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Sedentary behaviour and physical activity across pregnancy and birth outcomes

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Abstract

Background: Shorter gestation or smaller birth size are indicators of a suboptimal fetal environment and negatively impact short- and long-term offspring health. Understanding how modifiable maternal behaviours, such as moderate-to-vigorous intensity physical activity (MVPA) or sedentary behaviour (SED), improve fetal outcomes could inform strategies to improve health across the lifespan.

Objectives: The objective of this study was to examine the association of MVPA and SED across pregnancy trimesters on gestational age at delivery and newborn anthropometrics.

Methods: The MoM Health Study measured SED (thigh-mounted activPAL3 micro) and MVPA (waist-worn Actigraph GTX3) in each trimester of pregnancy. Birth outcomes (gestational age at delivery, birthweight, birth length, and head circumference) were abstracted from medical records and used to calculate ponderal index (grams*100/cm^3) and size-for-gestational age percentiles. Associations of group-based trajectories and trimester-specific SED and MVPA with birth outcomes were analysed using regression models.

Results: Low, medium, and high trajectory groups were generated SED and MVPA in 103 and 99 pregnant women, respectively. High vs low SED trajectory was associated with earlier gestational age at delivery β −1.03 weeks, 95% CI −2.01, −0.06), larger head circumference β 0.83 cm, 95% CI 0.24,1.63), longer birth length (β1.37 cm, 95% CI 0.09, 2.64), and lower ponderal index (β −0.24 g*100/cm^3, 95% CI −0.42, −0.06), after adjustment for demographics, pre-pregnancy BMI, and (for newborn anthropometric outcomes) gestational age. The association of high SED with lower ponderal index was the most robust across progressively adjusted models β −0.25 g*100/cm^3, 95% CI −0.44, −0.07). SED trajectory was not associated with birthweight or

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SUPPORTING INFORMATION

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size-for-gestational age. High vs low MVPA trajectory was only associated with smaller head circumference β −0.86 cm, 95% CI −1.70, −0.02).

Conclusions: Higher SED during pregnancy may result in shorter gestation and inhibited fetal growth. Further research evaluating the effect of reducing SED during pregnancy on birth outcomes is warranted.

Keywords

DOHaD; gestational age at delivery; newborn anthropometrics; objective activity monitoring

1 | BACKGROUND

The Developmental Origins of Health and Disease (DOHaD) theory[1] relates exposures in utero to lifespan health. Studies have consistently demonstrated a link between insufficient fetal environment and growth restriction with increased cardiometabolic disease morbidity and mortality across the lifespan.[2-4] Within this framework, it is hypothesised that an insufficient fetal environment leads to permanent alterations in the structure and physiology of the developing fetus, predisposing the individual to adult disease.[5] An improved understanding of how modifiable maternal factors affect fetal health may inform a novel approach to prevent the cascade of chronic disease development beginning in utero.

Outcomes at birth, including gestational age at delivery (GAD) and newborn anthropometric measures, have been extensively studied as indicators of the fetal environment and DOHaD related risk across the lifespan. From preterm to full term, a gradient of health risks exist[6] in which shorter gestation is associated with poorer motor development,[7-9] higher blood pressure, [10,11] poorer intellectual functioning,[11] and lower cardiorespiratory fitness.[12] Additionally, birth anthropometries, such as birthweight (BW), birth length (BL), head circumference (HC), weight-for-gestational age, and weight-for-length (eg ponderal index: BW (g) × 100/BL(cm)^3),are used as proxy of adequacy of the fetal environment.[13,14] Weight-for-gestational age uses population-based percentiles to categorise newborns as small (<10th percentile [SGA]) or large (>90th percentile [LGA]) for gestational age.[15] Ponderal index (PI) is a measure of body proportionality or “thinness” at birth and is considered a stronger indicator of growth restriction[16,17] and lifespan health risk.[13] Consistent with the DOHaD hypothesis, smaller birth anthropometric measures are associated with poorer metabolic function,[18] higher blood pressure,[18,19] and higher body fat in childhood[20,21] as well as type 2 diabetes and cardiovascular disease risk in adulthood.[14]

