Objectively Measured Physical Activity and Sedentary Time in Young Adults Born Preterm – The ESTER Study

Running title: Physical Activity in Adults Born Preterm

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Abstract

Background

Young adults born preterm have higher levels of cardiometabolic risk factors and they report less physical activity than their peers born at term. Physical activity provides important cardiometabolic health benefits. We hypothesized that objectively measured physical activity levels are lower and time spent sedentary is higher among preterm-born individuals compared to controls.

Methods

We studied unimpaired participants of the ESTER birth cohort study at age 23.3 years (SD: 1.2): 60 born early preterm (<34 weeks), 108 late preterm (34-36 weeks), and 178 at term (controls). Physical activity and sedentary time were measured by hip-worn accelerometer (ActiGraph®).

Results

As compared with controls' (mean physical activity, 303 counts per minute (cpm; SD 129)), physical activity was similar among adults born early preterm (mean difference=21 cpm, 95%CI -61, 19) or late preterm (5 cpm, -27, 38). Time spent sedentary was also similar. Adjustments for early life confounders or current mediating characteristics did not change the results.

Conclusion

In contrast to our hypothesis, we found no difference in objectively measured physical activity or time spent sedentary between adults born preterm and at term. The previously reported differences may be limited to physical activity captured by self-report.

Introduction

Follow-up studies of adolescents and adults born preterm suggest that those born smallest report less physical activity and are less fit than term-born individuals.[1-4] The differences can be substantial: as assessed by a comprehensive 12-month physical activity questionnaire, unimpaired adults born preterm at very low birth weight (VLBW; <1500 g) report over 50% lower energy expenditure from leisure-time conditioning physical activity than controls born at term.[3] This may contribute to the increased cardiometabolic risk profile reported in this group.[5,6] However, these infants constitute only a minority of preterm infants; for example, in the United States, 70% of preterm infants are born late preterm, between 34 and 36 weeks of gestation.[7] Recent studies have suggested that the adverse cardiometabolic risk profile and perhaps levels of physical activity, and in parallel muscular fitness, decrease with an increasing degree of prematurity and may extend to those born late preterm.[8,9]

Promoting increased physical activity and decreased sedentary time is important for preventing cardiometabolic risk.[10,11] However, few studies have measured physical activity and sedentary time objectively in adults born preterm.[12-14] We hypothesized that objectively measured physical activity levels are lower and sedentary time higher among preterm-born individuals and that there is a dose-response relationship between the degree of prematurity and physical activity and sedentary time.

Methods

Participants

The participants come from the ESTER (Ennenaikainen syntymä ja aikuisiän terveys [Preterm Birth and Early-Life Programming of Adult Health and Disease]) Preterm Birth Study comprizing 1890 young adults. They were identified through the Northern Finland Birth Cohort 1986 (NFBC; 49.8%; born in 1985–1986) or the Finnish Medical Birth Register (FMBR; 50.2%; born in 1987–1989 in the same geographical area). In 2009–2011, 753 individuals with verified length of gestation participated in a clinical study at 23.3 (SD 1.23) years.[8] All participants were offered an accelerometer, if available.

After exclusions (described in Figure 1), 60 participants born early preterm (below 34 weeks of gestation), 108 born late preterm (between 34 and 36 weeks), and 178 controls born after 37 completed weeks of gestation (referred to as “at term”) were unimpaired, and had sufficient accelerometer data (Figure 1).

Ethics

The study was approved by the Coordinating Ethics Committee at Helsinki and Uusimaa Hospital District. All participants provided written informed consent.

Perinatal data

Perinatal data for participants recruited through the Northern Finland Birth Cohort 1986 come from the cohort database, originally collected from hospital and maternal welfare clinic records.[15] We collected corresponding data for those invited through the Finnish Medical Birth Register. Length of gestation[16] and maternal gestational diabetes, hypertension (gestational or chronic), or preeclampsia (including superimposed) diagnoses according to prevailing criteria were independently confirmed by reviewing original hospital records.[17,18] Small for gestational age (SGA) was defined as birth-weight SD score < –2 SD and large for gestational age (LGA) as > 2 SD according to Finnish standards.[19]

Clinical Examination

Clinical measurements included anthropometry. Body composition was assessed by using segmental multifrequency bioelectrical impedance (InBody 3.0, Biospace Co., Seoul, Korea).

