Postpartum Breastfeeding and Cardiovascular Risk Assessment in Women Following Pregnancy Complications

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Abstract

Background: Breastfeeding is associated with lower cardiovascular (CV) risk over the long-term, however, less is known about its immediate effects among women with a recent complicated pregnancy. The objective of this study is to investigate the short-term effects of breastfeeding on markers of cardiovascular disease risk among women ~6 months after a pregnancy complicated by a hypertensive disorder, gestational diabetes, intrauterine growth restriction, abruption, or preterm birth.

Materials and Methods: Our cross-sectional analysis includes 622 women seen at 6 months postpartum (interquartile range: 5.7–6.7) between November 2011 and December 2017 at a tertiary care center. Self-reported breastfeeding status and measured CV risk factors were assessed at the same visit. CV risk factors were compared between women who did not breastfeed ($n=100$, 16%), those who breastfed for less than 6 months ($n=315$, 51%), and those who breastfed for 6 months or more ($n=207$, 33%) using multivariate logistic and linear regression.

Results: Increased breastfeeding duration significantly decreased the likelihood of metabolic syndrome (adjusted odds ratio [95% confidence interval; CI]: 0.89 [0.79–0.99]), abnormal fasting glucose (0.79 [0.64–0.96]), and ratio of total cholesterol to high-density lipoprotein-cholesterol (HDL-C) (0.86 [0.78–0.95]). Furthermore, body mass index (estimated beta coefficients [95% CI] –0.10 [–0.18 to –0.02]), fasting glucose (–0.05 [–0.08 to –0.02]), triglycerides (–0.07 [–0.10 to –0.04]), and ratio of total cholesterol to HDL-C (–0.06 [–0.10 to –0.03]) also decreased with increased breastfeeding duration, while HDL-C increased (0.02 [–0.01 to –0.04]).

Conclusions: Our findings suggest that breastfeeding is associated with decreased indicators of CV risk in a cohort of women with recent pregnancy complication.

Keywords: postpartum, breastfeeding, cardiovascular health, pregnancy complications

Introduction

CARDIOVASCULAR DISEASE (CVD) is the leading cause of death in women worldwide.¹ Evidence suggests that pregnancy acts as a cardiovascular (CV) stress test such that the development of certain pregnancy complications (hypertensive disorders of pregnancy [HDP], gestational diabetes [GDM], and intrauterine growth restriction [IUGR]), identifies a woman to be at increased risk of future CVD.^{2–4}

There is growing evidence suggesting that breastfeeding lowers specific CVD risk factors such as maternal blood pressure (BP), metabolic parameters, and risk of developing type 2 diabetes in the general population.^{5–11} A recent systematic review of 21 studies concluded that breastfeeding was associated with improvements in various CV risk factors

such as hypertension, type 2 diabetes, and inflammatory markers, including ghrelin and peptide YY.¹² Although there have been studies investigating the link between breastfeeding and long-term markers of CVD and morbidity in the general population, outcomes were usually measured decades after delivery, making it difficult to conclude direct associations.

There is a paucity of research on the short-term or long-term effects of breastfeeding on CVD risk specifically in women with pregnancy complications, although these women have lower initiation rates of breastfeeding and are at higher risk of early weaning.^{13–16} An analysis of 379 U.S. women with a history of gestational hypertension (GH) reported a mean decrease of 16.3 mmHg systolic/16.8 mmHg diastolic pressure in women who breastfed for more than 6 months compared with those who did not.¹⁷ Another

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prospective cohort study of 1,238 women in the United States showed a graded inverse association between breastfeeding duration and diabetes incidence.¹⁸

The postpartum period serves as a window of opportunity to implement targeted screening, counseling for lifestyle modification and potentially initiation of therapeutic interventions for CV health preservation and CVD prevention.¹⁹ Postpartum CV health clinics have been developed to initiate early screening, education, and intervention to reduce CVD risk in women at risk based on recent complications in pregnancy.^{20,21} In this study, we analyzed data from the Maternal Health Clinic (MHC) in Kingston, Ontario, a large Canadian clinical cohort of postpartum women with recent pregnancy complications (HDP, GDM, IUGR, placental abruption, and idiopathic preterm birth), to evaluate the short-term effects of breastfeeding on a variety of CVD risk factors at 6 months postpartum.

Materials and Methods

Study design, population, and setting

This cross-sectional analysis includes all women with a recent cardiometabolic complication in pregnancy, including HDP (pre-eclampsia, HELLP syndrome, or GH), GDM, IUGR, abruption, and preterm birth, who delivered at Kingston Health Sciences Center and attended the MHC. The Kingston Health Sciences Center is a tertiary referral center in Ontario, Canada serving a multiethnic population of 500,000 people, and where over 2,000 deliveries are performed annually. All eligible women are referred at the time of delivery for a 6-month follow-up at the MHC, where they undergo physical and biochemical CVD risk screening and self-report breastfeeding status and duration.²⁰ Women that attended the clinic from November 1, 2011 until December 31, 2017 were eligible for inclusion in this study. The Queen's University and Affiliated Teaching Hospitals Research Ethics Board reviewed the study for ethical conduct and participants provided informed written consent.