A novel hypothesis is that the maternal activity profile during pregnancy, including physical activity and sedentary behaviour (SED), could also affect offspring health risk across the lifespan. Activity during pregnancy is related to energy metabolism[22] and nutrient transport in the placenta[23] and therefore may impact the fetal environment and subsequent birth outcomes. Higher levels of moderate-to-vigorous intensity physical activity (MVPA) have not been associated with GAD[24] but are consistently associated with more optimal fetal growth by reducing LGA risk without increasing SGA risk.[24-28] Less is known about the associations of SED (low intensity behaviours in a sitting, reclining, or lying position)[29] during pregnancy with infant outcomes. Pregnant women spend more than half of their day

in SED[30] and a pattern of activity with excessive or limited SED could impact the fetal environment. The limited research assessing this relation has found no significant associations between sedentary behaviour and size at birth. However, these studies have measured sedentary behaviour by self-report,[31-33] which likely has significant error in measurement,[34] or only report birthweight, as an outcome [35,36] which may not capture the effects of inhibited growth as a weight-for-length measure would. Thus, more research is needed to understand associations between objectively measured SED with GAD and newborn anthropometrics.

The primary objective of this study was to examine the association of objectively measured SED and MVPA trajectories across pregnancy with GAD and newborn anthropometrics. A secondary objective was to evaluate trimester-specific associations of activity pattern with outcomes.

2 | METHODS

The present study is a secondary analysis of the Monitoring Movement and Health Study (MoM Health), a cohort study assessing objectively measured SED and MVPA across each trimester of pregnancy and associations with pregnancy outcomes. To be eligible, women were less than 14 weeks pregnant, receiving prenatal care at a University of Pittsburgh Medical Center facility, and between the ages of 18 and 45. Women were excluded from participation if they were taking medication for diabetes or hypertension, had a severe medical condition, had severely limited mobility, or were participating in a research study to modify lifestyle behaviours. Participants attended three study visits, once in each trimester, which occurred between 8 to <14 weeks, 20 to <23 weeks, and 32 to <35 weeks gestation. At each visit, participants received two monitors (described below) to objectively measure SED and MVPA using best-practice methodology.[37,38] All research procedures were approved by the University of Pittsburgh Institutional Review Board.

2.1 | Measures

2.1.1 | Maternal characteristics—Age, race, income, and education were obtained from a demographic questionnaire completed at the first trimester visit. Pre-pregnancy body mass index (BMI) was calculated using self-reported pre-pregnancy weight abstracted from patient medical records and height measured in duplicate at the first trimester visit using a stadiometer. Self-reported pre-pregnancy weight has been previously validated at the same recruitment site, Magee Womens Hospital ($r > .99$).[39]

2.1.2 | SED and MVPA measurement—At each visit, participants received two activity monitors and were instructed to wear both concurrently for the following 7 days. During this time, participants were instructed to complete a provided diary to record sleep and non-wear times.

SED was assessed using the thigh-mounted activPAL3 micro-accelerometer (PALtechnologies, Glasgow, Scotland) and recommended protocols for monitor use and data reduction.[37] Participants wore this monitor on the anterior midline of the upper thigh continuously (24-hour wear), only removed for swimming. Data were exported in event

format and trained research staff removed sleep and non-wear times using participant diaries.[37,40] A minimum 4 days with 10 hours of wear time were required to be included in analyses.[41] Mean SED (min) and monitor wear time (min) per day in each trimester were averaged across valid days.[26]

MVPA was assessed using a waist-worn Actigraph GT3X accelerometer (Actigraph, Pensacola, FL). Participants wore this monitor during waking hours on a waist belt with the monitor positioned in line with the right kneecap, below the gravid abdomen, and to remove the monitor for sleep, bathing, and swimming. Data were analysed in one-minute epochs using Actilife v6.12.2 software. Nonwear was classified using the Choi algorithm[42] and Freedson 2011 VM cutpoints were used for classifying MVPA.[43] Mean MVPA time per day (min) and monitor wear time per day (min) in each trimester were averaged across valid wear days. A minimum of 4 days with 10 hours of wear time were required to be included in analysis.[41]

To describe activity across pregnancy, trajectories were generated separately for SED and MVPA using group-based trajectory analysis.[44] Best fit for trajectory groups were selected based on the Bayesian information criteria (BIC), greatest percentage of participants placed in groups with a posterior probability of ≥70%, and clinical relevance. Participants were assigned to one SED and one MVPA trajectory group that most closely fit their activity pattern across pregnancy.

