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Physical activity in motherhood: intervention, trajectory, and mixed methods analyses

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Physical activity in motherhood: intervention, trajectory, and mixed methods analyses

by

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DISSERTATION

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Dedication and Acknowledgements

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PHYSICAL ACTIVITY IN MOTHERHOOD:

INTERVENTION, TRAJECTORY, AND MIXED METHODS ANALYSES

Maya Nina Mascarenhas

Abstract

The benefits of physical activity are wide ranging and substantial. Yet the majority of US adults do not meet the recommended minimum guidelines of activity. Mothers, in particular, experience a decline in physical activity after having children. In the transition to having children, the facilitators and barriers to being active change. Though inactivity after having children poses a significant risk, there is insufficient research on the patterns, barriers and facilitators, and potential pathways for intervention.

The first chapter of my dissertation explores patterns of physical activity and the association with having a child. The literature suggests that women experience a decline after birth but no studies examined more than 2 time points and thus we do not have sufficient insight into longtime patterns. We used a mixed model to estimate the percent change in physical activity with the event of birth, and for pre-specified times since birth. We found that there was a significant decrease in leisure time physical activity at birth and it persists through 5 years, however, by 10 years, women experience a rebound.

The second chapter of my dissertation examines more closely the experience of pregnancy and postpartum and how that affects women's' abilities to stay active. We examined data from low-income Latina pregnant and postpartum women affected by gestational diabetes in San Francisco and Sonoma counties. Using a mixed methods design, we collected quantitative survey data and qualitative data from 3 focus groups. We used descriptive statistics to analyze the quantitative survey data, and grounded

theory and the Capability, Opportunity, Motivation Behavior (COM-B) framework to code and identify themes from the focus groups. Our samples of pregnant and postpartum Latina women affected by GDM were predominately Spanish speaking, low-income, and born outside the US. In the transition from pregnancy to postpartum, women noted a shift from a focus on self-care in order to maintain a healthy GDM pregnancy to caring primarily for their children. Two strategies that helped postpartum women stay active were setting proximal and family-centered goals and engaging their families in providing instrumental support. Family-centered goals included modeling healthy behaviors for their children and staying healthy in order to support their families.

The last chapter of my dissertation was an 8-week arm, randomized trial comparing the effectiveness of a virtual exercise and mobile apps intervention to a waitlist control. Using Google Hangouts, mothers in the intervention exercised together in real time guided by a mobile exercise app of their choosing. We found that a web and mobile app group exercise intervention was a feasible and acceptable way to deliver a physical activity intervention to mothers with young children. The intervention significantly increased physical activity in inactive mothers.

As a body of work, my three dissertation papers add a significant contribution to our understanding of the impact of becoming a mother on physical activity level patterns and associated barriers and facilitators. My work also suggests a potential path forward to increasing activity levels for women with children.

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Chapter 1: Changes in physical activity after becoming a mother: The Coronary Artery Risk Development in Young Adults (CARDIA) study

Maya Mascarenhas, June Chan, and Eric Vittinghoff

Introduction

The benefits of exercise are well established. Sufficient levels of physical activity are associated with reductions in all-cause mortality, and the reduced risk of many chronic conditions such as cardiovascular disease, type 2 diabetes, and many cancers. Becoming a mother represents a huge lifestyle transition that often makes it harder to be sufficiently physical activity. Moreover, mothers can influence the activity levels of their children, and thus understanding their exercise patterns is important for their children's health as well as their own.

Research suggests that the transition to parenthood results in a significant decrease in physical activity, but there is a dearth of studies examining this relationship.[1–3] Most studies examining the impact of being a mother are cross sectional and examined these relationships at one time point[1–3] or used recall to examine two points.[4–7] Only a handful of studies look at longitudinal patterns.[8–15] Many of these studies assessed changes in activity over a period of less than 2 years,[13–15] while the longer studies had periods ranging from 3 to 7 years.[8–12] These longitudinal studies uniformly assessed physical activity at only two time points over the entire range of time periods, and were thus limited in their abilities to discern long term trajectories or patterns of physical activity.

The Coronary Artery Risk Development in Young Adults Study (CARDIA) is a cohort study that has been followed for over 25 years, with visits every 2-5 years. Taking advantage of the repeated measures of physical activity, updated birth information, and a wide range of psychosocial and demographic measures in the CARDIA dataset, we tested the hypothesis that having a child sets mothers on a trajectory of reduced physical activity

that persists across the lifecourse. We examined the association of having a child and years since having a child with changes in physical activity levels over time, adjusted for potential confounders.

Methods

Study population

CARDIA is a longitudinal study that was developed to examine the associations of lifestyle and physiologic measures with risk factors for the development of coronary heart disease in young adulthood. The cohort recruited 5115 black and white participants ages 18-30 between 1986 and 1990 and has followed them for 25 years, with follow-up visits at 2, 5, 7, 10, 15, 20, and 25 years. By design, the initial CARDIA sample was approximately balanced on sex, race (black and white), education (less than high school and greater than high school), and age (18-24 and 25-30 years), and study site (Alabama, Chicago, Oakland and Minneapolis). Informed consent was obtained from all participants and human subjects approval has obtained annually at each site. Additional details on the CARDIA study design and procedures have been reported elsewhere.

Birth variables

At each visit, an interviewer-administered questionnaire was conducted with female participants on any pregnancies and births that occurred in the interval prior to the previous visit. The date and outcome of all births (stillbirth, live birth, etc.) were collected. A time-dependent binary indicator for having a child was defined at each visit, with value 0 for women at visits prior to the birth of their first child or who had no children, and 1 for all visits after their first live birth. Time since first live birth, also a

time-dependent covariate, was calculated as the difference between the exam date and the date of birth date, and set to zero at visits prior to the first birth. For women who reported having children at baseline, we used the age of their eldest child living in their household to estimate time since birth. Women who reported having children who did not live in their household were omitted from the analysis.

Physical activity

Physical activity measures were collected using interview-administered questionnaires at each visit. Physical activity was assessed across 13 types of moderate and vigorous activity categories including occupational, home and child related activities and leisure time activities. The specific time spent in each activity was not collected so physical activity was calculated in exercise units (EU), that combined activity-specific duration thresholds (2-5 hours/week) per week and intensity scores (3-8 metabolic unit equivalents). The total activity score reflects average activity levels for the past 12 months. A total score of 300 EUs, for example, approximately reflects the CDC recommendations of least 150 minutes of moderate or 75 minutes of vigorous active minutes per week. The reliability and validity of these measures has been established compared to other physical activity instruments[16–18] and to physiological measures such as blood pressure and body mass index (BMI).[19,20] For our analysis, we assessed leisure time physical activity, which was calculated as total activity minus the category of occupational activity.

Additional measures

We included fixed measures of race, study center, and history of physical activity in our main model. History of physical activity was assessed on a 5-point scale of

'Physically inactive' to 'Very active' in answer to the question: "Compared to other people your age and sex, how would you rate your physical activity during high school?" We included a time updated measure of age, a measure collected by interviewers at the baseline visit and confirmed at the subsequent visit. In sensitivity analyses, we also considered the impacts of pregnancy, marital status, social support, baseline activity status, and significant conditions preventing physical activity on our model estimates. Pregnancy status was only assessed for women for each of their live births using their end date of birth to determine the timing of the pregnancy period. A self-reported measure of marital status was collected at each visit. Data on significant conditions preventing physical activity were collected twice at Visit 7 and 25 in response to questions about whether they had any medical conditions interfering with physical activity, and the extent of interference on a 1-5 scale. We classified any reports of interference with a ranking of more than 2 as significant interference.

