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ARTICLE

The Effectiveness of a Yoga Program on Heart Rate Variability in Postpartum Women

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Abstract

Background: Chronic stress in new motherhood may result in dysregulation of the autonomic nervous system. Yoga has been found to increase heart rate variability (HRV) in healthy adults. **Purpose**: It is unknown whether yoga is effective at improving HRV in this population. **Methods:** Thirty women, mean age 31.5 (3.9) years, were randomized into one of three 12-week intervention groups: 1) in-person yoga, 2) online yoga, and 3) control and completed HRV measurements. HRV was recorded daily by participants 3 minutes upon waking as the root mean square of successive R-R intervals for 14 days pre- and post-intervention. Furthermore, participants recorded self-compassion, fatigue, and depressive symptoms at baseline and follow-up. **Results:** HRV decreased in the in-person yoga group ($p<0.05$) but was not significant when compared to the control group. There were significant improvements in depression in the online yoga group ($p<0.05$). There were no significant associations between change in HRV and change in self-compassion, fatigue, or depression. **Conclusions:** Future research should consider a greater frequency of yoga classes to determine if there is a dose-response to HRV. To enhance the engagement of postpartum women in physical activity research, less stringent group assignments should be considered.

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Introduction

The transition to parenthood is monumental, but also fraught with challenges that can take a toll on the mental well-being of new mothers. Postpartum depression and anxiety are increasingly common among women after the birth of a child and are often associated with poor sleep quality (Cai et al., 2023; Okun et al., 2018). Due to the elevated and chronic stress experienced in new motherhood, there may be dysregulation of the autonomic nervous system (Pawluski et al., 2017). Monitoring heart rate variability (HRV) is a simple and non-invasive method of assessing autonomic nervous system function. A high HRV shows highly varied R-R intervals and is indicative of parasympathetic tone. Enhanced parasympathetic tone indicates greater autonomic balance and a state of relaxation, which means the body has a high capacity for stress and adaptation (Lujan et al., 2021). A low HRV shows R-R intervals with low variability and indicates high sympathetic tone, low adaptability to changing environments, and low capacity for stress (Ishaque et al., 2021; Lujan et al., 2021). Physical activity is one intervention that shows promise for improving the

mental well-being of new mothers (Hatfield et al., 2022; Lesser, et al., 2023a; Mullins et al., 2021).Despite the potential benefits of physical activity in this population, physical activity levels are low postpartum (Borodulin et al., 2009). New mothers express that a lack of support in beginning or returning to physical activity and vague recommendations from healthcare providers make physical activity engagement challenging (Bean et al., 2023; Ritondo et al., 2023). Yoga has become a popular form of low-impact (slower and gentler) physical activity for perinatal women (Corrigan et al., 2022). Yet, for postpartum women, there is a lack of low-impact physical activity opportunities, with post-natal yoga programs only recently gaining in popularity (Buttner et al., 2015; Eustis et al., 2019; Tully et al., 2017). Yoga may be an ideal form of physical activity for new mothers as a low impact physical activity that may serve as a stepping stone for returning to higher impact physical activity after the birth of a child. Among postpartum women who engage in yoga, researchers have reported an improvement in depression, anxiety, and health-related quality of life (Buttner et al., 2015). In addition, women have experienced an improvement in stress and dysfunctional coping, as well as a decrease in negative affect (Timlin & Simpson, 2017). Though not studied specifically in the postpartum population, yoga has been found to increase HRV in healthy adults and pregnant women (Chu et al., 2017; Žebeljan et al., 2022), suggesting the potential utility of yoga for improving autonomic nervous system functioning.

We have previously found that postpartum women who engage in more physical activity have greater self-compassion than those who engage in less physical activity (Lesser et al., 2023b). Therefore, physical activity engagement may improve self-compassion in this population. Furthermore, individuals with higher self-compassion have been found to have higher HRV, suggesting that self-compassion modulates HRV (Luo et al., 2018). This has been suggested to be due to the role of HRV in exerting flexible control over behavioural response to uncertainty with self-compassionate individuals more capable of adapting to stressful experiences (Thayer & Sternberg, 2010). Therefore, if physical activity such as yoga effectively improves self-compassion, this may be further associated with improvements in HRV in postpartum women.