2.2 | Birth outcomes

2.2.1 | Birth outcomes—Delivery and birth records were abstracted from mother and child's medical records including GAD, BW, HC, and BL. PI was calculated as a measure of thinness at birth for all newborns using the equation: BW (g) × 100/length (cm^3). Birthweight-for-gestational age percentiles were calculated using the Global Bulk Centile Calculator (BCC version 8.0.4,2019). Newborns were classified as LGA or SGA if classified as >90th or <10th percentiles, respectively.[15]

2.3 | Statistical analysis

Analyses were conducted using Stata v14 (College Station, TX). Demographics and clinical outcomes were summarised as mean (standard deviation [SD]) or number (percentage) overall and by trajectory group.

Associations of outcomes with maternal activity profile were analysed using three methods: 1) SED and MVPA across pregnancy using categorical trajectory groups, 2) trimester-specific SED and MVPA minutes (continuous) using separate models for each trimester, and 3) overall SED and MVPA minutes averaged across all three trimesters. Trimester-specific SED and MVPA were visually inspected for normality and were found to be roughly normally distributed. Linearity of activity associations with outcomes was assessed using lowess smoothing function and were found to be linear.

Trajectory group, trimester-specific, and overall associations of SED and MVPA with GAD were analysed using linear regression models. Results are presented as unadjusted (Model

1), partially adjusted (Model 2 including maternal age, pre-pregnancy BMI, and race), and fully adjusted (Model 3 adding concurrent activity adjustment to Model 2).

Trajectory group, trimester-specific, and overall associations of SED and MVPA with birth anthropometrics were analysed using linear regression models. Analyses are presented as unadjusted, adjusted only for GAD (Model 1), partially adjusted (Model 2 adding adjustment of maternal age, pre-pregnancy BMI, race), and fully adjusted (Model 3 adding concurrent activity adjustment to Model 2). Semipartial correlations were examined the effect size (meaningfulness) of associations in which <0.2 is considered weak, 0.2-0.5 moderate, and >0.5 strong effect.[45] Risk ratios for SGA or LGA by SED and MVPA trajectory groups were calculated using separate generalised linear models (adequate for gestational age (AGA) vs SGA and AGA vs LGA). Since the Global Bulk Centile Calculator provides birthweight-for-gestational age percentiles already adjusted for potential confounders such as race, sex, and pre-pregnancy BMI, these were not included as covariates in these models.

Of 120 women recruited, 103 women had valid SED in least one trimester and available infant medical records. Due to attrition, lost-monitors, or monitor failure (n = 4) fewer participants were available for models including MVPA. Beta coefficients in trimester-specific models were standardised to represent the estimated change in the outcome per one SD of SED (trimester one: 94.9, two: 85.4, three: 81.1 minutes) or MVPA (trimester one: 15.6, two: 16.1, three: 16.1 minutes).

3 | RESULTS

Participant characteristics are summarised in Table 1, overall and by trajectory groups. Participants were primarily highly educated (69%, college degree or higher) and high income (52%,>$75 000 per year). Approximately 24% were black/other. Characteristics did not significantly differ by trajectory groups.

3.1 | SED and MVPA trajectories

Pregnant women, on average, spent 3.6% (SD: 1.8%) of the day in MVPA while a much greater proportion of the day, 63.7% (SD: 9.7%), was spent in SED. Three trajectory groups (low, medium, and high) were generated for both SED and MVPA. These behaviours remained stable across pregnancy within trajectory groups. In the low, medium, and high groups, mean (SD) SED was 7.9 (0.7), 9.2 (0.7), and 10.7 (0.7) hours per day and MVPA was 15.9 (5.3), 31.6 (5.9), and 51.1 (10.1) minutes per day, respectively.

3.2 | Associations of SED and MVPA with GAD

SED trajectory was not associated with GAD in unadjusted models. In model 2, being in the high vs low SED group was associated with earlier GAD (β −1.03 weeks, 95% CI: −2.01, −0.06). In model 3, this association was attenuated (β −0.79 weeks, 95% CI: −1.64, 0.06). MVPA trajectory was not associated with GAD in unadjusted or adjusted models (Table 2).