Data collection procedures

Nurses and obstetricians at the clinic collected data based on standardized interview and data collection forms and data were entered in the database by a nurse and research assistant. Blood draws were performed 1–2 weeks before the clinic visit at a community laboratory as part of local standard of care.

Exposure to breastfeeding

At the time of the MHC visit, all women were questioned by the research nurse about breastfeeding using a standardized questionnaire. Breastfeeding exposure was defined by the duration (in months) of breastfeeding at the time of the woman's MHC appointment. While MHC visits are typically scheduled for 6 months postpartum, there is some variability in the timing of this visit, and a woman is invited to attend up to 1 year postpartum.

Breastfeeding exposure was defined as the reported number of consecutive or cumulative months she had breastfed, up to and including the date of the clinic visit. Number of months of breastfeeding was recorded to one decimal point.

For the present analysis we divided the cohort into three distinct groups based on breastfeeding exposure: Participants who did not breastfeed (none), participants with less than 6 months exposure to breastfeeding (<6 months), and participants with 6 months or more exposure to breastfeeding (≥6 months). Other sources of feeding (*i.e.*, formula, solids), reasons for not breastfeeding, and reasons for discontinuation before 6 months postpartum were not routinely recorded.

Outcome data

Seated systolic and diastolic blood pressure (SBP and DBP, respectively) were recorded by the research nurse for all participants at the clinic visit using the standard technique.²² Following a minimum of 10 minutes at rest in a sitting position, a total of six BP measures were taken using an automated BP machine; the first measure was excluded, and an average of the remaining measures was recorded. This method has been shown to improve the accuracy of measurements and correlate well with 24-hour ambulatory BP results, and is the preferred measurement recommended by Hypertension Canada.^{22–25} SBP was specified as elevated (120–129 mmHg) or hypertensive (≥130 mmHg), and DBP as hypertensive (≥80 mmHg).²⁶ Height, weight, and abdominal circumference were measured and body mass index was calculated on all women (weight [kg]/height [m]²). We categorized BMI as low (<18.5 kg/m²), normal (18.5–25 kg/m²), overweight (25–30 kg/m²), and obese (≥30 kg/m²) as per World Health Organization categories.²⁷

Biochemical measurements included serum total cholesterol, high-density lipoprotein-cholesterol (HDL-C), low-density lipoprotein-cholesterol (LDL-C), triglycerides, fasting glucose, ratio of total cholesterol to HDL-C, and non-HDL-C (referred to herein as the “metabolic panel”). Data collected at the MHC visit were used to calculate the Lifetime Risk of CVD score (the cumulative risk assessment of developing CVD in one's lifetime²⁸) and to determine the presence of metabolic syndrome. The Lifetime Risk Score is determined based on cholesterol, BP, smoking, and fasting glucose, with scores stratified as high (≥39%) or low risk (<39%).²⁸ This scoring system has shown better utility in young female cohorts, as compared with other risk scores such as the Framingham Risk Score.²⁹ Metabolic syndrome was defined by the presence of three or more of (1) abdominal obesity with waist circumference >88 cm in women, (2) triglyceride level ≥150 mg/dL, (3) HDL-C < 50 mg/dL in women, (4) SBP ≥130 mmHg or DBP ≥85 mmHg, or (5) fasting glucose ≥100 mg/dL.³⁰

Covariate data

Sociodemographic data collected at the MHC include ethnicity, highest level of education achieved (grade or high school, postsecondary school not completed, postsecondary school completed), household income (<\$29,000, \$30,000–\$59,000, \$60,000–\$89,000, and ≥\$90,000), tobacco use (any or none), and level of physical activity (days/week). Pre-pregnancy weight and height was abstracted from the patient's chart. Prepregnancy BMI and gestational weight gain was determined based on this value. This information was verified with the patient at their visit and missing values were filled in based on self-report. Days physically active was defined as self-reported days per week where the participant completed 30 minutes or more of moderate physical activity.

A list of pre-existing medical conditions, family history of medical conditions, prior pregnancies, births, and use of assisted reproduction were also recorded.