Given the challenges faced by this population in physical activity engagement, it is necessary to evaluate the feasibility of physical activity programming in diverse settings. Physical activity postpartum has been shown to be more widely engaged with higher adherence when offered as part of a supervised session (Mullins et al., 2021). However, engaging in physical activity in the home environment allows for more flexibility around infant nap schedules and childcare, which are known barriers to physical activity engagement in this population (Lesser et al., 2023a). Therefore, the purpose of this study was to assess the effectiveness of a 12-week bi-weekly yoga program offered in person and online on HRV when compared to an information control group. The secondary objective of the study was to assess whether there is an association between change in HRV and change in self-compassion, fatigue, or depression symptoms over the 12-week intervention.

Methods

This trial was part of a larger three-arm randomized controlled trial, which additionally assessed physical activity behaviour and psychological well-being. This paper explores the primary outcome of HRV and potential associated variables. This study was registered at ClinicalTrials.gov (***NCT05403983)*** and approved by the University of the Fraser Valley Human Research Ethics Board. All participants provided written informed consent.

Procedure

Women were recruited from local physicians' offices through paid Facebook ads, word of mouth, and local media. Potential participants were screened for eligibility by the research assistant and were provided further information about the study requirements. Eligibility included: (1) self-reported clearance by their physician to engage in physical activity, (2) having an infant ≤6 months of age, (3) understanding and speaking English, and (4) being willing to be randomized. Participants who were interested and eligible to participate completed a written consent form while meeting with the research assistant to complete the pre-intervention survey (Survey Monkey platform, an online survey software platform). Following completion of the online survey, participants were assisted with installing the Elite HRV app on their phones and provided a heart rate monitor (Polar H10; (Polar H10; Polar Electro Oy, Kempele, Finland). The research assistant instructed the participant on the methods of completing a 3-minute resting measurement and how to record the RMSSd HRV number provided at the end of the measurement interval. After completing the baseline assessment, participants received an envelope with their randomization, and the research assistant described the intervention assigned to the participant, which was one of the following: (i) a 12-week group-based bi-weekly yoga program (intervention 1), (ii) a 12-week asynchronous bi-weekly online yoga program (intervention 2) and (iii) an information control group (intervention 3). Randomization was conducted by the study investigator (IL), who assigned participants an ID number and a group associated with the number provided by a random number generator. Randomization was done in two blocks. Twenty-two participants were randomized in the first block and enrolled in the 12-week intervention running from October to December 2022, and 21 participants were randomized in the second block and enrolled in the 12-week intervention running from February to April 2023. The research assistant was unaware of their randomization until the participant opened the envelope.

To ensure adequate statistical power, a sample size calculation was conducted for the primary outcome of HRV. It was determined that the minimum target sample should be 27 participants in each group (i.e., a total study sample size of 81). However, we were unable to meet this intended sample size due to recruitment challenges and a lack of participants willing to enroll in a randomized controlled trial. Therefore, the study was closed early, and the decision was made to analyze existing data and publish important proof-of-concept data to inform future trials.

Yoga Program: BodyBalance™ (Intervention 1 and 2)

The yoga program used was the 55-minute class BodyBalance™, created by Les Mills International (Auckland, New Zealand). BodyBalance™ is a mixture of yoga, Tai Chi, and Pilates and ends with an approximately 10-minute guided meditation. Breathwork is emphasized throughout the class. This intervention has previously been shown to increase HRV (indicating improvements in autonomic nervous system function), increase confidence and motivation, and improve sleep quality in active adults (Gottschall et al., 2020). Participants were asked to participate in two classes per week at a community university campus. For the online intervention, participants were given digital access to previously recorded BodyBalance™ classes. Participants in the in-person group were given the option to bring their babies to class, which most women elected to do. In-person and online groups did the same version of BodyBalance™ (i.e., same music, same exercises) each week. The BodyBalance™ version was changed each month to maintain participant interest (i.e., three different BodyBalance™ releases were used over the 12-week intervention). The online group was instructed each month via email, which BodyBalance™ released to do at home.

All BodyBalance™ classes were taught by instructors certified in BodyBalance™ by Les Mills International (Les Mills USA or Les Mills New Zealand). The same instructor (GH) taught all of the in-person classes. Participants were offered various modifications throughout the sessions (both in-person and online) to increase/decrease intensity and were told what key things to look for and feel to ensure their technique was correct. For the in-person group, participants who brought their infant to class were encouraged to do as much of the class as they were able to do while attending to the needs of their baby.