Adjusted associations of overall and trimester-specific SED or MVPA with GAD are reported in Table S1. MVPA was not associated with GAD in any trimester. Consistent with

the trajectory findings, higher overall SED was related to a lower GAD (std. β −0.38 weeks, 95% CI −0.69, −0.07). Associations between higher SED and lower GAD approached statistical significance in the first (std. β −0.32 weeks, 95% CI −0.67, 0.02) and second trimesters (std. β −0.32 weeks, 95% CI −0.66, 0.01).

3.3 | Associations of SED and MVPA with newborn anthropometrics

Associations of SED and MVPA trajectories with newborn anthropometrics are presented in Table 3. High vs low SED was associated with larger HC (β 0.83 cm, 95% CI 0.24,1.63), longer BL (β 1.37 cm, 95% CI 0.09, 2.64), and lower PI (β −0.24 g*100/cm^3, 95% CI −0.42, −0.06) after adjustment in model 2. Associations between high SED trajectory and newborn anthropometrics remained significant for PI (β −0.25 g*100/cm^3, 95% CI −0.44, −0.07) with the additional adjustment for MVPA (model 3). SED explained 11% of the variance in PI and semipartial correlations indicate a moderate effect size (βstdXY: 0.264) in the fully adjusted model. SED trajectory was not associated with BW.

High vs low MVPA was associated with smaller HC in all models. In unadjusted models, high vs low MVPA was associated with smaller BW and shorter BL though this was attenuated with adjustment for GAD. MVPA was not associated with BW, BL, or PI in any adjusted models.

Adjusted associations of overall and trimester-specific SED and MVPA with newborn anthropometrics are reported in Table S2. Higher MVPA in the second trimester was associated with lower BW (std. β −96.81 g, 95% CI −189.81, −3.82) and smaller HC (std. β −0.35 cm, 95% CI −0.68, −0.01). Higher SED was not associated with BW or HC but was associated with longer BL in the first (std. β 0.60 cm, 95% CI 0.06, 1.13) and third trimesters (std. β 0.55 cm, 95% CI 0.12, 0.99) and overall across pregnancy (std. β 0.65 cm, 95% CI 0.17, 1.10). Consistent with trajectory models, the most robust finding was that higher SED was associated with lower PI overall and in all three trimesters (ranged from std. β −0.11 g*100/cm^3, 95% CI −0.18, −0.04, to std. β −0.08 g*100/cm^3 95% CI −0.14, −0.02).

Risk ratios for SGA or LGA, with AGA as the reference, are presented in Table S3. No SED or MVPA trajectories were associated with SGA or LGA risk. Trimester-specific and overall associations of SED and MVPA with risk of SGA or LGA were similar to those observed in trajectory models (data not shown).

4 | COMMENTS

4.1 | Principal findings

The main findings of this study are that the maternal activity profile during pregnancy is associated with fetal growth and length of gestation, with more robust findings observed for SED. Women in the highest vs lowest SED trajectory group had shorter length of gestation and, even after accounting for this shorter gestation, gave birth to infants with larger HC, longer BL, and lower PI (thinner infants). The association of higher SED with lower PI was the most robust across progressively adjusted trajectory models and trimester-specific associations. HC was the only outcome associated with MVPA, with women in the highest vs lowest MVPA trajectory group giving birth to infants with smaller HC. Combined with

the finding that SED, consumes the majority of the day, a much larger portion than MVPA, our findings highlight maternal SED across pregnancy as a potentially important factor in fetal growth.

4.2 | Strengths of the study

This study had several strengths including the use of best-practice SED and MVPA measurement as well as the prospective design with measurement in each trimester. There was also a high data capture rate from medical record data abstraction. This study included a group with diverse activity patterns, pre-pregnancy BMI, and age which makes these findings more generalisable.

4.3 | Limitations of the data

The small sample size of this study and the small number of adverse pregnancy outcomes, such as preterm births, may lead to unstable estimates and limits the strength of our conclusions. Though we statistically adjusted for important confounders, residual confounding or reverse causality due to underlying maternal chronic illness may be influencing our reported associations. Further, external validity of our findings may be limited by homogeneity of this study sample.