Statistical analysis

We used a linear mixed model (LMM) for repeated measures of leisure time physical activity, adjusting for current age at each visit, race, study center, and history of physical activity at baseline. To account for within-subject correlation of the repeated responses, the LMM included random intercepts and slopes. We flexibly modeled the effect of having a child on physical activity using the time-dependent indicator for having at least one child, as well as a time-dependent linear spline in years since first birth, with change-points at 5 and 10 years. To meet the normality assumptions of the LMM, leisure time activity scores were log-transformed; accordingly, back-transformed effect estimates are interpretable as percentage differences in activity. Based on a pre-specified test for

modification of the effects of having a child, we included interactions with race in our final model.

Sensitivity analyses

We first assessed the effects of having a child on total activity. To assess the potential confounding effect of marital status while minimizing possible problems with time-dependent confounding,[21] we also assessed the effect of adjusting for a time dependent indicator of having been married at least once. We also assessed the impact of omitting activity outcomes measured during pregnancy, which might be lower, in some cases due to medical complications. We used birth dates to identify visits where the 12 months of retrospective leisure time activity reporting included the last 6 months of any pregnancy that resulted in a live birth. Lastly, we assessed the impact of removing participants who reported significant medical conditions that prevented physical activity at visit 7 from our analysis sample.

Results

Population

CARDIA followed 2787 women over the study period (Table 1), with high retention rates among surviving participants of 91%, 86%, 81%, 79%, 74%, 72%, and 72% at sequential visits. We restricted our sample to the 2,743 women and 17,791 visits with complete data. This sample represented 98% of all women in CARDIA, and they contributed 6.5 (out of 8) visits on average. Over half of the sample was African American (53%), and almost a third attended college (35%). Among parous women in the sample, median age at first birth was 25 (IQR 20-31.7). The 36% of the sample with children at baseline had

an average age of 20 at first birth and 27 at recruitment into CARDIA and was 73% African American.

Birth and physical activity

Among both African American and White women, leisure time physical activity declined substantially after first birth, then recovered towards age-adjusted levels among childless women (Figure 1). Exercise levels were systematically lower among African-Americans than among Whites, both before and after first birth. Based on prior hypothesis and a borderline statistically significant test for interaction (P=0.065), the final LMM allowed for differences between the two groups in response to having at least one child. Relative to childless African American women of the same age, expected exercise levels decreased among African American women by 70.7% (95% CI 66.5-74.9%) immediately after first birth, and remained lower by 56.5% (95% CI 52.2-60.7%) after 20 years (Table 2). Among White women, the corresponding expected decreases were 38.4% (95% CI: 30.7, 46.2) immediately after first birth and 12.0% (95% 1.6-22.5%) at 20 years.

Sensitivity analyses

Our sensitivity analyses yielded remarkably similar results to our primary results (Table 3). Leisure time and total activity had practically identical trajectories. Adjusting for marital status produced slightly lower estimates for White women only at birth and no changes for African American women. Similarly, removing outcomes during the pregnancy window attenuated the estimated decline in activity at birth, in particular for White women, but gave similar estimates at other time points.

Discussion

In our analysis of a large cohort of women followed for 25 years, we found evidence that physical activity was significantly reduced by having a child. Among both African American and White women, activity declined sharply immediately after first birth and then recovered, but remained lower than among childless women of the same age for up to 20 years. Although African American and White women had qualitatively similar average trajectories, activity levels were systematically lower among African Americans, the decline immediately after first birth was larger, and the recovery was less complete.

There is compelling evidence that supports our findings on the significant reduction in physical activity that results when women become mothers, and some evidence to suggest that a rebound happens after the transition to becoming a mother. The longitudinal studies that have examined this question almost all uniformly compared women who did and did not have children, usually following women in their 20's for a period of 2-4 years. All studies reported a statistically significant risk of declined activity in women who had a child, similar to our findings, particularly in the years close to having a child.[8,9,11–14] Treuth et al. examined 3 time points in a small sample of 51 women, looking at a short window of time including pre pregnancy, 6 and 27 weeks postpartum using self report and objective measures of activity.[15] They observed that performance, fitness and strength all decline in the earlier postpartum period but improved by 27 weeks. Sallis et al. conducted a longitudinal study that examined mothers with young children (at least one child less than four) and examined their activity levels seven years later.[10] The authors were surprised to find an increase in all of their measures of physical activity (leisure and total activity) over the study period, counter to their

expectations of a decline that generally occurs with age. They hypothesized that these findings might have been due to having fewer younger children in the house over time. However, Sallis' findings match up well with the increase we see after birth over the following 5-10 years. Our findings are consistent with studies that examined the impact of having a child on maternal activity, including those that looked exclusively at the postpartum period, and those that focused only on later years after having a first child. A unique contribution of our study is the ability to examine longer lifecourse trajectories of physical activity patterns for women with and without children, in a large population based cohort, using data from the period prior to birth, the time of birth, and for decades after birth.

There is a large body of research that could point to cause of the decreased activity that results after women have their first child. Many studies examine the increased barriers and reduced facilitators that women experience upon having children.[22] These include time constraints, fatigue, and childcare. Many barriers noted, apart from childcare, are common to parents and nonparents alike, however, the common barriers tend to grow more insurmountable once women become mothers. There is less literature looking at the transitions that occur as children grow older, particularly as children enter school, which represents the first point of subsidized childcare for many parents. The 5-10 year window of markedly reduced activity after birth points to the difficulty of self-care that women experience once they have children, and possibly the lack of structural support that exists when children are young. The rebound after this time period suggests that public health messaging or the desire to return to previous patterns is motivating to a certain extent but highlights that structural changes and support might particularly be

needed by mothers during the early postpartum years. In lieu of structural changes, messaging around physical activity for mothers of young children should include an acknowledgement of the difficulty that maintaining activity levels pose for many women, and focus on helping mothers to set realistic goals and expectations in an attempt to support women to regain prior levels of activity in their new contexts.

Limitations

We had no measurements of physical activity immediately after first birth, so that our estimate of the effect of having a child at that time is model dependent. However, very similar results were obtained with categorical rather than linear spline transformations of time since first birth; results were also similar in a sensitivity analysis with time of first birth reset to 3 and 6 months before the actual date of birth, to capture pregnancy effects. The physical activity questionnaire in CARDIA relied on a measure that did not collect the duration of minutes of activity, but rather a threshold of minutes. As a result, physical activity scores are not directly comparable to other studies. These measures have been validated against other more standard measures. In our study, we present percent changes across trajectories which are comparable to other studies. Physical activity data based on self-report is vulnerable to reporting biases, where participants might not have accurate recall or reported biased data due to social desirability. Additionally, the social desirability bias might be affected by changing norms around physical activity over time (across visits). We tested for the impact of the instrument by adjusting for each visit in the model, but the impact on the effect estimates was not significant.

Conclusion

For many women, becoming a mother is a profound life event that has a rapid and large effect on physical activity patterns. This analysis points to diversity of the experience of having children, portraying physical activity trajectories that change as children age. Though a finding of a rebound in activity levels for black and white after 5-10 years of becoming a mother is promising, these rebounds do not close the gap that occurs between women who do and do not have children. Public health efforts and further research is warranted to understand and address the declines in activity associated with having children and the gap in physical activity trajectories for black and white women.

