


SHORT COMMUNICATION

Relations among maternal physical activity during pregnancy and child body composition

L. M. Mudd¹ , J. M. Scheurer², M. Pruet³, E. W. Demerath⁴, A. Kapur² and S. E. Ramel²

¹National Center for Complementary and Integrative Health, National Institutes of Health, Bethesda, MD, USA; ²Department of Pediatrics, University of Minnesota, Minneapolis, MN, USA; ³Department of Kinesiology, Michigan State University, East Lansing, MI, USA; ⁴School of Public Health, University of Minnesota, Minneapolis, MN, USA.

Received 31 October 2018; revised 14 January 2019; accepted 17 January 2019

Correspondence:

LM Mudd, National Center for Complementary and Integrative Health, National Institutes of Health, 6706 Democracy Blvd., Ste 401, Bethesda, MD 20892, USA.
E-mail: lanay.mudd@nih.gov

Summary

Objective

Physical activity (PA) during pregnancy is associated with lower neonatal fat mass, but associations with child body composition are mixed. The purpose of this study was to examine associations between trimester-specific pregnancy PA and child body composition at 4 years.

Methods

Participants of the Minnesota Infant Nutrition, Neurodevelopment, and Obesity Study were asked to recall participation in any moderate or vigorous PA in the first (T1), second (T2) and third (T3) trimesters at about 5 years postpartum. Child fat mass and fat-free mass were measured via air displacement plethysmography at 2 weeks, 3 months and 4 years of age. Multivariate linear regression was used for analyses.

Results

Of 51 possible participants, 37 recalled pregnancy PA. Any vigorous PA in T3 was associated with lower child fat mass at 4 years ($\text{adj}\beta = -1.077, p < 0.05$).

Conclusion

Late pregnancy PA may have lasting benefits for child body composition. Replication of these findings is needed in a larger sample with prospective measures.

Keywords: Exercise, fat mass, fat-free mass, prenatal.

Introduction

Current guidelines in both the USA and Canada recommend that pregnant women participate in 150 min per week of moderate-intensity aerobic activity throughout their gestations (1,2). These recommendations stem from research demonstrating relationships between physical activity (PA) during pregnancy with several maternal health benefits, including reduced risk of preeclampsia, gestational diabetes and gestational weight gain (1,2). Importantly, research has not substantiated concerns about possible harms of pregnancy PA, and it is now proposed as a beneficial intervention to optimize maternal and fetal outcomes.

Pregnancy PA has not been associated with delivery timing; however, there are consistent results showing that maternal PA is associated with reduced risk of

large-for-gestational-age birth, without increasing risk of small-for-gestational-age birth (3,4). Furthermore, recent meta-analyses of eight cohort studies indicated that PA in late, but not early, pregnancy was inversely associated with large-for-gestational-age birth (5). Results also showed stronger associations for higher intensity PA, indicating that both timing and intensity of maternal PA may be important for offspring health outcomes.

Literatures on longer-term relationships of maternal PA during pregnancy with child body composition have been mixed. While some reports show inverse associations between pregnancy PA and child adiposity (6–8), others found null results (9). Previous studies have measured PA at different points during pregnancy, which may contribute to variable findings if measurement timing does not align with the developmentally appropriate window of exposure. Through a series of mechanistic

studies, Clapp demonstrated that maintaining rigorous exercise throughout pregnancy selectively reduces fetal fat development and size at birth (7), making it biologically plausible that PA during the third trimester is necessary for a lasting impact on child adiposity.

Recently, the Minnesota Infant Nutrition, Neurodevelopment, and Obesity Study (MINNOWS) aimed to describe longitudinal body composition from infancy to preschool age in a cohort of children born full-term and preterm (10). Results showed that infancy body composition measurements correlated with body composition measurements at 4 years (11). Additionally, increased fat mass (FM) gains from 4 months to 4 years in full-term born children were associated with decreased intelligence quotient at preschool age (12). These results suggest a need to further understand the determinants of infancy and childhood body composition in order to optimize long-term health and development.

The aim of this study was to use the MINNOWS cohort to examine relations between trimester-specific recalled pregnancy PA and child body composition measured via air displacement plethysmography (ADP) at 2 weeks and 4 years of age. We hypothesized that pregnancy PA would be inversely related to child FM and third trimester PA would show the strongest relationship.

Methods

Mothers of full-term participants of the MINNOWS Preschool Follow-up Study were recruited for this ancillary study (both approved by the University of Minnesota's Institutional Review Board). Mothers provided verbal and written consent for participation in the MINNOWS as previously described (13). Inclusion criteria were healthy, singleton term infants, with appropriate-for-gestational-age birth weight and no pregnancy complications. Exclusion criteria were maternal pre-pregnancy underweight body mass index (BMI), diagnosed gestational diabetes or any infant health condition affecting body composition measures. Birth weight and gestational age at delivery were abstracted from medical records. At 2 weeks post-delivery, women self-reported demographics and pre-pregnancy weight and height measured (pre-pregnancy BMI calculated). Infant anthropometrics were assessed at 2 weeks and 3 months post-birth. A recumbent length measuring board measured infant length (cm). Infants were weighed without clothes to the nearest 0.0001 kg using the scale from the ADP Pea Pod (COSMED USA, Inc., Concord, CA), which also assessed infant FM and fat-free mass (FFM) (kg) using previously described and validated procedures (14,15). At 4 years of age, participants completed additional maternal surveys on child diet, PA, screen time and health, as well

as child anthropometric measures. Standard procedures were used to measure child height, weight and body composition via ADP (Bod Pod, COSMED USA) according to standard procedures. Rate of change in FM and FFM (2 weeks to 4 years) was calculated.