Muscular fitness was measured with the number of modified push-ups performed in 40 seconds and maximal handgrip strength of the dominant hand (N) and cardiorespiratory fitness with heart rate at the end of a 4-minute step test.[9] Data on medical history, socioeconomic status, daily smoking, and self-reported physical activity[9], were collected with questionnaires. Childhood socioeconomic status was assessed as the educational attainment of the more highly educated parent enquired at the time of clinical examination.

Physical Activity and Sedentary Time

Physical activity was measured with an accelerometer (ActiGraph GT1M, ActiGraph, Pensacola, Florida) worn on the right hip during waking hours for 7 consecutive days.[20] Participants with valid data for at least 500 min per day on 2 weekdays and 1 weekend day were included.[20] The epoch length was 60 sec, and non-wearing time was defined as continuous zero activity for > 60 min. The outcomes were overall physical activity (counts per minute, cpm), sedentary time (%/day, <100 cpm), light-intensity physical activity (LPA; min/day, 100–1,951 cpm), moderate-to-vigorous intensity physical activity (MVPA; min/day, ≥1,952 cpm), and $MVPA_{10min}$ (min/day) that was defined as continuous MVPA lasting at least 10 min at a time,[21,22] with a 1-min interruption allowed within a 5-min time frame. Accelerometer-based sedentary time was expressed as a proportion of daily monitoring time thus, participants who wore the accelerometers for different lengths of time per day were comparable. Self-reported physical activity was calculated in MET hours per week (MET=metabolic equivalents; ratio of metabolic rate during exercise and estimated metabolic rate at rest; 1 MET corresponds energy expenditure of approximately 1 kcal/kg x hour) on the basis of a questionnaire on (1) light (assuming a value of 3 METs), (2) moderate to vigorous (5 METs), and (3) commuting (4 METs) physical activity. [9]

Statistical Methods

We examined sex adjusted correlations between outcome variables and self-reported physical activity or physical fitness with Pearson's partial correlation. We compared the characteristics of the early and late preterm groups with those of the controls by using Student's *t* test and the χ^2 test, with Yeates' Correction for Continuity for 2 by 2 tables, and the outcomes using linear regression with a significance level of $P < .05$. We tested for interactions between early and late preterm birth and sex (significance level of < .01) by including a product term with these variables. Categorical adjusting variables were entered as dummy variables with a separate dummy indicating missing values. In Model 1 we adjusted for sex, age, cohort, and the season of physical activity measurement (December–February, March–May, June–August, September–November). In Model 2 we adjusted for potential early life confounders: parental education, maternal gestational diabetes, gestational hypertension, and birth weight SD score. In Model 3, we adjusted for potential adult mediators: asthma,[23] height,[2,3] body fat percentage, [8] and smoking.[24] Because of skewed distribution, we also reran the analyses after log-transforming [log10 (variable+1)] the outcome variables to attain normality, adjusting for SGA status, and replacing the adjustment for body fat percentage with lean body mass.

A detailed nonparticipant analysis of the ESTER Preterm Birth Study has been described previously.[8] Among the participants of the clinical study, we now compared the participants of the accelerometer study to the nonparticipants comprising those who did not attend accelerometer registration or were excluded from the analyses for insufficient accelerometer data (Figure 1). In this comparison, there was no significant difference in the participation of early or late preterm individuals as compared with the controls. As to participant characteristics listed in Table 1, the nonparticipants born preterm or at term were more likely to smoke daily (P<0.001-0.026). The women of the control group participated more actively than men (P=0.044), and they had higher body mass index (*P*=0.007) and body fat percentage (*P*=0.004) as compared with the nonparticipants. Among early preterm non-participants cardiorespiratory fitness was slightly lower (*P*=0.006). We performed analyses using SPSS 22.0 (IBM SPSS Statistics, IBM Corporation, Armonk, NY).