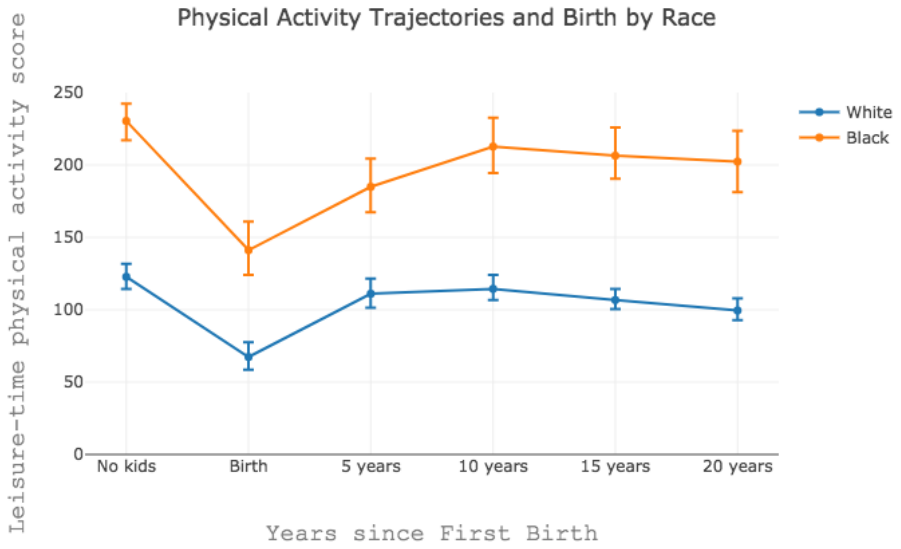
Table 1.1 Participant characteristics, n(%) unless otherwise indicated				
	Ever kids (n=1,954)		**Never kids (n=833)**	
Age at baseline visit (years; M [SD])	24.9	(3.7)	24.8	(3.6)
Age at first birth (years; M [SD])	25.9	(7.3)	-	-
Race/Ethnicity				
Black	483	(58.0)	824	(42.2)
White	350	(42.0)	1,130	(57.8)
Center				
Birmingham, AL	143	(17.4)	463	(23.9)
Chicago, IL	161	(19.5)	438	(22.6)
Minneapolis, MI	239	(29.0)	483	(24.9)
Oakland, CA	281	(34.1)	555	(28.6)
Married/living as married	169	(20.3)	769	(39.4)
College Education	391	(46.9)	591	(30.2)
Physical Activity in High School	3.8	(1.1)	3.6	(1.1)
Physical Activity Score				
Total Activity score	322.9	(246.9)	363.2	(256.6)
Leisure time score	292.4	(231.2)	332.7	(240.1)
Self reported condition interferes with PA	110	(17.4)	234	(14.5)

Table 1.2 Percent change in leisure time physical activity, by race			
	Percent Change (95% CI)		p-value
African American women			
Birth	-70.70	(-74.9, -66.5)	<0.001
5 years after first birth	-51.70	(-56.7, -46.6)	<0.001
10 years after first birth	-49.90	(-54.3, -45.5)	<0.001
15 years after first birth	-53.30	(-57.4, -49.2)	<0.001
20 years after first birth	-56.50	(-60.7, -52.2)	<0.001
White women			
Birth	-38.40	(-46.2, -30.7)	<0.001
5 years after first birth	-19.30	(-27.7, -10.9)	<0.001
10 years after first birth	-7.07	(-15.9, 1.74)	0.12
15 years after first birth	-9.59	(-18.3, -0.844)	0.03
20 years after first birth	-12.00	(-22.5, -1.56)	0.02

Table 1.3 Sensitivity analyses of adjusted percent changes in leisure time activity at birth and years since birth

	Years Since Birth - White Women				
	Black Women				
	Birth	**5 years**	**10 years**	**15 years**	**20 years**
White Women					
Main Model	-38.40 (-46.2, -30.7)	-19.30 (-27.7, -10.9)	-7.07 (-15.9, 1.74)	-9.59 (-18.3, -0.844)	-12.00 (-22.5, -1.56)
Main Model	-38.40 (-46.2, -30.7)	-19.30 (-27.7, -10.9)	-7.07 (-15.9, 1.74)	-9.59 (-18.3, -0.844)	-12.00 (-22.5, -1.56)
Total Physical Activity	-38.10 (-45.8, -30.4)	-18.00 (-26.4, -9.6)	-6.92 (-15.5, 1.64)	-8.10 (-16.7, 0.479)	-9.26 (-19.7, 1.16)
TD Marital Status	-36.70 (-44.8, -28.6)	-17.10 (-25.8, -8.28)	-5.20 (-14.3, 3.91)	-7.77 (-16.9, 1.32)	-10.30 (-21.2, 0.647)
Pregnancy 6+ Months	-30.20 (-40.7, -19.8)	-19.10 (-27.8, -10.4)	-7.07 (-15.9, 1.8)	-9.98 (-18.7, -1.21)	-12.80 (-23.2, -2.36)
White Women					
Main Model	-70.70 (-74.9, -66.5)	-51.70 (-56.7, -46.6)	-49.90 (-54.3, -45.5)	-53.30 (-57.4, -49.2)	-56.50 (-60.7, -52.2)
Total Physical Activity	-68.00 (-72.3, -63.1)	-47.10 (-52.1, -41.3)	-46.30 (-50.4, -41.2)	-48.60 (-52.5, -43.7)	-50.90 (-55, -45.5)
TD Marital Status	-70.40 (-74.7, -66.1)	-51.20 (-56.3, -46.2)	-49.40 (-53.9, -45)	-52.80 (-57, -48.7)	-56.00 (-60.4, -51.6)
6+ Pregnancy Months	-67.90 (-73.1, -62.7)	-51.80 (-56.9, -46.7)	-49.10 (-53.6, -44.6)	-52.90 (-57, -48.8)	-56.50 (-60.7, -52.2)

Figure 1.1 Adjusted Physical Activity Trajectories by race



Chapter 2: Physical activity behaviors among low-income Latinas affected by gestational diabetes –a qualitative and quantitative analysis of pregnant and postpartum women

Maya Mascarenhas, Judy Quan, Maria Chao, June Chan, Christina Rios, Elizabeth Harleman, and Margaret Handley

Introduction

Gestational diabetes mellitus (GDM) is a diagnosis of diabetes during pregnancy that affects approximately 7% of pregnancies in the United States.[23] Latinos, the largest and fastest growing ethnic minority group in the United States, are disproportionately impacted by GDM. A study in California reported that Latinas had an age adjusted GDM prevalence of 8.3% compared to 5.7% in non-Latina white women.[24] GDM is one of the fastest growing complications of pregnancy nationally, and this rate of increase is highest for Latina women.[25]

Gestational diabetes is a complication of pregnancy that increases the risks of adverse outcomes for the fetus (e.g. macrosomia, shoulder dystocia, birth injury, neonatal hypoglycemia) and pregnancy (e.g. higher risk of caesarean delivery and pregnancy-associated hypertensive disorders), and indicates lasting risks for the mother.[26] A GDM pregnancy is associated with an increased risk of metabolic syndrome, obesity, cardiovascular disease and type 2 diabetes for mothers. A pregnancy with gestational diabetes elevates her risk of developing type 2 diabetes by five fold in the first five years after delivery, and by nine-fold in subsequent years.[27,28] This risk continues to increase over time, and with each subsequent pregnancy.

Most women with a history of GDM have inadequate levels of preventive behaviors such as regular diabetes screening, good nutrition, and sufficient physical activity.[29–31] Physical activity reduces the risk of developing type 2 diabetes for women who have had GDM.[32] However, women with children are half as likely to be meet physical activity guidelines compared to women without children.[3,22,33] Furthermore,

Latinas have lower rates of exercise than white women and may face additional structural barriers to engaging in sufficient physical activity.[34–37]

Latinos represent 40% of the Californian population but almost 70% of the families with incomes below 250% of the federal poverty level.[38] In California, low-income Latina pregnant and postpartum mothers receive support through Medi-Cal and through programs such as California Special Supplemental Nutrition Program for Women, Infants, and Children (WIC).[38] More than half of Medi-Cal enrollees and 78% of WIC adult members are Latina. Through Medi-Cal and WIC, low-income women with a GDM pregnancy (considered high risk) receive intensive healthcare lifestyle coaching and enhanced clinical resources. Upon birth, Latinas can enroll their babies into WIC and Medi-Cal but are usually no longer eligible themselves after a short postpartum period (up to 6 months postpartum for WIC and up to 2 months for Medi-Cal). Thus, many of the resources that support Latinas during their GDM pregnancy shift from mother to child in the postpartum period.