4.4 | Interpretation

4.4.1 | Associations of SED and MVPA with GAD—Previous research has demonstrated a gradient of health risks from preterm to full term, with shorter gestation being associated with poorer health outcomes.[6] Shorter gestation is associated with a higher blood pressure[10,11] and poorer cardiorespiratory fitness[12] in adulthood, as well as slower cognitive and motor development in childhood.[7-9] Historically, misconceptions had surrounded MVPA during pregnancy with the belief that exercise may increase risk of preterm birth.[46] Since then, MVPA has proven to be safe and is encouraged during pregnancy.[47] Consistent with our findings where MVPA was not associated with gestational age, a meta-analysis of 17 randomised control trials found no difference in GAD between exercise intervention and control groups.[24] On the other hand, we did not identify any previous studies which examined SED during pregnancy and GAD. In the present study, women with high vs low SED had shorter gestation. The mechanisms by which SED may decrease gestation time are unclear. One possible explanation is that higher SED could be related to more scheduled inductions or medically indicated procedures, which may supersede the natural labour process. Taken together, longer gestation up to 40 weeks is preferable for short- and long-term infant health. Our research confirms MVPA appears to have no association with gestational age but provides preliminary evidence that high levels of SED are a novel risk factor for shorter GAD.

4.2.2 | Associations of SED and MVPA with newborn anthropometrics—Previous observational studies have found no associations of self-reported SED with HC, BW, or PI,[31,32] or objectively measured maternal SED at one time-point during pregnancy with BW only.[35,36] However, one randomised controlled trial, which delivered nutritional and/or physical activity education to mothers during pregnancy, found lower neonatal adiposity, measured by skinfold, in intervention versus control groups. A mediation analysis

in this study found that a reduction in self-reported SED explained the association with reduced neonatal adiposity.[33] Our group has previously demonstrated that self-report underestimates and is poorly associated with objectively measured SED[34]; therefore, the effects of SED during pregnancy on fetal growth remain poorly understood. Our study differs from previous research by the use of gold-standard measure of SED (activPAL3) across all trimesters of pregnancy and indicates a threshold effect in which being in the highest SED group (mean: 10.7 hours/day) appears to have an adverse association with fetal growth. The most robust association was with PI. During periods of malnutrition *in utero*, length is prioritised at the expense of weight, resulting in disproportionate growth and a lower PI.[48] Malnutrition *in utero* is the premise of the DOHaD theory in which a lower PI is associated with increased risk for higher adiposity in childhood[20] as well as hypertension,[49] type II diabetes,[50] and cardiovascular disease in adulthood.[51] Taken together with our findings in which higher SED was related to lower PI and longer BL, this suggests an important role of SED in some aspects of fetal development. While no standard population distribution data are available, similar differences in PI between high and low SED in our study have been associated with higher rate of coronary heart disease in adulthood,[52] indicating a potential clinical significance of this difference. Anthropometric measures such as BW or size-for-gestational age are commonly used as proxy measures of growth restriction throughout the literature; however, our results demonstrate the importance using weight-for-length measure to capture the effects of maternal factors on fetal growth. The consistent and strong associations of high SED with low PI in the present study highlight a need for more research on SED during pregnancy within the context of the DOHaD theory.

In contrast to the limited data available evaluating maternal SED and newborn anthropometrics, several meta-analyses have evaluated the effect of MVPA on birth size. These studies have demonstrated a favourable effect of reduced risk of LGA, without increasing the risk for SGA, in exercise groups.[24-28] The meta-analyses of randomised control trials demonstrating a decreased LGA risk may capture the effect of introducing exercise to typically inactive women. The observational nature of our study captures habitual exercise which could provide one explanation as to why we did not see a reduced risk of LGA in more active women. There is less evidence regarding other birth anthropometrics. One meta-analysis found no association between objective or subjective measures of MVPA with PI or BW.[25] In a meta-analysis of exercise timing, a modest inverse relation was found between self-reported MVPA in late pregnancy (30 + weeks gestation) with decreasing PI, BW, and risk of LGA, but the same associations were not observed in early (8-18 weeks) pregnancy.[53] In our trimester-specific models, only one unique association was found in which higher MVPA in the second trimester was associated with lower BW. The aforementioned meta-analysis on exercise timing used only early vs late pregnancy, and therefore is difficult to compare to our findings within the second trimester. Our study also found that being in the high MVPA trajectory was associated with smaller HC, lower BW, and shorter BL, however, only associations with HC remained significant after adjustment for GAD and other relevant covariates. The mean HC in the high MVPA group was 33.58 cm (SD = 1.45), compared to 34.7 cm (SD = 1.42) in the low MVPA group. We do not believe this to be a clinically meaningful finding as these values are within normal range for HC according to growth standards.[54] Taken together, MVPA has been shown to reduce risk

