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Maternal Physical Activity and Neonatal Cord Blood Lipid Levels: Findings From a Prospective Pregnancy Cohort

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Abstract

Background—Physical activity performed while pregnant is beneficially associated with maternal cardiovascular health. It is unknown if benefits extend to neonate cardiovascular health. This study investigated associations of maternal physical activity with neonatal cord blood lipid and lipoprotein concentrations.

Methods—Cord blood lipids were measured at birth in a pseudo-randomly selected subgroup of Born in Bradford birth cohort participants (*n*=1634). Pregnant women were grouped into four activity categories (inactive / somewhat active / moderately active / active) based on their self-reported physical activity at 26-28 weeks gestation. Regression was used to calculate adjusted mean differences in neonate cord blood lipid concentrations between the four groups of physical activity.

Results—Maternal physical activity was associated with higher neonatal cord blood high-density lipoprotein cholesterol (HDL-c). Cord blood HDL-c was higher in neonates of women who were somewhat and moderately active compared to neonates of women who were inactive. There were no associations of pregnancy physical activity with triglycerides, low-density lipoprotein, or very low-density lipoprotein cholesterol levels.

Conclusions—Maternal physical activity is favourably associated with neonatal cord blood HDL-c levels. This novel beneficial finding highlights the potential for physical activity in pregnancy to aid early prevention of cardiovascular disease.

Introduction

Physical activity confers myriad benefits to the uncomplicated pregnancy[1], benefits that can have long-term health impacts for the developing fetus.[2,3] Our understanding that intra-uterine environments can program susceptibility to future disease has developed over the last two decades.[4] This work has highlighted that in-utero exposures can influence the risk of cardiovascular disease (CVD)[5], the leading cause of global morbidity[6] and mortality.[7] We recently reported that maternal physical activity is favourably associated with lower levels of maternal pregnancy triglycerides and a higher concentration of high-density lipoprotein cholesterol (HDL-c)[8], established precursors of CVD.[9] It is unknown if maternal physical activity confers similar benefits, that is a more favourable blood lipid profile, to the

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developing fetus. This is important to investigate. Cord blood lipid profiles track over time to early childhood[10] (when they can begin to initiate and progress preclinical signs of CVD[11]) and subsequently to adulthood[12] when the clinical manifestations of CVD arise.[13] This study investigated associations of maternal physical activity with neonatal cord blood lipid levels.

Methods

Born in Bradford (BiB) is a prospective birth cohort study of 12,453 women who were recruited at 26-28 weeks gestation, and who delivered 13,818 live births between 2007 and 2010. Full study details are provided elsewhere.[14] In a pseudo-randomly selected subgroup of BiB participants cord blood lipid samples were collected.[15] For the purposes of this complete-case investigation, the subgroup was restricted to singleton pregnancies and women who were free from pre-existing hypertension and diabetes before pregnancy. The final sample comprised 1634 mother-neonate pairs. Characteristics of the included subgroup were similar to those of all other BiB participants (Supplementary Table 1), who were broadly representative of the obstetric population in Bradford at the time of recruitment.[14] The BiB study was approved by the Bradford Research Ethics Committee (ref 07/H1302/112) and all mothers provided written informed consent.

Maternal physical activity was assessed at recruitment using the General Practice Physical Activity Questionnaire (GPPAQ) which has been validated against accelerometry[16] and exhibits face validity in the BiB cohort.[8] Mothers were assigned to one of four activity levels (inactive / somewhat active / moderately active / active) based on their self-reported occupational physical activity level, physical exercise and walking in the last week. The active category is consistent with meeting the recommended minimum 150 minutes per week of moderate intensity physical activity.[17]

Cord blood samples were obtained at delivery by the attending midwife. Samples were refrigerated at 4°C in EDTA tubes until collected by laboratory staff within 12h. Samples were then spun, frozen and stored at −80°C.[15] Following transfer to the Biochemistry Department of Glasgow Royal Infirmary, enzymatic reagents were used to determine serum concentrations of total cholesterol, triglycerides, HDL-c, low density lipoproteins (LDL-c), and very low density lipoproteins (vLDL-c) (Cobas C311 autoanalyzer, Roche Diagnostics).