Programs such as WIC could help bridge the gap in care women experience postpartum by incorporating action planning and prevention messages to increase physical activity for mothers at risk of diabetes while continuing to support their infants. The aim of this study was to inform prevention strategies for Latina women affected by GDM through an analysis of qualitative and quantitative data of the barriers, facilitators, and success strategies around physical activity.

Methods

Study Design

Our mixed methods study combined focus group and survey data to describe physical activity related characteristics among pregnant GDM women and postpartum women with a history of GDM. We used data from STAR MAMA (support via Telephone Advice and Resources/Sistema Teléfonico de Apoyo y Recursos- MAMA), an ongoing randomized intervention trial.[39,40] STAR MAMA assesses whether automated telephone calls combined with live follow-up health coaching calls can promote healthy behaviors and, in turn, reduce diabetes risk for women with a history of GDM. The study was approved by the UCSF Institutional Review Board.

The current study reports data from two distinct groups of women: (1) pregnant women diagnosed with GDM who completed baseline surveys as part of the STAR MAMA randomized trial and (2) postpartum women with a recent GDM pregnancy who participated in focus groups to inform the STAR MAMA intervention design (Figure 1). We analyzed both the survey data (n=49) and the focus group data (n=3 focus groups, 14 women) to better understand perceived barriers and facilitators of physical activity for women with GDM. We used the survey data to characterize physical activity in our sample of GDM pregnant low-income Latina women, and the focus group data to further explore physical activity barriers and facilitators before and after birth in a similar, but distinct, sample of postpartum women with a history of GDM. All women were recruited from 3 sites: two safety net clinical practices, the Zuckerberg San Francisco General Hospital (ZSFGH) Women's Clinic and the Santa Rosa Community Health Center Vista Clinic (Vista), and one WIC program site in San Francisco (SF WIC).

Data Collection

Quantitative survey data were collected from women at the time of their enrollment into the STAR MAMA intervention trial between December 2014 and February 2016. Women were eligible for inclusion in STAR MAMA if they spoke English or Spanish, were between the ages of 18 and 39, had a confirmed diagnosis of gestational diabetes by 32 weeks, and did not have a prior diagnosis of type 1 or type 2 diabetes. Bilingual and bicultural study staff recruited women during their scheduled prenatal appointments, or via nutritionists at the WIC programs who reviewed their database to identify clinically confirmed GDM pregnant women, and then contacted them for consent. The current study includes a sub-sample of pregnant Latinas with a history of GDM (n=49), which represented the majority (64%) of STAR MAMA participants enrolled to date. Our sample included women from ZSFGH (n=46), Vista (n=2), and SF WIC (n=1).

Qualitative data were collected from postpartum women in focus groups during the design phase of the intervention trial. Post-partum women participated in three focus groups conducted between June 2011 and March 2013 from ZSFGH (n=6), Vista (n=4), and SF WIC (n=4). A total of 14 postpartum women (4-6 women per group) were enrolled in the focus groups which were conducted in Spanish (Vista and SF WIC) and English (ZSFGH). Women were eligible for inclusion if they had received a diagnosis of gestational diabetes in a recent pregnancy (past 2 years). Eligible participants for the focus groups were identified using convenience sampling of site-specific registries and recruited through letters and phone calls by site staff. The focus groups lasted approximately two hours and were conducted by bilingual study staff. Women received a

25-dollar gift voucher for their participation. Focus groups were audiotaped, and transcripts were transcribed and translated by the bilingual study staff.

Measures:

Surveys collected information that included demographic characteristics, use of health services such as Medicaid and WIC, and physical and medical characteristics of pregnant women with GDM at the time women were enrolled into the trial, but prior to randomization. Physical activity measures were based on activity questions covering frequency, intensity, and duration of a variety of types of activities in the past week including walking (recreation, exercise, or transportation), vigorous garden work, vigorous household work, vigorous leisure time activities (e.g. leisure jogging, cycling, aerobics), moderate childcare, and other moderate activites (e.g. leisure swimming, tennis, yoga) [41].

Women were also asked about their intentions to exercise after their pregnancy, including questions about frequency and intensity of planned exercise (e.g. at least three times a week for at least 10 minutes or three times a week for at least 30 minutes over a future period of six months).[41] Additional information was collected to understand perceptions about how conducive participants' neighborhood environment was to being physically active.[42] Participants responded to 11 statements about their perceptions of their neighborhood environment using a 5-point Likert scale (Strongly Agree to Strongly Disagree). Due to survey changes partway through data collection, a subset of surveys included questions on 3 types of social support for physical activity that women received from family and friends: a perception of support (supportive of me exercising),

informational support (gave me helpful reminders to exercise), and instrumental support (exercised with me) on a 5-point Likert scale (not often to very often).[43,44]

The goals of the focus groups were to understand barriers and facilitators of diabetes prevention behaviors (ZSFGH and Vista focus groups), and to elicit feedback about proposed STAR MAMA intervention content (SF WIC focus group). Participants discussed their understanding of diabetes and associated risks, as well as strategies on how to incorporate diabetes risk-reducing healthy behaviors such as exercise and healthy eating into their lives. To inform the development of the STAR MAMA automated telephone intervention, women were also asked to respond to test versions of audio-recorded 'healthy' narratives, e.g. an episode in which a mother describes how she danced with her toddlers to get exercise. All focus groups were audio recorded, transcribed, and translated for data analysis.

Analysis:

Using the quantitative survey data, we characterized activity patterns and the context in which they occurred for our sample of pregnant GDM women. Total weekly minutes of light, moderate and vigorous activity during pregnancy were derived by exercise type. Demographic characteristics, social support around exercise, and reports on their neighborhood environment were also summarized. STATA 14.0 was used for all analyses.

Consistent with previous qualitative analyses of these data and based on methods by Sandelowski and others, we used general topic prompts to orient our preliminary analysis of focus group data and used the Capability, Opportunity, Motivation Behavior (COM-B) framework to guide our coding of barriers and enablers of physical

activity.[40,45,46] The COM-B is a theoretical framework used in implementation science that classifies behaviors into three major domains – capability, opportunity, and motivation.[47] In order to perform a behavior, the model stipulates that individuals must be emotionally and physically able to do the behavior (capability), their social and environmental context must support the behavior (opportunity), and lastly, they need to have internal and external drive for the behavior (motivation). These domains, in turn, inform the creation of interventions and policies targeting behavior change.

The COM-B framework was used to guide transcript coding. Two researchers coded all of the focus group transcripts using open coding. Each researcher then categorized their codes into the three higher level COM-B themes of capability, opportunity, and motivation. Researchers then compared themes throughout the entire transcript to identify and discuss any coding differences. A third researcher was identified to make a final decision if differences were found that could not be resolved. All themes were further classified into three broad groupings of physical activity barriers, facilitators and success strategies.

Results

Sociodemographics

In our survey sample of pregnant Latinas with a history of GDM (n=49), most women were married or living with partner (81%), not US born (78%), had an average age of 30.2, and an average of 1.7 children (Table 1). A substantial proportion of women had less than a high school degree or equivalent (49%) and were not employed at the time of the interview (58%). Of women who reported an annual household income, the majority

made less than 10,000 dollars per year (67%), and the vast majority (96%) made less than 30,000 dollars per year. During the course of their pregnancy, almost all women were on Medi-Cal health insurance (98%) and had used WIC services in the past 6 months (85%).