for LGA newborn without increasing the risk of SGA and may be related to other measures of fetal growth. The lack of research examining associations of objectively measured MVPA with birth anthropometrics outside of size-for-gestational age makes it difficult to ascertain the relation with fetal growth.

5 | CONCLUSIONS

Our findings indicate that higher SED during pregnancy may result in poorer fetal growth and reduced GAD, while MVPA was not associated with measures of fetal growth in a clinical meaningful way. PI may best capture associations between maternal activity profile (ie SED) and fetal growth as neither SED nor MVPA were associated with BW or size-for-gestational age.

Currently, there are no recommendations for limiting SED during pregnancy. Reducing SED during pregnancy may be a novel strategy to improve fetal growth *in utero*. However, more observational and experimental evidence is needed to determine the optimal SED and activity patterns during pregnancy in order to inform clinical and public health recommendations. Future research should also address the association of SED during pregnancy with a broader scope of maternal-child health outcomes, including long-term offspring health consistent with the DOHaD hypothesis.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Synopsis

Study question

Does maternal activity profile during pregnancy relate to newborn anthropometrics or length of gestation?

What's already known

Shorter gestational age at delivery and smaller size at birth have previously been associated with poorer long-term offspring health.

What this study adds

High amounts of sedentary behaviour during pregnancy is associated with shorter gestation and thinner, smaller newborns.

TABLE 1

Participant characteristics overall and by sedentary and MVPA trajectory groups

	Overall (n = 103)	Sedentary Trajectory (n = 103)			MVPA Trajectory (n = 99)		
		Low (n = 21)	Med (n = 39)	High (n = 43)	Low (n = 24)	Med (n = 52)	High (n = 23)
Mean (SD)							
Maternal age, y	31.1(4.9)	32.4 (4.9)	31.6 (4.0)	29.9 (5.5)	31.6 (5.4)	31.3 (4.1)	30.7 (5.7)
Pre-pregnancy BMI, kg/m^2	26.4(7.0)	29.1 (8.5)	25.3 (6.3)	26.3 (6.7)	26.9 (7.8)	25.6 (5.6)	26.1 (7.9)
Gestational age at delivery, wk	39.1 (1.8)	39.7 (1.1)	39.1 (1.2)	38.8 (2.3)	39.1 (1.0)	39.4 (1.6)	38.8 (1.5)
Birthweight, g	3327.4 (485.0)	3439.7 (390.7)	3352.0 (444.0)	3246.0 (559.3)	3414.6 (408.5)	3371.1 (501.6)	3106.0 (491.8)
Birth length, cm	50.9 (2.6)	50.5 (2.3)	50.8 (2.0)	51.2 (3.1)	51.4 (3.1)	50.8 (2.4)	50.0 (1.8)
Head circumference, cm	34.4 (1.6)	34.2 (1.6)	34.4 (1.4)	34.5 (1.8)	34.8 (1.4)	34.4 (1.6)	33.6 (1.5)
Ponderal index, g × 100/cm^3	2.5 (0.3)	2.7 (0.4)	2.6 (0.3)	2.4 (0.3)	2.5 (0.3)	50.8 (2.4)	2.5 (0.3)
n (%)							
Education							
Highschool/GED or less	11 (11)	1 (5)	4 (9)	6 (15)	3 (13)	2 (4)	3 (13)
Some college or training	21 (20)	7 (35)	7 (17)	7 (17)	6 (25)	7 (13)	7 (30)
College graduate	26 (25)	5 (25)	7 (17)	14 (34)	7 (29)	15 (29)	4 (17)
Masters/ Doctoral	45 (44)	7 (35)	24 (57)	14 (34)	8 (33)	28 (54)	9 (40)
Household Income							
<$35k	22 (21)	6 (30)	8 (19)	8 (20)	3 (12)	9 (17)	8 (35)
$35-<75k	19 (19)	6 (30)	9 (2)	4 (10)	4 (17)	11 (21)	4 (17)
>$75k	54 (52)	8 (40)	24 (57)	22 (53)	11 (46)	32 (62)	11 (48)
Race							
White	78 (76)	15 (75)	34 (81)	29 (71)	17 (71)	41 (79)	20 (87)
Black	18 (17)	3 (15)	5 (12)	10 (24)	5 (21)	6 (11)	3 (13)
Other	7 (7)	2 (10)	3 (7)	2 (5)	2 (8)	5 (10)	0
Smoking Status							
No	100 (97)	20 (100)	41 (98)	29 (95)	22 (92)	52 (100)	22 (96)
Yes	3 (3)	0	1 (2)	2 (5)	2 (8)	0	1 (4)