Statistical analyses

Descriptive analyses were performed and compared in three groups based on exposure to breastfeeding: participants who did not breastfeed (none), participants with less than 6 months exposure to breastfeeding (<6 months), and participants with at least 6 months exposure to breastfeeding (≥6 months). The Kruskal–Wallis test was used to compare continuous variables and the chi squared test for categorical

variables between groups. All statistical tests were performed using two-sided tests and a family-wise level of significance of 0.05. The Bonferroni method was used to adjust for the family-wise error rate. The overall *p*-value of 0.05 was divided by three and *p* < 0.0167 was used to determine significance for each pairwise comparison. *p*-values are reported to three decimal places with values less than 0.001 reported as <0.001.

Multivariate analyses were performed using linear, logistic, or multinomial regression to examine the association between breastfeeding exposure and calculated CVD risk scores, presence of metabolic syndrome, physical measures (e.g., BP and BMI), and individual elements of the metabolic

TABLE 1. PARTICIPANT CHARACTERISTICS AT THE MATERNAL HEALTH CLINIC APPOINTMENT BY DURATION OF BREASTFEEDING

Characteristic	None (N = 100)	<6 Months (N = 315)	≥6 Months (N = 207)	p
Age (years), median (IQR)	32 (29–36)	31 (27–35)	32 (29–36)	0.028†
Prepregnancy BMI (kg/m ²), median (IQR)	28.6 (24.4–34.8) ^b	26.2 (22.4–32.0) ^b	25.5 (22.6–31.2)	0.004*‡
Overweight 25.0–29.9, n (%)	27 (27.6)	71 (22.7)	57 (27.5)	0.012*
Obese ≥30.0, n (%)	45 (45.9)	103 (32.9)	58 (28.0)	
Race, n (%)				
Caucasian	92 (92.9) ^a	270 (86.5) ^c	170 (83.3) ^c	0.072
Other	7 (7.1)	42 (13.5)	34 (16.7)	
Highest education level completed ^z , n (%)				
Postsecondary completed	67 (68.4) ^b	252 (81.3) ^d	184 (89.3) ^a	<0.001*,†
Postsecondary not complete	10 (10.2)	15 (4.8)	12 (5.8)	
Grade or high school	21 (21.4)	43 (13.9)	10 (4.9)	
Household income, n (%)				
≤\$29,000	14 (15.4) ^e	32 (10.7) ^g	8 (4.2) ^f	<0.001*,‡
\$30,000–\$59,000	31 (34.4)	64 (21.5)	32 (16.8)	
\$60,000–\$89,000	28 (31.1)	82 (27.5)	55 (28.8)	
≥\$90,000	17 (18.9)	120 (40.3)	96 (50.3)	
Smoking, n (%)	19 (19.0)	37 (11.7)	10 (4.8)	<0.001*†
Pre-existing diabetes, n (%)	1 (1.0)	3 (1.0)	1 (0.5)	0.82
Days physically active per week ^β , n (%)				
0	53 (53.0)	116 (37.4) ^d	74 (35.7)	0.014*,‡
1–3	19 (19.0)	95 (30.6)	70 (33.8)	
4–5	13 (13.0)	68 (21.9)	37 (17.9)	
6–7	15 (15.0)	31 (10.0)	26 (12.6)	
Parity, n (%)				
1	35 (35.0)	167 (53.2) ^a	86 (41.7) ^a	0.009*,‡
2	30 (30.0)	65 (20.7)	54 (26.2)	
≥3	35 (35.0)	80 (25.5)	66 (32.0)	
Gestational weight gain (kg), median (IQR)	13.0 (8.4–21.1) ^h	15.0 (10.0–20.6) ⁱ	14.0 (9.0–20.0) ^j	0.49
Excess gestational weight gain ^γ , n (%)	53 (57.6)	173 (59.5)	108 (55.4)	0.82
History of pregnancy complications ^δ , n (%)				
Gestational diabetes	27 (27.0)	81 (25.7)	63 (30.4)	0.49
Hypertensive disorder	55 (55.0)	173 (54.9)	97 (46.9)	0.16
Intrauterine growth restriction	12 (12.0)	27 (8.6)	19 (9.2)	0.59
Abruption	6 (6.0)	15 (4.8)	7 (3.4)	0.56
Preterm birth	11 (11.0)	47 (14.9)	24 (11.6)	0.43

Table information: ^aPostsecondary completed indicates that a degree or diploma has been completed, postsecondary not complete indicates that some classes were taken but a degree or diploma was not received, grade or high school completed categories were grouped into one category because of small cell counts; ^bSelf-reported days per week the participant completed 30 minutes or more of moderate physical activity; ^γGestational weight gain determined based on ppBMI: ppBMI <18.5 and >18.0 kg gained, ppBMI 18.5–24.9 and >16.0 kg gained, ppBMI 25.0–29.9 and >11.5 kg gained, and ppBMI >29.9 and >9.0 kg gained⁴⁷; ^δComplications from any previous pregnancy, a participant may have experienced more than one type of complication, if the participant experienced a given complication in multiple pregnancies it is only counted once. **p-Values:** The *p*-values presented are for the overall comparisons of the three groups by Kruskal–Wallis or chi square test. Further information on the corrected pairwise comparisons are provided by the asterisks. **Pairwise comparisons:** *≥6 Months versus none; †≥6 Months versus <6 months; ‡<6 Months versus none; For three pairwise comparisons at *p* = 0.05/3 = 0.0167. **Missing values:** a: 1; b: 2; c: 3; d: 5; e: 10; f: 16; g: 17; h: 7; i: 24; j: 12.