The focus group sample consisted of 14 postpartum women. All but two of the focus group participants were Latinas, and most were immigrants from Latin and Central America. All but two spoke Spanish at home. Four of the women were residents of Sonoma county and 10 of San Francisco county. All women had a diagnosis of GDM in their most recent pregnancy.

Physical Activity during Pregnancy

Physical Activity Patterns

All women in our survey sample were in their third trimester of pregnancy. For analyses of physical activity, we excluded women who were on bed rest (n=13, 27%). Most women in our sample were able to exercise (n=36). For these women, walking, household, and childcare activities were the most commonly reported sources of physical activity in the past week.

Nearly all women (97%) engaged in walking in the past week. Participants reported an even distribution of time walked in the past week, with a mean of 2.6 hours and an interquartile range (IQR) of 1 hour to 3.5 hours. For all activities apart from walking, the duration of activity reported was skewed, with a large proportion of women reporting 0 active minutes. The mean minutes of activity and the proportion reporting any active minutes were as follows – vigorous household work (67 minutes, 64%), vigorous yardwork (11 minutes, 8%), or vigorous leisure time activities (24 minutes, 14%),

moderate childcare (67 minutes, 53%), and moderate leisure time activities (59 minutes, 25%).

Support for Exercise

Most women who answered support questions (n=33) felt that their family and friends were supportive of participants engaging in physical activity. Women reported feeling more supported to exercise from family members (94%) than friends (58%) (Figure 2). Informational support (provided reminders to exercise) was much more readily available from family and friends than instrumental support (exercising with participants), though the majority of participants did not report receiving either frequently. Family members more frequently (often and very often) provided reminders to exercise than friends, 46% compared to 18%. Family members also exercised more frequently with participants than friends, 30% compared to 16%.

Neighborhood Environment

Most pregnant women reported that their neighborhoods offered opportunities to be physically active (45%) and that they could easily walk to places (61%). On the other hand, close to one-third of women reported feeling unsafe walking around (31%) and reported that there was heavy traffic (31%) and violence (36%) in their neighborhoods.

Physical Activity Intentions

Almost all women expressed an intention to exercise in the postpartum period (specifically the following 6 months); 100% had the intention of exercising at least 3 times weekly for 10 minutes, and 98% for 3 times weekly for 30 minutes.

Physical Activity during Postpartum Period

Our COM-B analysis looked at physical activity behavior in our focus groups through the themes of capability, opportunity and motivation. Three overarching topics that emerged were the barriers, facilitators and successful strategies around physical activity. During the focus groups, women talked about the transition between pregnancy and postpartum and how their abilities to exercise shifted accordingly. We captured these changes by examining the postpartum and pregnancy-specific physical activity barriers and facilitators, and the successful physical activity strategies postpartum (Table 2).

Physical Activity Barriers

Once they became mothers, women found that it was harder to prioritize their own wellbeing and reflected on how previous activity patterns were hard to sustain. For postpartum women, the presence of children increased the complexities of exercising and, correspondingly, produced new barriers to being active. They noted new structural barriers to exercise had arisen such as distance, costs, and need for childcare. Needing gear for strollers and added safety concerns were barriers to accessing even freely available resources such as parks. In addition, women found it difficult to prioritize self-care in the face of the many new competing demands on their time that having children created.

> *"I have a gym close to my house but I'd have to pay gas and the class is $7 and we are two people with my daughter, so it would be $15"*
>
> *It's hard when you have 2 or 3 children. You have to take care of them but you have to make time for yourself, to exercise.*

Physical Activity Facilitators

The facilitators of physical activity changed in the transition from pregnancy to postpartum. In pregnancy, the motivators were stronger and more short-term than in the postpartum period. Women felt motivated to be active because they knew it would directly benefit their babies during pregnancy. The clinical and WIC program pre-natal monitoring and support also provided external accountability. However, in the transition to postpartum, these motivations and resources shift.

> *"Six weeks [after] I delivered my baby, I had my last diabetes check. And then, everything ended there because they tell you that you are OK and one remains thinking 'and now what?' And that makes things difficult because after you had someone for some time telling [you] what to do and suddenly you don't have it anymore, you may feel like you had been left out in the air (alone)…*

When talking about the postpartum period, women recognized that they needed to find internal motivation to exercise. Women who were active postpartum were able to reframe exercise as serving their family. They considered being active as a way to model healthy behaviors that they wanted their children to adopt and as a path to staying healthy so that they could continue to provide and support their family.

> *"We're the model for them. So, I say, Dios mio I want to be different. What I'm doing (what I'm teaching them)"*

During a GDM pregnancy, women received support for building capacity around increasing physical activity and they had the direct motivator of a healthy pregnancy. They also had more opportunities to be active due to the relative ease of fewer or no kids. However, in the transition to postpartum, there was a much stronger reliance on indirect

motivation, and both the capacity building and physical activity opportunities were reduced.

Physical Activity Success Strategies

Women who successfully stayed active postpartum employed a variety of strategies. Many reported using family support to stay active. They relied on family members to provide childcare, motivation, and actively exercise with them. Active women created new routines that were family-centric and restructured existing routines and their physical environment to accommodate their children and their desire to stay active.

> *"My daughter, the middle one, she is like the telephones, very intelligent, she push me to do exercise. She tells me: "mom, remember your doctor told you, to exercise, let's go for a walk". So now we dance with the Zumba videos we find on internet."*

> *"Now I take my baby and go buy groceries with him. I walk for like 15-20min going to the market.If one of my family members call me and they want to do something, I leave my car at home and walk 10 or 15 blocks."*

Successful strategies mainly relied on creating opportunities to be active, both socially (exercising with kids) and environmentally (incorporating baby into life). They also relied on family members to provide support both emotionally through encouragement and instrumentally by helping watch kids or acting as an exercise partner.

Discussion

In this analysis of quantitative and qualitative data, Latinas affected by GDM reported many barriers, facilitators, and strategies for staying active, noting how these often changed in the transition from pregnancy to the postpartum period. In our study, women found that their desire for a healthy pregnancy (motivation) and institutional support (capability) through WIC and their health clinics supported their abilities to create opportunities to stay active. The institutional and individual forces that supported mothers' healthy behaviors all shifted towards the infant postpartum, yet some women found ways to incorporate exercise in a family-centric manner.

Our study population consisted of women facing an elevated risk of developing type 2 diabetes postpartum due to a diagnosis of GDM. Possibly motivated by the well understood benefits of exercise and the extra support and education they received to be more active during their GDM pregnancy, practically all of the pregnant women (97%) surveyed reported an intention to exercise at 3 times weekly for 10 minutes postpartum. Yet our qualitative data showed that our sample of postpartum women struggled with motivating to stay active after pregnancy. Research shows that there is discounting of GDM risk when applied to oneself,[48] and a discounting of time associated with goals, so that proximal goals have greater success than distal goals.[49] Postpartum women expressed that it was easier to be active during pregnancy knowing that it was directly helping their unborn baby. After the birth, their proximal goals shifted towards their children, often at the expense of their own self-care. Women who were successful at staying active were able to reframe family centered goals as proximal reasons to exercise. These included

modeling good behavior for their kids and keeping healthy to be a good provider to their kids.