Information Control Group (Intervention 3)

The information control group received the national guidebook "Mothers Moving Forward: A Postpartum Guide to Being Physically Active" written by Dr. Iris Lesser and Dr. Corliss Bean in collaboration with the *Sport Information Resource Center* (Bean & Lesser, 2023). The guidebook helps women get started on their return to physical activity, learn how to take care of their postpartum selves, and incorporate strategies to support their physical activity journey. At the end of the trial (i.e., after filling out the online survey three months from baseline), women allocated to the information control group were given online access to the BodyBalance™ program for 12 weeks.

Primary Outcome

The primary outcome was HRV measured before and after the 12-week intervention. Participants were given chest straps (Polar H10; Polar Electro Oy, Kempele, Finland) and asked to measure their supine resting HRV first thing in the morning (within 30 minutes of waking and prior to ingestion of caffeine) for 3 minutes using the Elite HRV App with breathing cues (Asheville, NC USA). Participants were asked to stay as still as possible during measurements but may have been holding an infant during measurement. When measuring root mean square of successive differences (RMSSd in athletes, a minimum 3-minute window has been established as appropriate for HRV measurement (Bourdillon et al., 2017). Participants recorded the RMSSd daily for 14 days (7 days prior to the

intervention and 7 days once the 12-week intervention started). RMSSd is a time-domain HRV measurement which is reflective of the variance in heart rate and provides an estimation of the autonomic nervous system activity (Shaffer & Ginsberg, 2017). Measures were repeated one week prior to the intervention ending and one week after the intervention had ended. Thus, there was a total of 14 days of HRV recording at baseline and 14 days of HRV recording at follow-up. These participant recordings were noted in a logbook and given to the research team at the beginning and the end of the intervention.

Secondary Outcome Measures

Participants provided demographic and maternal health information, which included the age of the participant, ethnicity, age of the infant, number of children, and pregnancy risk factors. They also indicated how much moderate to vigorous activity they typically got in a week (minutes/week). Participants reported their weekly physical activity engagement as type (what physical activity they did), frequency (how often they engaged in each physical activity) and duration (how long they engaged in each physical activity) (Davenport et al., 2020). Physical activity types were further classified into moderate or vigorous intensity (Ainsworth et al., 2011). The volume of physical activity was then totalled to moderate physical activity minutes/week, vigorous physical activity minutes/week, and total physical activity minutes/week.

At baseline and follow-up, participants responded to questionnaires on psychological well-being. Measures included in this study were those hypothesized to be associated with HRV, including self-compassion, fatigue, and postnatal depression.

Self-Compassion

The Self-Compassion Scale long-form (Neff, 2003) was used to assess self-compassion. Participants rated 26 items on a 5-point Likert scale from 1= almost never to 5= almost always (e.g., when things are going badly for me, I see the difficulties as part of life that everyone goes through (Neff, 2003). A higher mean score is representative of a higher level of self-compassion. This scale has been shown to be valid and reliable and has previously been used in a postpartum population (Monteiro et al., 2019; Neff, 2003).

Fatigue

Fatigue was measured using the multidimensional assessment of fatigue (MAF) with 16 items on a 5-point scale from 1= yes to 5= that is not true (e.g., I am rested). Questions aim to indicate how one has been feeling over the previous seven days through four dimensions based on severity, distress, degree of interference with activities of daily living, and fatigue timing (Belza et al., 2018). A higher score is representative of greater fatigue. This scale has previously been validated in postpartum women (Fairbrother et al., 2008).

Postnatal Depression

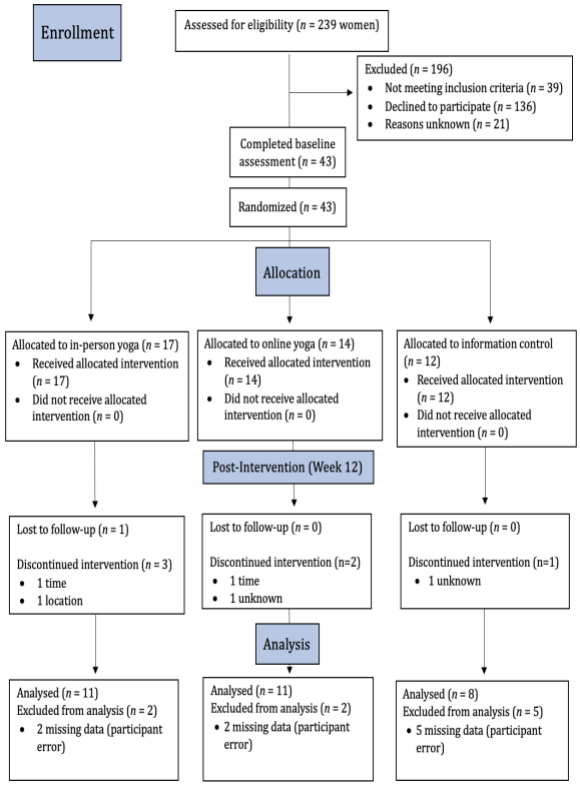
The Edinburgh Postnatal Depression Scale (EPDS) is a widely used scale to measure depression symptomology in the postpartum period (Cox et al., 1987). The scale has 10 items ranked on a 4-point scale from 1= yes, all the time to 4= no, not at all (e.g., in the past 7 days I have looked forward to things). A higher score is