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TABLE 2

Differences in gestational age at delivery by sedentary and MVPA trajectory

	Low	Medium		High	
Trajectory	**β (95% CI)**	**β (95% CI)**	**βstdXY**	**β (95% CI)**	**βstdXY**
SED (n = 103)					
Model 1	0.00 (Reference)	−0.61 (−1.54, 0.33)	0.171	−0.88 (−1.82, 0.06)	0.247
Model 2	0.00 (Reference)	−0.65 (−1.62, 0.31)	0.182	−1.03 (−2.01, −0.06)	0.290
Model 3[a]	0.00 (Reference)	−0.69 (−1.51, 0.14)	0.230	−0.79 (−1.64, 0.06)	0.264
MVPA (n = 99)					
Model 1	0.00 (Reference)	0.23 (−0.49, 0.95)	0.079	−0.38 (−1.23, 0.47)	0.110
Model 2	0.00 (Reference)	0.26 (−0.46, 0.99)	0.090	−0.35 (−1.22, 0.51)	0.102
Model 3	0.00 (Reference)	0.10 (−0.64,0.85)	0.142	−0.49 (−1.36, 0.38)	0.036

Abbreviation: β, beta coefficient (wk)

Model 1 presents unadjusted associations.

Model 2 adjusted for age, pre-pregnancy BMI, race.

Model 3 adds concurrent adjustment of SED or MVPA to Model 2.

βstdXY: Semipartial correlation represents effect size in which $\beta < 0.2$ is weak, $0.2 < \beta < 0.5$ moderate, and $\beta > 0.5$ strong effect.

[a]Model 3 sample size limited by MVPA (n = 99).