Women in our study reported barriers to physical activity that included the cost of childcare and gyms, the distance to get to places, and the safety of their neighborhoods. These are well established barriers that contribute to the declining prevalence of physical activity for mothers.[22] Our study participants consisted of predominately low-income Latinas, born outside the US. Most barriers to physical activity related to complexity of being pregnant and having children, and these were likely exacerbated by a lack of income. Cultural barriers related to physical activity were also reported. One participant described a shift from a walking culture to a driving one. Yet the vast majority of women surveyed reported that their neighborhood offered many opportunities to be physically active and that walking was easy in their neighborhood. This discordancy may reflect a walking culture that incorporates a social component that cannot be replaced or reflective of the third of women who reported that their neighborhoods did not feel safe while pregnant, a concern that might have magnified in the postpartum period when the concern included their infant, as was reported in our focus groups. The successful strategies women described for overcoming these types of barriers involved incorporating their kids into an active routine, or their activity into their kids' routines. Walking their younger children in a stroller to the store rather than driving, and walking around the field while older kids played sports were some successful strategies of incorporating activity and children into existing routines.

The presence and lack of social support around physical activity was a recurrent and influential theme. Types of social support include: instrumental (e.g. receiving offers

to exercise with you), emotional (e.g. receiving encouragement) and informational (e.g. providing reminders or advice).[50] From the survey data, most women "felt supported" around exercise (emotional). However, women did not frequently receive reminders to exercise (informational) nor did they have family or friends who frequently exercised with them (instrumental). With the added complexities of having children, instrumental social support is a key facilitator to physical activity,[51] yet was by far the least frequently provided of the three types. The lack of instrumental support reported in the survey is consistent with the qualitative data, where only a few women found success in being active. The minority of women who reported being able to stay active did so by enlisting their family members to either exercise with them, or watch their kids so they could exercise independently. The importance of social support, particularly for Latinas, is well documented in the literature.[34,52] Less explored, yet very important for women in the postpartum period, is how social support around physical activity needs to change and adapt with growing families in order for mothers to stay active. Overall, these data indicate that increasing support, particularly instrumental support, could significantly improve levels of activity for post-partum Latina women.

Strengths and Limitations

This paper both draws and builds upon previous work on physical activity for women with GDM,[31,53–57] physical activity in Latinas generally, [34,36,37,58,59] and more specifically for Latinas during pregnancy or postpartum.[35,51,52] Our mixed methods study of perinatal, low-income Latinas provides a unique contribution to this body of work. Our sample of low-income Latina women with a history of GDM is an understudied group with high needs of social services, and thus a population we need to better understand and

serve. We incorporated two samples, pregnant and postpartum women, whose perspectives serve to compare and contrast against one another, and help us capture what is changing during that transition. In addition, we used two types of data, quantitative and qualitative, which further strengthened our analysis, allowing us to draw from the strength of a large sample and pair it with detailed qualitative narratives to help form a full picture. There were limitations in our study, including our reliance on self-report data for physical activity. Our sample for the focus group was 14 women participating in a multi-hour group session. Although our sample was small, it is comparable to other focus groups examining Latinas and physical activity.[52] We used different samples of pregnant and postpartum women so we could not compare our pregnancy survey and postpartum focus group data for the same individuals, though our use of different women for the pregnancy and postpartum period gave us a wider range of experiences to draw upon.

Implications for Policy

The implications of our findings can inform prevention strategies and interventions designed to reduce diabetes risk for pregnant and postpartum Latinas. Our findings show that messages focused on family-centered approaches to increasing physical activity are more likely to resonate and be motivating for this group. Acknowledging the shifting context from pregnancy to postpartum, while suggesting sources of support, proximal goal setting, and action planning could help women prioritize being physically active. Action planning could include drawing on existing social support networks (e.g. including family members in exercise activities) or joining mothers' groups that have the goals of exercising together (e.g. mommy stroller boot

camps). These mechanisms have been shown to support behavior change around physical activity and could be incorporated into existing programs.[60–62]

There are a multitude of resources that support low-income pregnant Latina women. WIC is one such program in California. These resources shift predominately to children once a woman is more than 6 months postpartum. This shift represents both a problem and an opportunity to effect change. Existing services and resources could be modified to include action planning and messaging around creating *family-centered* approaches to increasing healthy behaviors. This could include informational content around supporting physical activity for postpartum Latina women, particularly those with a history of GDM and their children, which would, in turn, decrease the mothers' diabetes risk and support their child's health. This would provide a novel way of creating care continuity for mothers using existing resources and would amplify the impact on the children these programs are supporting. Active mothers benefit physically and mentally from physical activity,[2,63–66] as do their children through healthier pregnancies[67] and more active childhoods.[68–70]

Table 2.1 Participant characteristics		
Pregnant Women - Survey (n=49)[3]		
	M	***SD***
Age (years)	30.4	4.9
Total children (n)	1.7	1
	No.	***%***
Latino/Hispanic	49	100%
Spanish spoken at home	46	94%
County of residence		
Sonoma	2	4%
San Francisco	47	96%
Married/Living together	44	90%
Born in the US	5	10%
Food Insecurity[1]	8	17%
Completed High School	20	41%
Working		
Full/part time	10	20%
Homemaker	24	49%
Other	15	31%
Household Income[2]		
Under 10,000	22	50%
10-30,000	21	48%
30,000+	4	9%
Postpartum Women - Focus Group (n=14)[4]		
Latino/Hispanic	12	86%
Spanish spoken at home	12	86%
County of residence		
Sonoma	4	29%
San Francisco	10	71%

1- 2 missing responses

2- 5 missing responses

3- Pregnant women with a confirmed GDM diagnosis completed surveys prior to randomization into STAR MAMA

4- Postpartum women with a GDM diagnosis in a recent pregnancy participated in focus groups

Table 2.2 Focus group themes and quotes from postpartum women

Themes	Representative Quotes
1. Barriers	
Personal Factors [Capability & Motivation]	I don't understand what's happening to us. I don't know if it's in part a problem with our self-esteem. It might be that, because I am sure that all of us know what's good and what's bad for us but we don't do it. And I don't know why we don't do anything for ourselves...if we wanted to we could have time for ourselves.
	...there's always time but one may say: oh! It's time to go get the children, oh! I have to do the laundry and we don't make time to do things for us
Structural barriers [Opportunity]	I noticed now that I have my baby, I can't go out certain days because I don't have the proper gear to protect from the wind or the rain.
	I have a gym close to my house but I'd have to pay gas and the class is $7 and we are two people with my daughter, so it would be $15
2. Facilitators	
Pregnancy	
Keeping baby healthy [Capability & Motivation]	It was easier when I was pregnant. When I was pregnant, they told me I had diabetes so I did the best I could for her. Once she was born, she was my first baby and everything was new to me.
	It is true what they said, once you have your baby we are not so careful. We try to take care ourselves but it is less than when we were pregnant.
	We were doing it as an obligation… Because we were feeling the pressure. [Vista]
Postpartum	
Family well being [Motivation]	To do things not because someone will recognize you, not because someone will tell you how good you look but because you have to think that you have children and if I get sick I'll be a problem for them and I won't be able to help them.
Self-care [Motivation]	We need to make effort for ourselves because we are talking about our health to be well.

Table 2.2 Focus group themes and quotes from postpartum women

3. Success Strategies	
Family Support [Motivation & Opportunity]	That's why I started doing Zumba with videos; we dance with videos at home. My daughter… She tells me: "mom, remember your doctor told you, to exercise, let's go for a walk". So now we dance with the Zumba videos we find on internet.
	For me it has been a little more difficult because I have 2 [children]. But when one of them is sleeping or with her dad, I go and walk for a long time.
	I tried already to start running in the mornings. My husband goes to work at 6:30am so every day I wake up at 5 am and I walk for 30-40min and it is very good. I have more energy during the day and I feel very good. It's very good to run in the morning because I don't have time during the day and I have to go to school with my other son and start the busy day. I think for me is the best time to go.
Incorporating child into routine [Opportunity]	Sometimes the kids don't give you a chance. We have to take them to the park so then we can walk.
	Now I take my baby and go buy groceries with him. I walk for like 15-20min going to the market. If one of my family members call me and they want to do something, I leave my car at home and walk 10 or 15 blocks.