BMI, body mass index; IQR, interquartile range; ppBMI, prepregnancy body mass index.

FIG. 1. Flow diagram of eligible participants.

panel (e.g., high-density lipoprotein [HDL], low-density lipoprotein and glucose). For these models, breastfeeding exposure was considered as a continuous variable measured in months. For all models the following were considered as confounding variables: age, ethnicity, education, income, smoking, parity, physical activity, time postpartum, pre-pregnancy BMI, and gestational weight gain. The categorical variable levels are outlined in Table 1. Multivariate analyses were also performed, where breastfeeding exposure was considered a binary variable using “no breastfeeding” as the referent group. Unadjusted and adjusted models are included as Supplementary Tables S1–S4 (See Appendix).

A sensitivity analysis was performed for participants who visited the MHC between 5 and 7 months to ensure that all individuals had an equal opportunity to breastfeed for ~6 months. We thus excluded women who visited the MHC at <5 or ≥8 months (9 women from the “None” group, 29 from the “<6 Months” group, and 21 women from the “≥6 Months” group), resulting in a sample size of 563 women included in this analysis. Similar multivariate analyses using linear, logistic, or multinomial regression models were performed for this subgroup. All analyses were performed using SPSS Statistics version 24 (SPSS, Inc., Chicago, IL).

Results

Between November 2011 and December 2017, 638 women attended the MHC for a pregnancy complication (Fig. 1).

After excluding 16 women with unknown breastfeeding status at their MHC visit, 622 women were included in the analysis. Of these women, 325 (49%) had HDP, 171 (26%) had GDM, 58 (9%) had IUGR, 28 (4%) had abruption, and 82 (12%) had preterm birth, and these complications were not mutually exclusive. The median time postpartum at the time of the MHC visit was 6.1 months [interquartile range 5.7–6.7] with a range of 1.8–14.9 months. The women were analyzed by three groups based on breastfeeding exposure: 207 (33%) women breastfed for ≥6 months, 315 (51%) breastfed for less than 6 months, and 100 (16%) did not breastfeed.

Baseline characteristics are presented in Table 1. Women who breastfed ≥6 months reported a higher level of education completed compared with those who breastfed <6 months, and compared with those who did not breastfeed. Household income, physical activity, and parity were also significantly higher in breastfeeding women (<6 and ≥6 months) compared with women who did not breastfeed. There were no between-group differences in race, pre-existing diabetes, or a prior history of pregnancy complications.

Table 2 presents CVD risk factors according to category of breastfeeding duration. All the following pairwise comparisons are statistically significant at the adjusted p -value <0.0167. Women who breastfed for ≥6 months had significantly lower triglycerides, fasting serum glucose, ratio of cholesterol to HDL-C and higher HDL-C. BMI, waist circumference, and SBP were also significantly lower in women who were still breastfeeding at 6 months. The

TABLE 2. BIOCHEMICAL MEASUREMENTS, PHYSICAL MEASUREMENTS, AND RISK ASSESSMENTS AT THE TIME OF MATERNAL HEALTH CLINIC VISIT BY DURATION OF BREASTFEEDING