Mothers were contacted by phone after the 4-year MINNOWS visit and provided verbal consent for the ancillary study. Participants recalled participation in PA during the index pregnancy for a typical week in each trimester. Validated PA questions were used with standard intensity descriptions (16). Women first reported participation in any moderate (MOD) or vigorous (VIG) PA in each trimester. They then reported usual frequency and duration of each intensity. Total minutes per week of MOD, VIG and TOT (MOD + VIG) PA were calculated for each trimester.

Data were analysed with SPSS 23.0 (IBM, Armonk, NY). Linear regression analyses were used to examine relations between recalled participation in any trimester-specific MOD or VIG PA (yes/no variables) and offspring body composition at 4 years (FM and FFM), as well as the rate of change in body composition from 2 weeks to 4 years. Based on previous literature, gestational age at delivery, pre-pregnancy BMI, maternal education, maternal smoking during pregnancy, race, breastfeeding, parity, child sex, child PA, child screen time and child juice intake were all considered as covariates. Variables that were related with maternal PA and offspring body composition were retained in the final adjusted models.

Results

Of the 97 participants with complete data at birth, 51 completed the 4-year follow-up, and 38 recalled pregnancy PA (4.76–9.5 years postpartum). There was a higher percentage of female offspring (56% vs. 36%, $p < 0.05$) among participants who responded to the PA recall survey vs. those who did not; however, other offspring characteristics were similar. One woman reported >900 min per week of TOT PA in the first and second trimesters and was removed as an outlier, leaving $n = 37$ for the current analyses. Participant characteristics are shown in Table 1. Considered covariates that were homogenous in the sample (i.e. maternal smoking, race, education, breastfeeding, child PA and child screen time) were not used in regression analyses. Participation in MOD PA in any trimester was unrelated to child body composition. VIG PA participation in the third trimester was related to significantly lower child FM ($\beta = -1.077$, $p = 0.038$) and rate of change in FM from birth to 4 years ($\beta = -0.006$, $p = 0.025$; Table 2), including after adjustment for covariates. Women reporting VIG PA in the third trimester also had significantly higher total PA

Table 1 Participant Characteristics

	Analytic Sample (n = 37)
Continuous Variables*	
Gestational weight gain (kg)	14.7 ± 5.2
Gestational age at delivery (wks)	39.92 ± 1.03
Two Week Child Body Composition:	
Weight (kg)	3.9 ± 0.4
Length (cm)	53.0 ± 2.0
Fat Mass (kg)	0.59 ± 0.17
Fat Free Mass (kg)	3.34 ± 0.35
Three Month Child Body Composition:	
Weight (kg)	6.2 ± 0.6
Length (cm)	61.7 ± 1.7
Fat Mass (kg)	1.62 ± 0.45
Fat Free Mass (kg)	4.56 ± 0.37
Four Year Child Body Composition:	
Weight (kg)	17.1 ± 2.0
Height (cm)	105.6 ± 3.4
Fat Mass (kg)	3.47 ± 1.21
Fat Free Mass (kg)	13.66 ± 1.43
Two week to Four year Fat Mass Change (kg/wk)	0.013 ± 0.005
Two week to Four year Fat Free Mass Change (kg/wk)	0.046 ± 0.006
Recalled first trimester:	
MOD PA (min/wk) [^]	75 ± 76
VIG PA (min/wk)	35 ± 63
TOT PA (min/wk)	109 ± 113
Recalled second trimester:	
MOD PA (min/wk) [^]	58 ± 66
VIG PA (min/wk)	19 ± 54
TOT PA (min/wk)	76 ± 87
Recalled third trimester:	
MOD PA (min/wk) [^]	59 ± 66
VIG PA (min/wk)	17 ± 52
TOT PA (min/wk)	76 ± 88
Categorical Variables*	
White Maternal Race	30 (81%)
Maternal Education:	
HS/GED/Assoc/Tech [^]	9 (24%)
BS/BA or more	28 (76%)
Overweight Pre-pregnancy BMI (> 25 kg/m ²)	14 (38%)
Nulliparous	23 (62%)
Smoking during Pregnancy	1 (3%)
Child Sex Male	18 (49%)
Any Breastfeeding	36 (97%)
Recommended Child PA [^] (>1 hr/d)	35 (95%)
Recommended Child Screen Time (<2 hr/d)	29 (78%)
Recommended Child Juice Servings (none/day)	19 (51%)
Recalled first trimester:	
ANY MOD PA [^]	23 (62%)
ANY VIG PA	11 (30%)
Recalled 2 nd Trimester:	
ANY MOD PA [^]	22 (60%)
ANY VIG PA	6 (16%)
Recalled 3 rd Trimester:	
ANY MOD PA [^]	21 (57%)
ANY VIG PA	5 (14%)

*Continuous variables are reported as mean ± standard deviation; all PA data are positively skewed. Categorical variables are reported as n (%).