Figure 2.1 Participants- survey and focus group

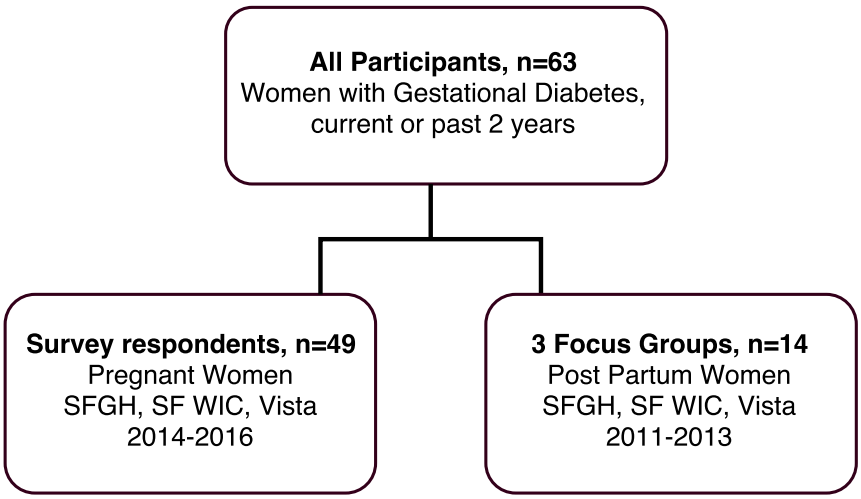
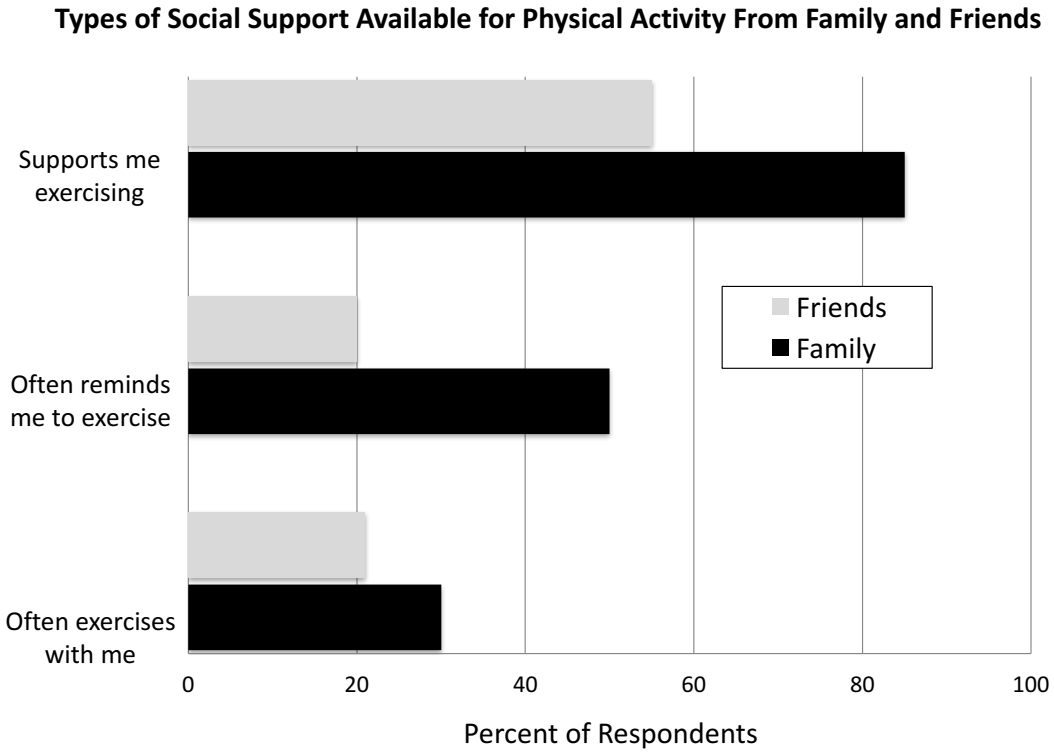


Figure 2.2 Friends and family support for physical activity



Chapter 3: Using virtual exercise groups and apps to increase physical activity in mothers: a randomized controlled trial

Maya Mascarenhas, June Chan, Erin Van Blarigan, and Frederick Hecht.

Introduction

Despite strong evidence of the health benefits of physical activity and decades of efforts to increase activity levels, almost half of the US adult population fails to meet federal exercise guidelines of 150 minutes of moderate or 75 minutes of vigorous exercise per week, and 70% fail to meet the biweekly muscle strengthening guidelines.[64,65,71–74] One group with unique challenges to being sufficiently active are women with young children. Women significantly reduce their activity levels in the transition to motherhood.[2,75,76] Mothers are less likely to be active than fathers, women of the same age who do not have children, and compared to their own activity levels prior to having children.[2] The proportion of hours per week that mothers with young children are physically active has decreased by 14 hours per week in the past 45 years, while sedentary activities such watching television and driving have increased by 6 hours per week.[77] These decreases in physical activity are not only a concern for mothers, but also for their potential impact on their children. Active mothers have a positive influence on the activity levels of their children.[68–70] In addition, when mothers exercise, they report being able to manage better the demands of raising children.[78–81] Due to mothers' unique needs and risks, it is important that we better understand their barriers and facilitators to physical activity and design appropriately tailored interventions to help mothers be more physically active.

Mothers experience a wide range of barriers to exercising including isolation, a lack of leisure time, lack of social support, lack of childcare, lack of spousal support, and the need to put family obligations before themselves.[80–84] Reviews

suggest that two characteristics of effective physical activity interventions that can overcome such barriers include 1) adapting to individual needs and 2) incorporating community-based social support.[60,85] Individually adaptive interventions are able to tailor to individuals' needs, preferences, and context. Social support interventions build and strengthen social networks, enabling individuals to support and keep one another accountable. These two elements have been tested individually in interventions with mothers, but their combined impact is not known.[2] Unfortunately, individually adaptive and group interventions can be costly and complicated to deliver and in-person groups can be particularly inconvenient for mothers.

Digital technology interventions represent a convenient, cost-effective, and scalable delivery mechanism for providing socially supportive and individually adaptive interventions.[86] In the US, 77% of the adult population owns a smartphone and this proportion continues to increase rapidly.[87] More than 50% of downloaded apps are in the health and fitness domain, yet few exercise apps incorporate evidence-based content.[88–92] Mothers, in particular, are heavy users of technology, and thus represent an important group to test evidence-based technology interventions.[93] Technology interventions have a growing evidence base for being effective at increasing activity, though this research is in its early stages.[94–97] Additionally, video conferencing tools such as Google Hangouts and Skype have been tested for virtual exercise coaching but not as a way to bring participants, and mothers specifically, together virtually for real-time activity groups.[98]

In this study, we determine the feasibility and acceptability, and estimate the effectiveness of a digital physical activity intervention that incorporates video conferencing and mobile apps. This intervention relies on providing evidence-based elements of social support and individualization to increase physical activity in mothers.

Methods

The MOVE Study was an 8-week randomized trial comparing the effectiveness of a virtual exercise group paired with mobile apps arm to a waitlist control arm.