Biochemical measurements	None (N=100)	<6 Months (N=315)	≥6 Months (N=207)	p
Total cholesterol (mmol/L), median (IQR) ≥5.16 (mmol/L), n (%)	4.61 (4.04–5.31)^a 21 (27.3)	4.62 (4.09–5.21)^c 70 (27.3)	4.48 (3.96–5.04)^g 35 (20.7)	0.22 0.27
HDL-C (mmol/L), median (IQR) <0.90 (mmol/L), n (%)	1.24 (1.09–1.51)^a 5 (6.5)	1.39 (1.20–1.62)^d 9 (3.5)	1.42 (1.23–1.67)^g 5 (3.0)	<0.001^{*,‡} 0.38
LDL-C (mmol/L), median (IQR) ≥3.50 (mmol/L), n (%)	2.83 (2.21–3.27)^b 13 (17.3)	2.63 (2.21–3.18)^e 43 (16.9)	2.62 (2.15–2.99)ⁱ 22 (13.2)	0.36 0.54
Triglycerides (mmol/L), median (IQR) ≥1.70 (mmol/L), n (%)	1.20 (0.84–1.57)^a 17 (22.1)	0.95 (0.66–1.51)^c 44 (17.2)	0.73 (0.55–1.05)^g 22 (13.0)	<0.001^{*,‡} 0.19
Fasting glucose (mmol/L), median (IQR) >5.6 (mmol/L), n (%)	4.9 (4.5–5.2)^b 6 (8.0)	4.7 (4.4–5.0)^f 14 (5.6)	4.6 (4.4–4.9)^h 2 (1.2)	<0.001^{*,‡} 0.028 [*]
Ratio total cholesterol:HDL-C, median (IQR) ≥3.5, n (%)	3.7 (3.0–4.3)^a 49 (63.6)	3.2 (2.7–4.0)^d 98 (38.4)	3.2 (2.6–3.8)^g 62 (36.7)	<0.001^{*,‡} 0.018 [*]
Non-HDL-C (mmol/L), median (IQR) ≥4.3 (mmol/L), n (%)	3.36 (2.78–4.10)^a 12 (15.6)	3.12 (2.61–3.74)^d 33 (12.9)	2.99 (2.51–3.64)^g 18 (10.7)	0.018[*] 0.54
Physical measurements				
SBP (mmHg), median (IQR) Elevated 120–129 (mmHg), n (%) Hypertensive ≥130 (mmHg) ^z , n (%)	120 (111–130)^j 25 (25.3) 28 (28.3)	117 (111–127)^k 72 (23.1) 58 (18.6)	114 (108–122) 41 (19.8) 27 (13.0)	0.001^{*,‡} 0.006 [*]
DBP (mmHg), median (IQR) Hypertensive ≥80 (mmHg) ^z , n (%)	81 (73–90)^j 55 (55.6)	80 (74–87)^k 172 (55.1)	78 (73–85) 94 (45.4)	0.067 0.07
Antihypertensive use, n (%)	5 (5.0)	6 (1.9)	5 (2.4)	0.23
BMI (kg/m ²), median (IQR) Overweight 25.0–29.9 (kg/m ²), n (%) Obese ≥30.0 (kg/m ²), n (%)	32.5 (26.8–39.6)^j 28 (28.3) 57 (57.6)	28.4 (24.8–34.9) 93 (29.5) 134 (42.5)	27.1 (23.7–33.7) 57 (27.5) 79 (38.2)	<0.001^{*,‡} 0.003 ^{*,‡}
Waist circumference (cm), median (IQR) 80.0–88.0 (cm), n (%) >88.0 (cm), n (%)	100.6 (89.3–116.5)^j 12 (12.1) 76 (76.8)	93.0 (83.7–109.4)^j 62 (19.7) 197 (62.7)	90.0 (82.0–104.3)^j 49 (23.8) 115 (55.8)	<0.001^{*,‡} 0.014 ^{*,‡}
Risk assessments				
High lifetime risk of CVD ^β , n (%)	48 (63.2)^l	115 (45.1)^d	67 (39.9)^h	0.003^{*,‡}
Metabolic syndrome criteria Met ^γ , n (%)	22 (29.3)^b	52 (21.0)^m	26 (15.7)ⁿ	0.049[*]

Table Information: ^aOr using an antihypertensive; ^βThe Lifetime risk score (the cumulative risk assessment of developing CVD in one's lifetime) is determined based on cholesterol, BP, smoking, and fasting glucose, with scores defined as high when ≥39%²⁸; ^γMetabolic syndrome was defined by the presence of three or more of (1) abdominal obesity with waist circumference >88 cm in women, (2) triglyceride level ≥150 mg/dL, (3) HDL-C <50 mg/dL in women, (4) SBP ≥130 mmHg or DBP ≥85 mmHg, or (5) fasting glucose ≥100 mg/dL.³⁰ **p-Values:** The p-values presented are for the overall comparisons of the three groups by Kruskal–Wallis or chi square test. Further information on the corrected pairwise comparisons are provided by the asterisks. **Pairwise comparisons:** ^{*}≥6 Months versus none; [†]≥6 Months versus <6 Months; [‡]<6 Months versus none; for three pairwise comparisons at p=0.05/3=0.0167. **Missing values:** a: 23; b: 25; c: 59; d: 60; e: 61; f: 64; g: 38; h: 39; i: 40; j: 1; k: 3; l: 24; m: 67; n: 41.

Values in bold indicate statistical significance.

BP, blood pressure; DBP, diastolic blood pressure; HDL-C, high-density lipoprotein-cholesterol; LDL-C, low-density lipoprotein-cholesterol; SBP, systolic blood pressure.

proportion of women with a high lifetime risk of CVD was significantly lower among women with any breastfeeding compared with those who did not breastfeed. The percentage of women with metabolic syndrome was lower in women who breastfed ≥6 months compared with women who did not breastfeed.