Results

Participant characteristics are presented in Table 1 and outcomes by exposure group in Table 2. Sex adjusted correlation coefficient between objectively measured daily physical activity (counts per minute) and self-reported physical activity was 0.25, and between objectively measured physical activity and fitness measures correlation coefficients were -0.29 for cardiorespiratory fitness and 0.12 for the number of modified push-ups performed. Other correlations between objectively measured physical activity and self-reported physical activity or fitness measures were similar or less. The mean physical activity level and sedentary time were similar among young adults born early and late preterm compared with the controls. Adjustments for potential early life confounders or current mediating characteristics did not change the results (Table 3). The results remained when log-transformed outcome variables were used and when adjusted for SGA and lean body mass instead of body fat percentage. There was no interaction between association of sex and preterm birth with the outcomes.

Discussion

We objectively measured physical activity and sedentary time with a hip-worn accelerometer in young adults born early and late preterm as compared with their peers who were born at term. In contrast to our hypothesis, we did not observe any difference in physical activity levels or the proportion of sedentary time per day between young healthy adults born early or late preterm and controls born at term. Accounting for a wide range of early life confounders and possible adult mediators did not change our results. Although our sample size did not allow us to exclude subtle differences, our findings suggest preterm birth is not a determinant of physical activity captured by accelerometry in adulthood.

Our findings contradict earlier observations of lower self-reported physical activity among adults born preterm.[2-4] This discrepancy parallels previous observations among young very-low-birth-weight adults who reported undertaking approximately 50% less conditioning physical activity than controls.[2-4] These findings were not replicated when physical activity was assessed objectively.[12,13] Self-report and accelerometry reflect different aspects of physical activity. Self-report enables the assessment of a broad range of physical activities in any circumstances providing an average of physical activity in a longer period of time. Objective measurement is again more precise in registering the intensity of physical activity and sedentary time in a shorter time frame.[25] The correlations between accelerometer-measured and self-reported physical activity tend to be low-to-moderate, in the present study 0.25 and in recent meta-analyses around 0.3-0.4 [25-27]. Indeed, both types of measurements have been reported to be associated with cardiometabolic and other health benefits[11,28-31], although associations with accelerometer-measured physical activity tend to be stronger.[31] These methodological differences may explain why VLBW adults report lower levels of conditioning leisure-time physical activity[3] and lower sports participation [2] despite this has not been detected with objective measurement in the same cohort[32] or in our present study including the full range of preterm birth.

Strengths and Limitations

The strengths of our study include objective measurement of physical activity and sedentary time with a reliable hip-worn accelerometer with a seven-day-registration [20] and a study population enabling the evaluation of physical activity across the full range of preterm birth. We also had access to reliable and diverse perinatal data, including verified length of gestation. It is possible that individuals who are more physically active may have participated in the accelerometry study. The lower rate of smoking among participants would seem to suggest this [33] as also in our study smoking was associated with lower amount of continuous moderate-to-vigorous physical activity lasting at least 10 min at a time and self-reported physical activity. However, fitness levels were similar in participants and non-participants, except among early preterm non-participants cardiorespiratory fitness was slightly lower than among early preterm participants. The potential participation of more active individuals would only be expected to introduce bias if the association between preterm birth and physical activity would be different among participants and non-participants. This seems unlikely although cannot be excluded.

Conclusions

In conclusion, we did not observe differences in objectively measured physical activity and sedentary time among young adults born early or late preterm compared with controls born at term. This suggests that lower levels of physical activity in adults born preterm are likely to be limited to physical activity preferentially captured by self-report, including broad range of activities that accelerometry is not able to detect in a short time frame.