Women consented to the abstraction and use of data from their obstetric medical records, and at recruitment completed an interviewer administered questionnaire. The questionnaire collated information regarding ethnicity, social and economic circumstances, smoking, alcohol, caffeine intake, and sleep. Interviews were conducted in a variety of languages. Maternal weight at ~12 weeks gestation was combined with height to derive early-pregnancy body mass index (BMI, kg/m^2). Gestational age at birth was calculated as the number of weeks elapsed between conception (based on ultrasound examination at ~12 weeks) and delivery. Full details of covariables are available elsewhere.[8]

For description, participant characteristics were summarised by maternal pregnancy physical activity level, and Pearson correlation coefficients were calculated between maternal blood

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lipid levels (measured at recruitment[8]) and cord blood lipid concentrations. For the main analysis, linear regression models were used to calculate differences in cord blood lipid concentrations between the four groups of maternal physical activity (reference group: inactive); *p*-values from trend tests across physical activity categories are also presented. Models were initially adjusted for maternal age, ethnicity, early-pregnancy BMI, SES, parity, season of physical activity assessment, and neonate sex. Adjustments for maternal smoking in pregnancy, delivery mode, birth weight, and gestational age were subsequently added as they changed β-coefficients between exposures and outcomes by ≥10%.[18] All cord blood lipid distributions were skewed and were natural log transformed prior to analyses; the data have been back-transformed by exponentiation. Results are presented as marginal means with 95% confidence intervals. Analyses were performed in Stata/SE version 15.0 software.

Results

Descriptive statistics for the cord blood lipid subgroup are presented in Table 1. More than half of women (60.4%) were inactive, one-fifth were somewhat active (18.2%), and fewer were classified as moderately active (12.0%) and active (9.4%), respectively. Inactive women were more frequently of Pakistani-origin, multiparous, and were moderately or most deprived. Correlations between maternal and cord blood lipids were calculable for 1510 mother-neonate pairs and were consistently weak (total cholesterol: 0.08; HDL-c: 0.16: LDL-c: 0.06; triglycerides: 0.08).

Table 2 shows neonate cord blood lipid levels stratified by maternal pregnancy physical activity. There was no strong evidence for effect modification by ethnic group ($p \geq 0.11$), so the results are presented for the whole sample combined and adjusted for ethnicity. There was a significant trend across categories to indicate that higher physical activity was associated with higher cord blood total cholesterol; levels were significantly higher in neonates of women who were moderately active in pregnancy compared to neonates of women who were inactive. Analysis of individual components revealed that there was only a positive association of maternal physical activity with cord blood HDL-c; values were significantly higher in neonates of women who were somewhat active and moderately active, respectively, compared to neonates of women who were inactive. For neonates of active women, the confidence interval was consistent with higher cord blood HDL-c in comparison to neonates of inactive women, but the difference was not statistically significant, likely due to type 2 error caused by fewer observations. There was no evidence for associations of pregnancy physical activity with neonate cord blood trigylcerides, LDL-c, or vLDL-c.

Discussion

This study found that maternal pregnancy physical activity was favourably associated with a higher concentration of neonatal cord blood HDL-c. The association was modest in scale, but may be underestimated due to errors in self-reported physical activity. It is also important to consider that any positive influence on cord blood HDL-c may be meaningful, because cord blood lipid levels track over time[10,12] and an adverse lipid profile in childhood can initiate preclinical signs of CVD.[11] Furthermore, even in the absence of any other blood lipid abnormality, low HDL-c has been shown to elevate CVD risk in adulthood.[19]

We are aware of only two other studies that have investigated this topic. In a Canadian study of 442 mother-neonate pairs, there was no evidence for an association between self-reported physical activity with a latent parameter that represented cord blood HDL-c, apolipoprotein A1, and LDL-c.[20] Similarly, no associations with traditional blood lipids were found in 51 women from Austria, who underwent an assessment of physical activity by accelerometry at 10-14 weeks gestation. However, in that study, unadjusted analyses did show that cord blood exhibited a more favourable composition of HDL-c (lower oxidised HDL-c and higher apolipoprotein A1) in neonates of women who met the recommended level of physical activity when pregnant compared to those who did not.[21] This study is the first to provide evidence of an independent association between pregnancy physical activity with higher cord blood HDL-c. Importantly, compared to neonates of women who were inactive, cord blood HDL-c levels were higher even in neonates of women who were merely somewhat active in pregnancy. Hence, even small volumes of physical activity, well below the recommended minimum (150 minutes per week of moderate intensity physical activity), were beneficial. This supports current UK guidelines that ‘every activity counts’ and that inactive pregnant women should gradually accumulate physical activity throughout the week.[17]