The effect of increasing breastfeeding duration in months (up to 6 months) on the odds of abnormal risk scores, physical measures, and blood work, before and after adjusting for confounding variables with logistic or multinomial regression, can be found in Table 3. The following outcomes were found to have adjusted odds ratios for breastfeeding duration in months that were significant at p<0.05. The odds of having metabolic syndrome were statistically significantly decreased with increasing breastfeeding duration. The odds

of having abnormal fasting glucose or ratio of total cholesterol to HDL-C also decreased significantly.

The effect of increasing breastfeeding duration in months on physical measures and blood work, before and after adjusting for confounding variables with linear regression, can be found in Table 4. BMI, fasting glucose, triglycerides, and the ratio of total cholesterol to HDL-C significantly decreased with increasing breastfeeding duration. HDL significantly increased with increasing breastfeeding duration.

The sensitivity analyses include women who visited the MHC within 5–7 months postpartum (N=563) (see Supplementary Tables S5–S8 in Supplementary Appendix SA1). Increased breastfeeding duration was associated with lower physical and chemical markers for CV risk. The proportion of

TABLE 3. ODDS RATIO ESTIMATES FOR DURATION OF BREASTFEEDING (MONTHS)—LOGISTIC OR MULTINOMIAL REGRESSION

Outcome for the model	N	Unadjusted OR (95% CI)	p	N	Adjusted OR ^a (95% CI)	p
Risk scores						
Metabolic syndrome ^b	489	0.83 (0.76–0.91)	<0.001	415	0.89 (0.79–0.99)	0.035
High lifetime risk score ^c	499	0.87 (0.81–0.94)	<0.001	423	0.95 (0.86–1.04)	0.25
Physical measures						
BMI (kg/m ²)						
Overweight 25.0–29.9 vs. normal <25.0	621	0.90 (0.82–0.98)	0.012	523	0.89 (0.74–1.06)	0.20
Obese ≥30.0 vs. normal <25.0		0.85 (0.78–0.92)	<0.001		0.82 (0.65–1.04)	0.10
Waist circumference (cm)						
80.0–88.0 vs. Normal <80.0	619	0.99 (0.89–1.10)	0.83	520	1.01 (0.85–1.21)	0.89
>88.0 vs. Normal <80.0		0.87 (0.80–0.95)	0.003		0.85 (0.70–1.04)	0.11
SBP (mmHg)						
Elevated 120–129 vs. normal <120	618	0.91 (0.84–0.99)	0.022	520	0.91 (0.83–1.00)	0.051
Hypertensive ≥130 vs. normal <120		0.85 (0.78–0.92)	<0.001		0.94 (0.84–1.04)	0.22
DBP (mmHg)						
Hypertensive ≥80 vs. normal (<80)	618	0.93 (0.87–0.99)	0.022	520	0.94 (0.87–1.02)	0.16
Blood work						
Total cholesterol ≥5.16 mmol/L	502	0.95 (0.88–1.03)	0.20	425	0.96 (0.86–1.06)	0.42
HDL-C <0.09 mmol/L	501	0.82 (0.68–0.98)	0.03	425	0.92 (0.74–1.14)	0.46
LDL-C ≥3.50 mmol/L	496	0.93 (0.84–1.02)	0.13	421	0.97 (0.85–1.09)	0.59
Fasting glucose >5.6 mmol/L	494	0.78 (0.66–0.93)	0.005	419	0.79 (0.64–0.96)	0.019
Triglycerides ≥1.70 mmol/L	502	0.85 (0.77–0.93)	0.001	425	0.89 (0.79–1.01)	0.066
Total cholesterol:HDL-C ≥ 3.0	501	0.84 (0.78–0.90)	<0.001	425	0.86 (0.78–0.95)	0.003
Non-HDL-C ≥ 4.30 mmol/L	501	0.90 (0.81–0.99)	0.047	425	0.94 (0.82–1.07)	0.33

^aAdjusted for age (years), race, education, income, smoking, parity, physical activity (days/week), time postpartum (months), ppBMI (kg/m²), and gestational weight gain (kg). Groupings for the categorical variables as described in Table 1; ^bMetabolic syndrome was defined by the presence of three or more of (1) abdominal obesity with waist circumference >88 cm in women, (2) triglyceride level ≥150 mg/dL, (3) HDL-C < 50 mg/dL in women, (4) SBP ≥130 mmHg or DBP ≥85 mmHg, or (5) fasting glucose ≥100 mg/dL³⁰; ^cThe Lifetime risk score (the cumulative risk assessment of developing CVD in one's lifetime) is determined based on cholesterol, BP, smoking and fasting glucose, with scores defined as high when ≥39%.²⁸

Values in bold indicate statistical significance.

CI, confidence interval; CVD, cardiovascular disease; OR, odds ratio.

women with a high lifetime risk of CVD and metabolic syndrome was associated with increased breastfeeding.