TABLE 3

Differences in newborn anthropometrics by SED and MVPA trajectory

	Low	Medium		High	
Trajectory	**β (95% CI)**	**β (95% CI)**	**βstdXY**	**β (95% CI)**	**βstdXY**
SED (n = 103)					
Birthweight, g (n = 101)					
Unadjusted	0.00 (Reference)	−87.67 (−349.79, 174.44)	0.089	−193.68 (−456.86, 69.51)	0.200
Model 1	0.00 (Reference)	24.30 (−199.47, 248.07)	0.025	−77.76 (−302.62, 147.10)	0.079
Model 2	0.00 (Reference)	95.37 (−125.75, 316.49)	0.097	−31.36 (−261.24, 198.53)	0.032
Model 3[a]	0.00 (Reference)	101.37 (−123.04, 325.78)	0.102	−74.86 (−309.28, 159.56)	0.076
Head circumference, cm (n = 98)					
Unadjusted	0.00 (Reference)	0.17 (−0.71, 1.04)	0.051	0.27 (−0.60, 1.14)	0.084
Model 1	0.00 (Reference)	0.41(−0.39,1.22)	0.127	0.57 (−0.23, 1.38)	0.178
Model 2	0.00 (Reference)	0.65 (−0.13, 1.43)	0.199	0.83 (0.24, 1.63)	0.258
Model 3[a]	0.00 (Reference)	0.58 (−0.21, 1.38)	0.178	0.73 (−0.10, 1.55)	0.225
Birth length, cm (n = 99)					
Unadjusted	0.00 (Reference)	0.36 (−1.04, 1.77)	0.070	0.70 (−0.70, 2.10)	0.135
Model 1	0.00 (Reference)	0.87 (−0.34, 2.09)	0.168	1.29 (0.07, 2.50)	0.248
Model 2	0.00 (Reference)	0.95 (−0.28, 2.18)	0.182	1.37 (0.09, 2.64)	0.264
Model 3[a]	0.00 (Reference)	0.80 (−0.46, 22.06)	0.155	1.25 (−0.06, 2.56)	0.245
Ponderal Index, g × 100/cm^3 (n = 99)					
Unadjusted	0.00 (Reference)	−0.13 (−0.30, 0.04)	0.193	−0.27 (−0.44, −0.10)	0.414
Model 1	0.00 (Reference)	−0.12 (−0.29, 0.05)	0.179	−0.26 (−0.43, −0.09)	0.398
Model 2	0.00 (Reference)	−0.08 (−0.25, 0.10)	0.116	−0.24 (−0.42, −0.06)	0.364
a	0.00 (Reference)	−0.05 (−0.23, 0.12)	0.080	−0.25 (−0.44, −0.07)	0.396
MVPA (n = 99)					
Birthweight, g (n = 98)					
Unadjusted	0.00 (Reference)	−43.47 (−277.15, 190.22)	0.045	−308.58 (−588.09, −29.08)	0.264
Model 1	0.00 (Reference)	−84.63 (−282.36, 113.10)	0.200	−233.27 (−470.45, 3.90)	0.087
Model 2	0.00 (Reference)	−55.81 (−250.77, 139.16)	0.057	−198.46 (−432.75, 35.84)	0.171

	Low	Medium		High	
Trajectory	**β (95% CI)**	**β (95% CI)**	**βstdXY**	**β (95% CI)**	**βstdXY**
Model 3	0.00 (Reference)	−81.86 (−280.83, 117.12)	0.084	−210.11 (−446.20, 25.97)	0.181
Head circumference, cm (n = 95)					
Unadjusted	0.00 (Reference)	−0.31 (−1.07, 0.45)	0.099	−1.18 (−2.11, −0.24)	0.299
Model 1	0.00 (Reference)	−0.42 (−1.12, 0.29)	0.131	−1.05 (−1.91, −0.18)	0.269
Model 2	0.00 (Reference)	−0.31 (−0.99, 0.37)	0.097	−0.99 (−1.83, −0.16)	0.255
Model 3	0.00 (Reference)	−0.18 (−0.87, 0.52)	0.056	−0.86 (−1.70, −0.02)	0.221
Birth length, cm (n = 96)					
Unadjusted	0.00 (Reference)	−0.65 (−1.89, 0.59)	0.127	−1.53 (−3.03, −0.44)	0.247
Model 1	0.00 (Reference)	−0.85 (−1.94, 0.24)	0.169	−1.26 (−2.57, 0.05)	0.208
Model 2	0.00 (Reference)	−0.71 (−1.80, 0.38)	0.142	−1.17 (−2.49, 0.15)	0.192
Model 3	0.00 (Reference)	−0.47 (−1.59, 0.64)	0.093	−0.95 (−2.28, 0.38)	0.156
Ponderal Index, g x 100/cm^3 (n = 96)					
Unadjusted	0.00 (Reference)	0.05 (−0.11, 0.21)	0.076	−0.01 (−0.20,0.18)	0.012
Model 1	0.00 (Reference)	0.04 (−0.12, 0.20)	0.065	0.00 (−0.19, 0.19)	0.002
Model 2	0.00 (Reference)	0.05 (−0.12, 0.20)	0.075	0.02 (−0.17, 0.20)	0.020
Model 3	0.00 (Reference)	−0.01 (−0.16, 0.14)	0.015	−0.03 (−0.21, 0.16)	0.034

Note: Model 1 adjusted for gestational age at delivery.

Model 2 adds adjustment for maternal age, pre-pregnancy BMI, sex, and race to Model 1.

Model 3 adds concurrent adjustment of SED or MVPA to Model 2.

βstdXY: Semipartial correlation represents effect size in which $\beta < 0.2$ is weak, $0.2 < \beta < 0.5$ moderate, and $\beta > 0.5$ strong effect.

[a] SED model 3 is limited by MVPA sample size.