indicative of higher depressive symptomology (Figueiredo & Conde, 2011).

Statistical Analysis

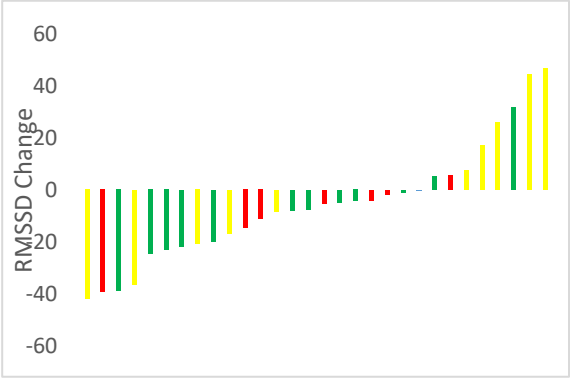
The primary analysis included all participants who completed HRV monitoring at baseline and follow-up. Participants who were lost to follow-up or did not complete follow-up HRV monitoring were not included in the analyses. There were 43 participants who enrolled in the study. Of the 43 participants, *n* = 17 were assigned to the in-person yoga program, *n* = 11 completed HRV measures (65%), *n* = 14 were assigned to the online yoga program, and *n* = 11 completed HRV measures (79%), and *n* = 12 were assigned to the information control group and *n* = 8 completed HRV measures (67%) (Figure 1).

Figure 1. CONSORT flow diagram of participant randomization and completion of the study.



Baseline demographics, maternal health characteristics, and physical activity data were compared between groups using a one-way ANOVA. HRV data were averaged with missing data considered missing at random and replaced with the average participant value. Outliers in HRV data were determined as 2 standard deviations from the mean. There were *n* = 13 datapoints at baseline and *n* = 13 datapoints at follow-up that were outside of this criterion and were excluded from the HRV mean. Outliers were randomly distributed but a larger number were from the yoga intervention groups due to the lower number of completed HRV measures in the control group. Figure 2 shows the interindividual differences in HRV change over time in each allocated intervention.

Figure 2. Individual participant RMSSD HRV change from baseline to follow-up. Green is in-person yoga, yellow is online yoga, and red is information control.



HRV change over time was assessed using linear regression with follow-up HRV mean as the dependent variable and baseline HRV mean as the independent variable to determine whether there were differences in HRV at the end of the intervention between yoga programs and the information control. Due to the small sample size, baseline and follow-up comparisons were assessed using the

signed rank test, and mean change in variables between groups was assessed based on nonparametric means using the Kruskal-Wallis test. Bivariate Pearson correlations were used to determine relationships between changes in HRV and changes in self-compassion, fatigue, and Depressive symptomology significance level was 0.05. All analyses were completed using SPSS Version 21.0 (IBM, Chicago, USA).

Results

There were no significant differences in age, number of pregnancies or number of live births between the three intervention groups ($p > 0.05$). The majority (93%) of participants were white. There was a small (<10%) proportion of participants who reported gestational diabetes and/or hypertension. Approximately 17% and 10% of participants reported anxiety and depression, respectively (see Table 1).

Table 1: Participant demographics, maternal health and physical activity data.