Safety concerns are often cited by pregnant women as a barrier to physical activity.[22] This may partly explain why fewer than 10% of our study participants were active. Reassuringly, the results of this study, coupled with previous observations made in the same cohort[8], add to growing evidence that pregnancy physical activity is not only safe, but is beneficial for the short and long-term health prospects of both mother and child. Women should be encouraged to be physically active while pregnant and reassured that evidence suggests that it is safe. A recent systematic review concluded that multicomponent interventions can successfully increase pregnancy physical activity levels, with the most promising strategies including group exercise classes, information provision about recommended levels of physical activity and suitable exercises, and guidance about how to overcome perceived barriers including the management of various pregnancy-related symptoms.[23] This information should also be disseminated to healthcare professionals, who are well placed to advocate physical activity but who may lack the confidence, knowledge and resources to deliver appropriate and safe advice.[24] The results of this study further highlight that Pakistani-origin women and women from deprived backgrounds are the most inactive in pregnancy, and thus they may be considered priority recipients of efforts to increase physical activity. Targeting these women (who are also more susceptible to pregnancy complications[25]) could help to reduce health inequalities, by reducing the risk of adverse pregnancy outcomes and their long-term sequelae in high-risk groups.

In line with observations made at birth[26], we found that maternal blood lipids were weakly correlated with neonate cord blood lipids. This is reassuring, as it highlights that cord blood lipids represent neonate cardiovascular status (likely as a consequence of fetal and placental influences on cord blood biochemistry) as opposed to merely reflecting maternal lipids. It is a limitation of this study, however, that information for several covariables were self-

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reported and that the analyses were not adjusted for maternal dietary factors. Future studies should investigate longer-term influences of maternal pregnancy physical activity on offspring cardiovascular health.

Conclusion

Maternal physical activity is beneficially associated with neonate cord blood HDL-c levels. This novel finding highlights the potential for promoting physical activity in pregnancy to aid early prevention of CVD.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Maternal and neonatal characteristics, overall and stratified by pregnancy physical activity level

	Overall (*n*=1,634)	Inactive (*n*=987)	Somewhat active (*n*=298)	Moderately active (*n*=196)	Active (*n*=153)	*p*-difference
Maternal age (y)	27.2 ± 5.5	27.1 ± 5.5	27.4 ± 5.7	27.3 ± 5.7	27.3 ± 5.3	0.84
Ethnicity (*n* (%))						
White British	627 (38.4)	280 (28.4)	144 (48.3)	109 (55.6)	94 (61.4)	
Pakistani-origin	779 (47.7)	583 (59.1)	101 (33.9)	56 (28.6)	39 (25.5)	
Other / Mixed	228 (13.9)	124 (12.6)	53 (17.8)	31 (15.8)	20 (13.1)	<0.001
Socioeconomic status (*n* (%))						
Least deprived	621 (38.0)	274 (27.8)	163 (54.7)	101 (51.5)	83 (54.3)	
Moderately deprived	759 (46.5)	522 (52.9)	117 (39.3)	66 (33.7)	54 (35.3)	
Most deprived	254 (15.5)	191 (19.4)	18 (6.1)	29 (14.8)	16 (10.5)	<0.001
Parity (*n* (%))						
0	603 (36.9)	322 (32.6)	134 (45.0)	78 (39.8)	69 (45.1)	
1	489 (29.9)	288 (29.2)	93 (31.2)	65 (33.2)	43 (28.1)	
≥2	542 (33.2)	377 (38.2)	71 (23.8)	53 (27.0)	41 (26.8)	<0.001
Early pregnancy BMI (kg/m^2)	24.8 (7.0)	24.7 (7.2)	25.1 (6.6)	25.0 (7.5)	24.3 (6.1)	0.59
Smoked in pregnancy or 3m before (*n* (%))						
No	1,353 (82.8)	838 (84.9)	244 (81.9)	150 (76.5)	121 (79.1)	
Yes	281 (17.2)	149 (15.1)	54 (18.1)	46 (23.5)	32 (20.9)	0.017[a]
Season of PA report (*n* (%))						
Spring	364 (22.3)	226 (22.9)	55 (18.5)	41 (20.9)	42 (27.5)	
Summer	457 (23.0)	256 (25.9)	85 (28.5)	74 (37.8)	42 (27.5)	
Autumn	412 (25.2)	247 (25.0)	79 (26.5)	41 (20.9)	45 (29.4)	
Winter	401 (24.5)	258 (26.1)	79 (26.5)	40 (20.4)	24 (15.7)	0.007
Delivery mode (*n* (%))						
Vaginal	1258 (77.0)	774 (78.4)	228 (76.5)	140 (71.4)	116 (75.8)	
Caesarean	376 (23.0)	213 (21.6)	70 (23.5)	56 (28.6)	37 (24.2)	0.19
Neonate sex (*n* (%))						
Male	824 (50.4)	482 (48.8)	153 (51.3)	104 (53.1)	85 (55.6)	
Female	810 (49.6)	505 (51.2)	145 (48.7)	92 (46.9)	68 (44.4)	0.35