Discussion

This study found that in a cohort of postpartum women with a pregnancy complication associated with an increased risk of future CVD, there seemed to be a dose-response effect of increased breastfeeding on various biochemical, physical, and metabolic markers of CVD risk measured at 6 months postpartum. The results of our study are mostly congruent with previous research investigating the effects of breastfeeding duration and various CVD markers. In a meta-analysis of 21 retrospective and prospective studies, breastfeeding was associated with lower odds of metabolic risk factors, hypertension, type 2 diabetes, and prevalent CVD in the general population. The same review reported little or no association between breastfeeding and postpartum weight change and body composition.¹² However, our cohort differs from previous published work in the inclusion of women with excess risk of future CVD based on a recent complicated pregnancy.

Evidence of the effects of breastfeeding specifically in women with HDP is still scarce and inconclusive. One other study of 379 women found a reduction in BP in women with a history of GH when comparing those who breastfed for greater than 6 months to those who did not breastfeed at all.¹⁷ Another cohort study of 1,238 women in the United States

showed an inverse association between breastfeeding duration and diabetes incidence.¹⁸ A recent study by Countouris et al. found that breastfeeding duration among women with GH and preeclampsia was not associated with specific measures of inflammation and renal function.³¹

Overall, the results from our study build on the existing body of literature suggesting that breastfeeding is associated with potential improvements of short-term cardiometabolic health outcomes, and that these benefits may be further augmented among women who have had a pregnancy complication. Although CVD risk is a long-term matter and we can presently only speculate on any future benefits of breastfeeding, our results demonstrate the importance of early identification of these higher risk women to receive primary prevention as opposed to management later in life when there is potentially a greater disease burden on CVD. The addition of supportive breastfeeding interventions as part of an overall CVD risk reduction strategy should be tested and implemented in both the perinatal period and in specialized postpartum CVD risk reduction clinics such as the MHC.

Clinical implications

While the WHO recommends exclusive breastfeeding for 6 months,³² only 26% of Canadian women follow this guideline and many incur a sharp drop-off in EBF by 6 weeks postpartum due to factors such as perceived poor milk supply,

TABLE 4. PARAMETER ESTIMATES FOR DURATION OF BREASTFEEDING (MONTHS)—LINEAR REGRESSION

Outcome for the model	N	Unadjusted parameter estimate (95% CI)	p	N	Adjusted parameter estimate ^a (95% CI)	p
Physical measures						
BMI (kg/m ²)	621	-0.56 (-0.80 to -0.33)	<0.001	522	-0.10 (-0.18 to -0.02)	0.019
Waist circumference (cm)	619	-1.35 (-1.91 to -0.80)	<0.001	520	-0.28 (-0.60 to 0.03)	0.073
SBP (mmHg)	618	-0.68 (-1.07 to -0.28)	0.001	520	-0.30 (-0.76 to 0.17)	0.21
DBP (mmHg)	618	-0.34 (-0.65 to -0.02)	0.035	520	-0.06 (-0.44 to 0.32)	0.76
Blood work						
Total cholesterol (mmol/L)	502	-0.02 (-0.06 to 0.01)	0.15	425	-0.01 (-0.05 to 0.03)	0.57
HDL-C (mmol/L)	501	0.03 (0.02 to 0.05)	<0.001	425	0.02 (0.01 to 0.04)	0.001
LDL-C (mmol/L)	496	-0.02 (-0.05 to 0.01)	0.12	421	-0.004 (-0.04 to 0.03)	0.81
Fasting glucose (mmol/L)	494	-0.05 (-0.08 to -0.02)	0.001	419	-0.05 (-0.08 to -0.02)	0.004
Triglycerides (mmol/L)	502	-0.10 (-0.13 to -0.07)	<0.001	425	-0.07 (-0.10 to -0.04)	<0.001
Total cholesterol:HDL-C	501	-0.10 (-0.13 to -0.06)	<0.001	425	-0.06 (-0.10 to -0.03)	0.001
Non-HDL-C (mmol/L)	501	-0.06 (-0.09 to -0.03)	<0.001	425	-0.03 (-0.07 to 0.01)	0.086

^aAdjusted for age (years), race, education, income, smoking, parity, physical activity (days/week), time postpartum (months), ppBMI (kg/m²), and gestational weight gain (kg). Groupings for the categorical variables as described in Table 1.
Values in bold indicate statistical significance.

difficulty with breastfeeding techniques, and fatigue.^{33,34} Women with pregnancy complications such as HDP are at even higher risk of early weaning and lower initiation rates of breastfeeding due to specific biological (endothelial dysfunction, metabolic syndrome, obesity), psychosocial (depression, anxiety), and contextual (low birth weight or preterm birth) factors.^{13–16} Our results support the recommendation that breastfeeding at least until 6 months postpartum may provide protective effects against preclinical CVD.