	In-Person Yoga (*n* = 11)	Online Yoga (*n* = 11)	Information Control (*n* = 8)	Total (*n* = 30)
		Mean (SD)		
Age	31.0 (3.2)	32.5 (5.1)	30.8 (3.1)	31.5 (3.9)
Number of Pregnancies	1.9 (1.1)	2.1 (1.2)	1.3 (0.7)	2.2 (1.1)
Number of Live Births	1.7 (1.0)	1.8 (1.1)	1.00 (0.00)	1.6 (0.9)
		***n* (Proportion)**		
Ethnicity				
White	11 (100.0%)	9 (81.8%)	8 (100.0%)	28 (93%)
South Asian	0	1 (9.1%)	0	1 (2.3%)
Latino	0	1 (9.1%)	0	1 (2.3%)
Gestational Diabetes	0 (0.0%)	2 (18.2%)*	0 (0.0%)	2 (6.7%)
Gestational Hypertension	0 (0.0%)	0 (0.0%)	1 (12.5%)*	1 (3.3%)
Perinatal Anxiety	2 (18.2%)*	3 (27.3%)*	0 (0.0%)	5(16.7%)
Perinatal Depression	1 (9.1%)*	2 (18.2%)*	0 (0.0%)	3 (10.0%)
		Mean (SD)		
Moderate to Vigorous Physical activity (minutes per week)	193.2 (147.2)	131.8 (120.8)	225.0 (149.8)	179.2 (139.3)

*Significant group difference in incidence of gestational diabetes, gestational hypertension, perinatal anxiety and perinatal depression $p > 0.05$.
Note: that the perinatal measures were a participant reflection on their overall pregnancy.

All participants with baseline anxiety and depression symptoms were randomly selected for the yoga groups. The self-reported mean minutes of moderate to vigorous physical activity in each group was high; the in-person yoga and information control groups both met the Canadian Physical Activity guidelines of 150 minutes per week at baseline, and the online yoga group reported 132 minutes per week at baseline. There was no significant difference in self-reported baseline physical activity between the three groups ($p > 0.05$).

When compared with the information control group, there was no significant change in the primary outcome of HRV after 12 weeks for either the online (0.865, 95% confidence interval [CI] = −26.18 to 24.45) or the in-person program (−1.074, 95% CI = −24.55 to 22.40). However, when examining changes within group and not comparing the change to the control group, there was a reduction in HRV and self-compassion in the in-person yoga intervention ($p < 0.05$, Table 2) and a reduction in depression in the online yoga intervention. There were no significant correlations between change in HRV with change in self-compassion, fatigue, or depression symptomology (data not shown). There was a significant correlation between change in fatigue and change in depression in the control group ($p = 0.001$).

Discussion

A 12-week bi-weekly yoga program, either in person or online, was ineffective at increasing HRV and, therefore, improving autonomic nervous system function in postpartum women compared to an information control group. In fact, there was a within-group decrease in HRV ranging from 14.1% to 21.6% in all groups,

Table 2: Heart rate variability, self-compassion, fatigue, and postnatal depression at baseline and follow-up.

	In-Person Yoga (n = 11)		Online Yoga (n = 11)		Information Control (n = 8)		Between-group change p value
	Pre	Post	Pre	Post	Pre	Post	
Heart Rate Variability (RMSSd)	78.3 (41.5)	61.4 (37.9)*	66.7 (26.2)	54.4 (27.3)	60.8 (23.6)	52.2 (22.6)	0.834
Self-Compassion	82.8 (12.7)	70.0 (12.8)*	75.9 (12.4)	63.3 (26.0)	85.7 (17.4)	67.3 (20.9)	0.855
Multidimensional Fatigue Index	55.5 (10.3)	55.1 (8.7)	59.5 (13.3)	53.8 (25.5)	49.3 (8.9)	49.9 (11.1)	0.696
Depression	6.7 (4.5)	5.5 (4.2)	10.4 (7.4)	5.1 (6.7)*	6.0 (4.8)	5.1 (5.6)	0.074

Note: There were no between-group differences using the Kruskal Wallis test $p < 0.05$.
*There were significant within-group differences in baseline to follow-up comparison in the in-person group for HRV and self-compassion and for depression in the online group $p < 0.05$.

which reached statistical significance for the in-person yoga group.

This change is contrary to our hypothesis and indicates higher sympathetic tone, lower adaptability to changing environments, and lower capacity for stress (Ishaque et al., 2021; Lujan et al., 2021) compared to baseline.

It is possible that the amount of yoga completed over the 12-week trial was not adequate to induce an improvement in autonomic nervous system function. A short-term (one-month) yoga intervention in healthy male adults was found to result in an improvement in HRV; however, the participants practiced 60 minutes of yoga 6 times per week for one month (Vinay et al., 2016). Comparatively, postpartum women are challenged to find time to engage in physical activity. Our in-person group completed 59% and the online group 50% of the bi-weekly classes over 12 weeks. An intervention requiring the time commitment of the study by Vinay and colleagues (2016) would likely not be feasible in the postpartum population.

