.25) | 0.647 |

* Final model (n=609) includes multiple imputation on missing values. Prior to imputation, n=575. There were no statistically significant differences in MVPA category according to the frequency of missing responses for any variable.

** SUI=Stress urinary incontinence; UUI= Urgency urinary incontinence; AI=Anal incontinence

*** Omitted from multivariable model due to small cell counts

[#]The multivariable model based on the directed acyclic graph designed to test the total effect of MVPA on symptom burden is also appropriate to test the total effect of age and high-risk delivery factor on worse support, but reflects direct or 'partial' effects for the other variables after MVPA, a downstream intermediate variable, has been adjusted. The total effects of these variables include indirect effects that may be mediated via MVPA. Therefore, guided by separate DAGs to determine adjustment factors for the other variables in the above model, we created additional models designed to test the total effect of each of the other variables after adjustment. The total effects of these other variables are as follows: Ethnicity: PR 0.80 (95% CI 0.64, 0.99), p=0.04 (adjusted for age, high-risk delivery factor, antenatal SUI, UUI or AI, education, breastfeeding at 5-10 weeks postpartum, BMI at 5-10 weeks postpartum). Antenatal SUI, UUI or AI: PR 1.93 (95% CI 1.60, 2.32), p<0.0001 (adjusted for age, high-risk delivery factor, antenatal support, ethnicity, education, breastfeeding at 5-10 weeks postpartum, BMI at 5-10 weeks postpartum).

Education: PR 0.90 (95% CI 0.76, 1.06), p=0.20 (adjusted for age, high-risk delivery factor, antenatal SUI, UUI or AI, ethnicity, breastfeeding at 5-10 weeks postpartum, BMI at 5-10 weeks postpartum). Breastfeeding at 5-10 weeks postpartum: PR 0.97 (95% CI 0.77, 1.22), p=0.81 (adjusted for age, high-risk delivery factor, antenatal SUI, UUI or AI, ethnicity, education, BMI at 5-10 weeks postpartum). BMI at 5-10 weeks postpartum: PR 1.01 (95% CI 0.84, 1.21), p=0.93 for 25- <30 vs < 25 kg/m², and PR 1.02 (95% CI 0.75, 1.37), p=0.92 for ≥ 30 vs < 25 kg/m² (adjusted for age, high-risk delivery factor, antenatal SUI, UUI or AI, ethnicity, breastfeeding at 5-10 weeks postpartum, education, pre-pregnancy BMI).