	Overall (n=1,634)	Inactive (n=987)	Somewhat active (n=298)	Moderately active (n=196)	Active (n=153)	p-difference
Gestational age (weeks)	39.6 ± 2.4	39.5 ± 1.6	39.8 ± 1.4	39.5 ± 1.7	39.6 ± 1.6	0.12
Birth weight (g)	3263 ± 523	3236 ± 514	3316 ± 516	3302 ± 588	3293 ± 498	0.062

For continuous variables, values are mean ± standard deviation or median (interquartile range) given skewness. Differences between physical activity categories calculated by Chi-square, ANOVA and Kruskal-Wallis tests as appropriate.

[a]Significant difference did not persist in a logistic regression analysis that included adjustment for ethnicity (p-difference=0.13).

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Table 2

Associations of maternal pregnancy physical activity with neonatal cord blood lipid concentrations

	Number of participants (*n* in each activity category)	Inactive	Somewhat active	Moderately active	Active	*p*-trend
Total cholesterol	1634 (987 / 298 / 196 / 153)	1.63 (1.60 to 1.65) Ref	1.66 (1.62 to 1.71) 0.19	**1.69 (1.64 to 1.75) 0.044**	1.68 (1.62 to 1.75) 0.13	**0.027**
Triglycerides	1634 (987 / 298 / 196 / 153)	0.49 (0.48 to 0.50) Ref	0.48 (0.46 to 0.50) 0.21	0.50 (0.47 to 0.52) 0.76	0.49 (0.46 to 0.52) 0.99	0.26
HDL-c	1634 (987 / 298 / 196 / 153)	0.61 (0.60 to 0.62) Ref	**0.64 (0.62 to 0.67) 0.020**	**0.64 (0.61 to 0.67) 0.039**	0.64 (0.61 to 0.67) 0.10	**0.016**
LDL-c	1634 (987 / 298 / 196 / 153)	0.74 (0.72 to 0.76) Ref	0.75 (0.72 to 0.79) 0.43	0.77 (0.73 to 0.81) 0.16	0.76 (0.72 to 0.80) 0.41	0.17
vLDL-c	1634 (987 / 298 / 196 / 153)	0.22 (0.22 to 0.23) Ref	0.22 (0.21 to 0.23) 0.24	0.23 (0.21 to 0.24) 0.73	0.22 (0.21 to 0.24) 0.96	0.92
Adiponectin	1634 (987 / 298 / 196 / 153)	29.6 (28.8 to 30.4) Ref	30.2 (28.7 to 31.7) 0.50	28.7 (27.0 to 30.5) 0.37	28.7 (26.8 to 30.8) 0.46	0.35

Data are estimated marginal means (95% confidence interval) adjusted for maternal age, ethnicity, early-pregnancy BMI, SES, parity, season of physical activity assessment, maternal smoking in pregnancy, neonate sex, delivery mode, gestational age, and birth weight. Below the estimates are *p*-values. Bold font denotes significantly different values compared to the referent inactive group ($p<0.05$) or across physical activity categories (*p*-trend <0.05). Adjusting for other maternal lifestyle factors (alcohol consumption, caffeine intake, sleep problems, use of dietary supplements), measurement factors related to maternal physical activity (gestational age at the time of reporting, if women were feeling well and were able to enjoy their normal daily activities, whether or not maternal physical activity was reported during Ramadan), pregnancy complications (diagnosis of gestational diabetes and gestational hypertension), and neonate abdominal circumference did not appreciably influence associations and so were not retained in models.