[^]MOD PA: moderate physical activity; VIG PA: vigorous physical activity; TOT PA: total physical activity; HS/GED/Assoc/Tech: completed high school, completed general educational development tests, obtained an Associates or Technical Degree/Certification; BS/BA or more: completed a Bachelors of Science or Arts degree, or advanced degree; PA: physical activity

(185 ± 114 min per week) vs. those who did not (59 ± 68 min per week; *t*-test *p*-value < 0.05).

Discussion

There is mounting evidence for the specificity of maternal PA during the third trimester and its impact on offspring weight and body composition. Individual meta-analyses of eight cohort studies recently showed reduced risk of macrosomia and large-for-gestational-age birth associated with moderate to vigorous PA and vigorous PA late in pregnancy but not with early pregnancy PA (5). Furthermore, these results were not mediated by maternal gestational diabetes and persisted after adjustment of maternal BMI suggesting that PA late in pregnancy may have a direct effect on birth size.

Very few studies have considered relations between maternal PA during pregnancy and offspring body composition later in life. In Clapp's landmark studies on pregnancy PA, offspring of women who continued exercise into late pregnancy were the leanest through 5 years of age, as compared with offspring of mothers who quit exercise in early or mid-pregnancy (7,17,18). Other

Table 2 Pregnancy physical activity and offspring body composition at 4 years of age

Four-year fat mass models					
	Model	Adj <i>R</i> ²	<i>β</i>	Std. error	<i>p</i> -value
Third trimester	Unadjusted	0.12	-1.230*	0.551	0.032
	Adjusted [†]	0.44	-1.077*	0.500	0.038
Any VIG PA					
Two-week to four-year fat mass change models					
	Model	Adj <i>R</i> ²	<i>β</i>	Std. error	<i>p</i> -value
Third trimester	Unadjusted	0.11	-0.005*	0.002	0.047
	Adjusted [‡]	0.35	-0.006*	0.002	0.025
Any VIG PA					

VIG PA, vigorous physical activity.

*Significant *p*-value < 0.05.

[†]Adjusted for gestational age at delivery, pre-pregnancy body mass index and fat mass at 3 months of age.

[‡]Adjusted for gestational age at delivery, pre-pregnancy body mass index and parity.

studies have shown the strongest relations between third trimester PA and body composition measures at birth (19) and 18–24 months (6) and null findings for pre-pregnancy or early pregnancy PA (9,19). Our results similarly found that only third trimester VIG PA was associated with child body composition. Longer-term offspring follow-up of cohort studies that included prospective measures of pregnancy PA is needed to confirm or refute our findings.

The specificity of the third trimester PA association with a long-term impact on child body composition has biological plausibility; this is the time period of the most rapid fetal weight gain and is potentially a developmentally appropriate window for fetal programming of FM accumulation. Work in a rat model showed that male offspring of rats who exercised throughout pregnancy had improved insulin sensitivity and smaller fat depots compared with offspring of sedentary rats, even when fed a high-fat diet (20). These results provide support for a biological mechanism through which maternal PA may impact child body composition; however, additional work on specifying timing and intensity of maternal PA in animal models is needed.

This study has several limitations, including the use of recalled pregnancy PA and a homogeneous sample, which may limit our finding's generalizability. However, given our sample experienced healthy pregnancies, the homogeneity in regard to factors that influence child body composition may indicate that differences in FM were specific to the presence/absence of pregnancy PA. Additionally, one study found that women accurately recalled PA during pregnancy at 6 years postpartum (correlations between prospective and recall measures 0.57–0.86) using similar PA questions as utilized in this study (21). Further, the current study also utilized detailed ADP body composition data that previous investigations have often lacked.

In conclusion, our results indicate that third trimester PA may have lasting benefits for child body composition, but vigorous PA, or a high total volume of PA, may be necessary. These results need replication using prospective and objective measures of maternal and child PA, diet and body composition. If replicated, these results may have public health significance as most women decrease their PA participation throughout pregnancy.

Disclaimer

The opinions expressed in this article are the author's own and do not reflect the view of the National Institutes of Health, the Department of Health and Human Services or the US government.

Acknowledgements

J. S., E. D., A. K. and S. R. conceived and carried out the original and follow-up MINNOWS. L. M., J. S., M. P., A. K. and S. R. conceived and carried out the ancillary study for recalling pregnancy PA. All authors were involved in writing the paper and had final approval of the submitted and published versions.

Funding

Funding of the study is provided by the National Institutes of Health (U54 CA116849 and 5K12 HD065879-03), a University of Minnesota Academic Health Center Faculty Research Development Grant, the Benjamin Walker Hanson Fund of the University of Minnesota Foundation and Center for Neurobehavioral Development at the University of Minnesota.

Conflict of Interest Statement

The authors report no conflicts of interest.

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