In addition, women reported challenges with focusing on the yoga session while attending to their babies, which may have impacted their ability to practice appropriate breathing techniques to induce benefit. In support of this, a previous study has found that changes in HRV were only seen among participants who were experienced in the practice of yoga compared to those who were considered yoga naïve (Shinba et al., 2020).

We did not find there to be a significant correlation between changes in HRV and changes in self-compassion in our population of postpartum women. Previous research has found there to be an association between HRV and self-compassion (Luo et al., 2018). However, this was assessed in a laboratory environment with an induced stressor. While having greater self-compassion has been speculated to induce greater parasympathetic activity and, therefore, be associated with greater HRV, less is known about whether longitudinal changes in self-compassion would be reflected through changes in HRV (Kirby, 2017). One study found that those who engaged in compassionate training and positively improved their self-compassion improved their HRV. However, there was no overall increase in HRV without improvements in self-compassion (Steffen et al., 2021). Our yoga intervention was found to reduce self-compassion in both the online (not significant) and in-person groups. Therefore, other factors may have been impacting the benefits of engaging in yoga, such as confidence in physical activity and body image. For instance, participants in our study as well as in other studies on postpartum physical activity, discuss being hard on themselves and comparing to others, negatively impacting confidence and self-worth (Bean et al., 2023). Furthermore, participants in this study noted that they were often overwhelmed and distracted by their Furthermore, participants in this study noted that they were often overwhelmed and distracted by their infants' presence, which may have negated any positive impact from the yoga practice(Lesser et al., 2024).

While there were no significant improvements in HRV and self-compassion, postpartum depression scores decreased in all three groups, with larger decreases in the yoga groups and reaching statistical significance in the online yoga intervention group. This suggests some benefits of the yoga program to mental well-being. However, it

must be noted that the within-group changes in depression scores were not significant when compared to the changes in depression scores in the information control group. Other physical activity trials in postpartum women have found there to be significant improvements in depression compared to usual care (Daley et al., 2015). The lack of between-group differences in changes in depression scores may reflect that our control group received a resource with information on getting started or returning to physical activity after the birth of a child, which included learning how to take care of their postpartum selves and strategies to support their physical activity journey through this phase of life. Thus, this was not a "usual care" control group, so between-group differences may not have been as pronounced as with a typical control group.

There were limitations to this study. Participants were asked to record their supine HRV within 30 minutes of waking. Given that this population is often woken by the needs of their infants and has inconsistent wake times, it is possible that waking HRV was not reliable in this sample. While a 3-minute recording of RMSSd has been shown to be a valid indicator of HRV in athletes, it is possible that a 24-hour measure would have been more responsive to the varying stressors of motherhood, as has been shown in medical students (Bourdillon et al., 2017; Guo et al., 2022). In addition, further consideration of high and low-frequency time domains may provide a greater understanding of the autonomic function of participants. Participant adherence to attending the yoga classes or completing the online classes was less than 60%, and therefore, the dose of the yoga intervention may not have been adequate to induce changes in HRV. Furthermore, we did not account for physical activity outside of the intervention. The majority of participants were of European descent, limiting the generalizability of the findings, and the mean self-reported physical activity at baseline was high. This indicates that this was a very active group of postpartum women, and it is possible that more pronounced changes would have been observed in sedentary participants at baseline. Lastly, given the challenges in participant recruitment and not meeting sample size requirements, a lack of statistical power may have limited study interpretation. Consideration of study designs that are more favourable to participants and allow for participant preference of group allocation may be beneficial in reaching statistical power. A recent commentary on participant bias in physical activity research has discussed the utility of single-arm trials and those that offer participants choice (e.g., preference-based trials) (Lesser et al., 2023b). Future studies should consider more participant flexibility in research study design and wearable technology for 24-hour monitoring of HRV, given the inherent challenges in this population for daily measures.

Conclusions

While a 12-week yoga intervention either online or in person did not improve HRV, future research should consider whether a greater frequency of yoga classes is effective at improving HRV. To enhance engagement of postpartum women in physical activity research there should be consideration of less stringent group assignment. Lastly, childcare would be advised to facilitate greater engagement in physical activity classes and limit distractions.

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Authors' Qualifications

The authors' qualifications are as follows: Iris Lesser MSc Exercise Physiology, PhD Biomedical Physiology and Kinesiology, CSEP CEP, Pre and Postnatal Exercise Certification; Gillian Hatfield MSc Rehabilitation Research, PhD Biomedical Engineering.

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