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Figure legends

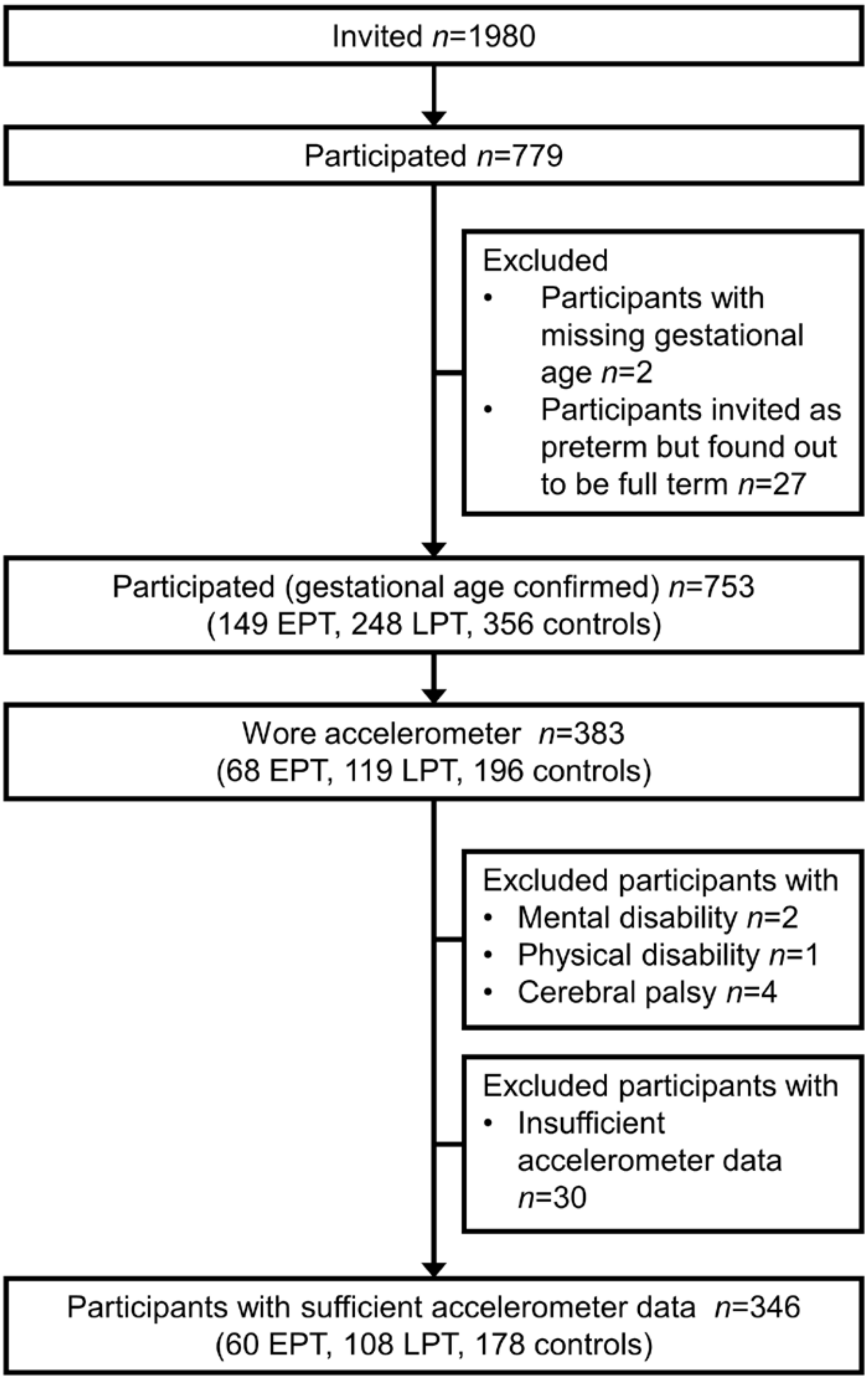

Figure 1. Flow chart of the study population. EPT, early preterm (<34 gestational weeks); LPT, late preterm (34–36 gestational weeks).

Table 1. Perinatal, neonatal, and current characteristics of young adults born preterm and their controls born at term