Furthermore, women with pregnancy complications who have difficulty initiating and maintaining breastfeeding should especially be supported through breastfeeding interventions. Enhancing breastfeeding self-efficacy has the potential to overcome the challenges of engaging these women in postpartum maintenance of healthy behaviors other than breastfeeding.³⁵ Furthermore, since many women with HDP carry a new diagnosis of hypertension within the first postpartum year and many others have raised BP below hypertension threshold,^{36,37} encouraging successful breastfeeding in the perinatal period may have significant impact in this population. Given the unique vulnerability and challenges of women with pregnancy complications and lack of previous breastfeeding trials in this population, further research should be conducted on the feasibility of perinatal breastfeeding interventions.

Strengths and limitations

Although randomized controlled trials are the gold standard for determining causal relationships, it is not ethical to randomize women to not breastfeed. Therefore, well-designed prospective studies that control for potential confounders render the next best evidence. Our study uses data from the largest Canadian cohort of postpartum women with a history of pregnancy complications with robust collection of clinical variables.³⁸ As shown in Figure 1, approximately half of the eligible population invited chose to attend the clinic. Previous work has demonstrated that women are more likely to attend if they are older, do not smoke, live closer to the hospital, and live in a Census Metropolitan Area with higher median earnings.³⁸ The biases in this clinical population should be considered when generalizing results.

Given the largely Caucasian demographic and higher education and socioeconomic status (SES), the cohort may not be fully representative of the Canadian population. While multivariate modeling has been used in an attempt to account for differences in SES, there may be residual confounding. Furthermore, the relationship among SES, breastfeeding, and CVD risk is complex. This study cannot describe that relationship in entirety and conclusions that are drawn should be limited to the timeframe of the study. Prepregnancy BMI and gestational weight gain were abstracted from the patient's chart and missing values were filled in based on self-report. However, due to the nature of the database, we were unable to ascertain the proportion of these measurements that were self-reported or abstracted from charts.

Due to the fact that breastfeeding status was self-reported, recall or reporting bias may have given rise to misclassification of breastfeeding duration. However, previous research has shown that women with shorter durations of breastfeeding tended to overestimate while women with longer durations tended to underestimate.³⁹ This trend would bias our observed effect to the null value and show less of a significant

difference, suggesting that the effect of breastfeeding might be even more potent. Due to the cross-sectional nature of the measurement, only breastfeeding length in months until the time of the MHC appointment was used in the analysis. Therefore, the measurement used represents exposure to breastfeeding at the time of the CV risk factor assessments. While participants reported the number of months they intended to breastfeed beyond the clinic visit, this was not used in the analysis. Breastfeeding exclusivity or intensity was unknown and the reasons why a woman chose not to breastfeed or decided to stop breastfeeding early were not collected. Breastfeeding and the decision to breastfeed may also be associated with other maternal health behaviors such as physical activity and likelihood of smoking, which were also self-reported. Although many of these demographic factors and lifestyle behaviors were controlled for in the analysis, there may still be residual confounding.

The relationship between breastfeeding and CVD risk indicators may be bidirectional. Women who already have pregnancy complications are likely to have other CVD-related health issues such as obesity, hypertension, and diabetes, which may exacerbate the challenges associated with initiating or maintaining breastfeeding. Research has found that maternal obesity is associated with discontinuation of breastfeeding and delayed onset of lactogenesis following delivery.^{40,41} This association also gives rise to the causality dilemma of whether breastfeeding prevents metabolic syndrome or if metabolic syndrome prevents breastfeeding.⁴¹ Observational studies have demonstrated that longer duration of breastfeeding is associated with reduced risk of metabolic disease as lactation is thought to mobilize energy stores in the mother.^{43,44} However, other studies suggest that specific metabolic risk factors such as insulin resistance and elevated BMI are associated with lower breastfeeding rates, suggesting that the direction of the association is inconclusive due to confounding health factors.^{45,46}

Conclusion

Our findings show that increased breastfeeding duration is significantly associated with a decreased trend in various short-term markers of CVD risk in a cohort of postpartum women who were diagnosed with a pregnancy complication. Although a causal relationship cannot be definitively established, breastfeeding duration for at least 6 months correlated with potential short-term improvements of direct and indirect measures of maternal CV health. More research is needed to elucidate the physiological basis and duration of the effect of breastfeeding on CVD risk factors. Further investigations are required to determine the ongoing long-term benefits of breastfeeding duration and exclusivity on maternal health.

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Supplementary Material

Supplementary Appendix SA1
Supplementary Table S1

Supplementary Table S2
Supplementary Table S3
Supplementary Table S4
Supplementary Table S5
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Supplementary Table S7
Supplementary Table S8

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