	Early preterm[a] n = 60	**Late preterm[a] n = 108**	**Controls n = 178**	**Missing**
Men, n (%)	23 (38.3)	49 (45.4)	75 (42.1)	0/0/0
NFBC member[b], n (%)	28 (46.7)	53 (49.1)	106 (59.6)	0/0/0
Peri- and neonatal				
Maternal hypertension[c], n (%)	10 (16.7)	14 (13.0)	14 (7.9)	0/1/3
Maternal pre-eclampsia[d], n (%)	19 (31.7)†	13 (13.0)**	6 (3.4)	0/1/3
Maternal gestational diabetes[e], n (%)	0 (0.0)	4 (3.7)	3 (1.7)	13/11/4
Maternal smoking during pregnancy, n (%)	8 (13.3)	16 (14.8)	27 (15.2)	3/2/3
Gestational age, mean (SD), weeks	32.0 (2.0)†	35.8 (0.8)†	40.1 (1.2)	0/0/0
Birth weight, mean (SD), g	1734 (451)†	2668 (514)†	3541 (477)	0/0/0
Birth weight SD score, mean (SD) (SD)	–1.0 (1.4)†	-0.6 (1.3)†	-0.1 (1.0)	0/0/0
Small for gestational age, n (%)	13 (21.7)†	10 (9.3)*	4 (2.2)	0/0/0
Current				
Age (SD), y	23.2 (1.2)	23.1 (1.3)*	23.5 (1.0)	0/0/0
Height (SD), cm				0/0/0
Men	178.3 (5.0)	179.1 (6.4)	177.4 (7.3)	
Women	163.3 (5.3)	165.1 (4.8)	163.5 (6.0)	
Body mass index mean (SD), kg/m^2				0/0/0
Men	23.5 (3.7)	24.5 (4.9)	24.1 (3.1)	
Women	24.7 (6.3)	23.5 (4.4)	24.1 (4.9)	
Body fat percentage mean (SD), %				
Men	16.6 (5.4)	17.9 (7.2)	17.5 (5.5)	0/0/1
Women	31.7 (7.5)	28.2 (7.35)	29.2 (7.9)	2/1/5
Lean body mass mean (SD), kg				
Men	61.9 (7.9)	63.6 (9.5)	62.5 (8.3)	0/0/1
Women	44.3 (8.3)	45.3 (5.1)	44.7 (5.5)	2/1/5
Parental education				0/1/1
Basic or less, n (%)	4 (6.7)	9 (8.3)	10 (5.6)	
Secondary, n (%)	37 (61.7)	61 (56.5)	107 (60.1)	
Lower-level tertiary, n (%)	7 (11.7)	14 (13.0)	21 (11.8)	
Upper-level tertiary, n (%)	12 (20.0)	23 (21.3)	39 (21.9)	
Daily smoking, n (%)	11 (18.3)	13 (12.0)	24 (13.5)	0/0/0
Asthma, n (%)	14 (23.3)	14 (13.0)	32 (18.0)	0/0/0
Season of physical activity measurement				0/0/0
Winter, n (%)	7 (11.7)	27 (25.0)	39 (21.9)	
Spring, n (%)	21 (35.0)	29 (26.9)	43 (24.2)	
Summer, n (%)	7 (11.7)	17 (15.7)	25 (19.7)	
Fall, n (%)	25 (41.7)	35 (32.4)	61 (34.3)	
Volume of self-reported leisure-time physical activity, mean (SD), METh/wk	36.7 (29.3)	38.3 (26.7)	40.6 (37.1)	6/13/14
Number of modified push-ups/ 40 seconds, mean (SD)	11.8 (3.9)	11.8 (3.7)	12.5 (3.8)	5/7/10
Handgrip strength, mean (SD), N	438.4 (172.3)	487.3 (184.1)	477.3 (188.1)	0/0/1
Heart rate after step test, mean (SD), beats per minute	162 (14)*	156 (16)	158 (14.8)	2/6/9

[a] *P* values *<0.05, **<0.01, †<0.001 refer to the statistically significant differences in comparisons between preterm groups and controls, using Student's t-test or Pearson's chi-square test with Yeates' Correction for Continuity for 2 by 2 tables.
[b]Participants invited from Northern Finland Birth Cohort 1986. The remaining population identified through Finnish Medical Birth Register.

[c] Gestational or chronic hypertension
[d] Includes superimposed pre-eclampsia
[e] Subjects whose mother's gestational diabetes data are missing include those whose mothers did not undergo an oral glucose tolerance test despite risk factors and thus have uncertain gestational diabetes status

Table 2. Mean physical activity and sedentary time values of young adults born preterm and their controls born at term

	Early preterm n = 60	**Late preterm n = 108**	**Controls n = 178**
Time of wearing accelerometer, mean (SD), min/day [b]			
Men	859 (73)	886 (90)	892 (83)
Women	869 (62)	881 (79)	870 (84)
All	865 (66)	883 (84)	879 (84)
Daily physical activity, mean (SD), counts per minute			
Men	263 (105)	341 (191)	315 (114)
Women	293 (102)	283 (118)	294 (138)
All	282 (103)	309 (157)	303 (129)
Sedentary time, mean (SD), % of daily monitoring time[b]			
Men	68.2 (9.3)	63.9 (11.8)	64.5 (10.8)
Women	64.4 (7.9)	65.8 (9.1)	64.5 (8.3)
All	65.9 (8.6)	65.0 (10.4)	64.5 (9.4)
Light-intensity physical activity, mean (SD), min/day[b]			
Men	247.5 (83.0)	280.9 (97.6)	283.2 (103.5)
Women	281.5 (74.1)	272.3 (83.0)	280.5 (77.2)
All	268.5 (78.7)	276.2 (89.6)	281.7 (88.9)
MVPA, mean (SD), min/day[b]			
Men	28.6 (18.5)	38.2 (30.4)	35.0 (20.6)
Women	28.4 (16.9)	29.2 (19.5)	29.7 (21.0)
All	28.5 (17.4)	33.3 (25.3)	31.9 (20.9)
$MVPA_{10min}$ (SD), min/day[b]			
Men	7.5 (9.3)	9.8 (13.5)	8.5 (11.9)
Women	13.0 (13.6)	11.8 (12.3)	12.0 (14.2)
All	10.9 (12.4)	10.9 (12.8)	10.6 (13.3)

[a] *P* values refer to comparisons between preterm groups and controls, using Student's t-test or Pearson's chi-square test with Yeates' Correction for Continuity for 2 by 2 tables. Level for statistical significance *P* value <0.05.
[b] The variables were computed as weighted averages of daily physical activity (PA) during weekdays (WD) and weekend days (WED) (daily PA – [5 * average WD PA + 2 * average WED PA] / 7).

Table 3. Daily physical activity (mean counts per minute, cpm), sedentary time (% of monitoring time), light physical activity (min/day), moderate to vigorous physical activity (MVPA, min/day) and $MVPA_{10min}$ (min/day) in preterm groups compared with term-born controls

Outcomes[a]	Controls n = 178	Model[b]	Early preterm n = 60	Late preterm n = 108	Total N
	Mean (SD)		Mean difference (95% CI)	Mean difference (95% CI)	
Daily physical activity, mean cpm	303 (129)				
		1	–21 (–61; 19)	5 (–27; 38)	346
		2	–16 (–62; 30)	5 (–29;39)	346
		3	–16 (–63; 31)	4 (–31; 39)	337
Sedentary time, % of monitoring time	64.5 (10.8)	1	1.20 (–1.64; 4.04)	0.19 (–2.14; 2.53)	346
		2	0.80 (-2.45; 4.05)	0.02 (–2.43; 2.47)	346
		3	0.95 (-2.34 ; 4.24)	–0.36 (–2.84;2.12)	337
Light-intensityphysical activity, min/day	281.7 (88.9)				
		1	–13.6 (–39.7; 12.5)	–3.1 (–24.4;18.1)	346
		2	–11.8 (–41.3; 17.7)	–1.6 (–23.7; 20.5)	346
		3	–15.9 (–45.7 ;13.9)	2.0 (–20.3; 24.2)	337
MVPA, min/day	31.9 (20.9)				
		1	–3.6 (–10.2; 2.9)	0.8 (–4.5; 6.1)	346
		2	–3.7 (–11.1; 3.6)	0.2 – 5.3;5.7)	346
		3	–3.3 (– 10.8; 4.2)	–0.4 (–6.0; 5.3)	337
$MVPA_{10min}$, min/day	10.6 (13.3)				
		1	0.2 (–3.6; 4.1)	0.3 (–2.8; 3.5)	346
		2	–0.2 (–4.6; 4.2)	–0.1 (–3.4; 3.2)	346
		3	0.1 (–4.4; 4.7)	–0.1 (–3.5; 3.3)	337

[a] The variables were computed as weighted averages of daily physical activity (PA) during weekdays (WD) and weekend days (WED) (daily PA – [5 * average WD PA + 2 * average WED PA] / 7).
[b] Model 1: sex, age, cohort, season
Model 2: Model 1+ socioeconomic status, maternal smoking, gestational diabetes and hypertension, birth weight SD score
Model 3: Model 2 + diagnosed asthma, adult body size: height, body fat percentage, smoking
No statistically significant (*P* value <0.01) interactions between sexes in the associations of preterm birth and the outcomes were observed.