Recruitment

We recruited participants using advertisements in parent-specific Facebook groups and email listservs. Participants were recruited from all over the country, though the recruiting efforts and time zones available were targeted to the West Coast. In addition to email and Facebook advertisements, all recruited participants were asked to share the advertisement with any relevant email listservs or Facebook groups, and any individuals they thought might be interested. Participants signed informed consent electronically using Docusign before enrollment began. Recruitment efforts took place between July 2016 and November 2016. Prior to recruitment, we received approval from the UCSF IRB (14-15344) and registered our trial with the Clinical Trials Registry: https://clinicaltrials.gov/ct2/show/NCT02805140.

Participants

Our eligibility criteria stipulated that women needed to be between the ages of 18 and 60, speak and understand English, be able to give consent, and have at least one child under the age of 12. Enrolled women could not be pregnant or plan on being pregnant during the study period. Participants had to be capable of exercising safely, assessed using the validated Physical Activity Readiness (PAR) Questionnaire.[99] Participants were also required to have access to two devices, one with video conferencing capacity and one with mobile app capacity. These devices could include cell phones, computers, and smart tablets.

Protocol

Women who were eligible for the study were asked to complete one introductory phone call, a baseline survey, and a practice group virtual session in order to be randomized. Informed consent was obtained in the introductory phone call and consent forms were electronically signed using DocuSign. In practice group video sessions, participants signed into Google hangouts, introduced themselves, and then opened up a mobile app to complete a short workout using the Johnson & Johnson mobile app 7-minute workout routine.[100] Participants who confirmed their continued interest in participating in the study after the practice session were randomized to the intervention or waitlist control. After an 8-week study period, women filled out end of study surveys and women in the intervention arm were given the option of continuing for an additional 8 weeks, and those in the waitlist control were invited to join a virtual group for 8 weeks.

Prior to randomization, women were asked to pick a virtual exercise morning time slot that they could consistently attend every weekday for 8 weeks.

We offered time slots on the half hour from 6.00am to 9.30am PST, and 1 group per time slot. Group sizes ranged from 2-5 participants. We enrolled participants over a period of 5 months. Groups grew over time as more participants enrolled and those from the waitlist group chose to join a group after their 8-week waiting period. Group sessions lasted no more than a total of 30 minutes, beginning with a check-in lasting up to 5 minutes. Women usually did their workouts while remaining on video so they could virtually exercise together. We provided recommended mobile apps and YouTube exercise videos routines. Participants were also encouraged to find exercise apps and videos that were not on the list. The choices were not required to be coordinated within groups, so participants in groups were often doing a wide range of workouts simultaneously. Participants each had an individualized website with a link to their group video call and a tracking form that they filled out before each session.

Randomization

Participants were randomized using equal allocation (1:1) and block randomization (random block sizes of 2 and 4 participants). The randomization was stratified on the participant's morning time slot of choice and the participant's baseline activity status, a binary variable of whether they met ACSM guidelines of 150+ active minutes per week. Our statistician generated a stratified block random sequence using STATA and stored it in REDCap (Research Electronic Data Capture), a web-based database application. The sequence was concealed from the primary investigator, who used REDCap to reveal the computer assigned randomization for each participant.

Measures

During the recruitment phase, participants filled out a screening survey to establish eligibility. Once eligibility was confirmed, participants were asked to fill out online surveys at baseline and 8 weeks. Mothers who were randomized to the intervention arm were asked additional intervention evaluation questions in their 8-week survey. All surveys were completed online using Qualtrics software.

Physical Activity

We assessed our primary outcome of physical activity using a self-administered questionnaire, the Active Australia Survey.[101,102] Participants reported their frequency and duration of the past 7 days of activity in the following categories: walking (for at least half a mile), moderate (makes you breathe harder than normal) activity, and vigorous activity (makes you sweat, out of breath). Moderate to vigorous physical activity (MVPA) minutes per week were calculated by the sum of vigorous minutes multiplied by a factor of 2 plus the number of moderate minutes. The Active Australia survey has good reliability and good validity compared to accelerometry and was found to be responsive to change in clinical trials.[103,104] Furthermore, it has been used in a number of physical activity trials with mothers.[105]

Psychosocial Measures & Study Evaluation

We assessed psychosocial measures specific to physical activity, which included social support for physical activity and physical activity self-efficacy.[44,105,106] We also used NIH PROMIS short form measures for anxiety, sleep disturbance, depression, and fatigue, and converted summary scores into

standardized T-scores.[107] We assessed participant adherence by monitoring their session attendance per week throughout their 8-week participation. Adherence took into account holiday weeks, the rate for the week excluding the holiday was applied to the whole holiday week. Acceptability was assessed through survey evaluation questions administered to participants in the intervention arm at the end of the study.

Statistical Analysis

We used linear regression to compare change in minutes per week of physical activity across the 8-week study period across randomized groups for the following categories: MVPA, vigorous, and moderate minutes per week. We included the following additional covariates in our model: baseline value of the outcome and the time at which women chose to join their sessions. Time was included as a 3-part variable (6-7am, 7.30-8.30am, 9-10.30am) and included in the model using dummy variables. We used an intention-to-treat analysis. Based on our a priori hypothesis that inactive women would benefit most from the study, we analyzed results for all women who completed 8 week surveys, followed by an analysis stratified by whether women met ACSM guidelines (150+ minutes of MVPA per week) at baseline. We used these same linear regression models and covariates to analyze our secondary outcomes of changes in weight and psychosocial measures. We assessed recruitment and retention rates, adherence (measured by attendance of video sessions in the intervention arm), and acceptability (through questionnaire feedback from intervention participants). Our sample size was estimated based on our informal pilot data where we found an average increase of 30 minutes per week

(standard deviation of 15 minutes per week) in 5 adherent participants over 8 weeks using a single intervention arm. We calculated that we needed at least 32 participants to have 80% power (with alpha = 0.05) to detect a 20-minute difference in MVPA between groups if attrition was less than 10% and we assumed an increase of 10 minutes per week in the control arm. As we found that it was feasible to recruit more participants during the planned recruitment period, we exceeded the minimum number of participants we aimed to enroll based on these sample size estimates.

Results

We randomized 64 participants who were recruited over 4 months; 30 were allocated to the intervention and 34 to the control arm (Figure 1). All participants completed baseline surveys, and 3 participants were unable to be contacted at the 8-week follow-up time, 2 from the control arm and 1 from the intervention arm, an overall loss of less than 5% of participants.

The mean age of women who enrolled in the trial was 37 years, and on average, had less than 2 children (Table 1). Participants were predominately married, white, and had a high level of education, the majority with a post-graduate degree. Most women worked full-time or part-time jobs.

Physical Activity

Mothers in the intervention arm increased their mean number of MVPA minutes per week by 46.9 more minutes than mothers in the control arm (p=0.08), adjusted for baseline MVPA and group time slot (Table 2, Figure 2). The intervention

arm mothers increased moderate activity by 14.4 more minutes per week (p=0.16), and vigorous activity by 16.1 more minutes per week (p=0.09)

Mothers who were inactive at baseline (n=51) increased their MVPA minutes per week by 55.8 more in the intervention compared to the control arm (p=0.02; Table 2, Figure 2). Inactive mothers at baseline assigned to the intervention arm increased their vigorous minutes per week by 21.0 more minutes (p=0.01) on average compared to the control arm, and increased their moderate activity minutes by 11.8 more minutes (p=0.27). In contrast, for mothers who were active at baseline (n=10), the intervention arm had a greater decrease of 39.3 MVPA minutes per week, a greater decrease of 1.7 vigorous minutes per week, and a greater increase of 27.9 moderate minutes per week compared to the control arm, but none of these differences approached statistical significance.

Secondary Outcomes

We examined several secondary outcomes: weight, physical activity self-efficacy, social support for physical activity, and four health-related quality of life measures (Table 3). Women in the intervention group lost 1.4 more pounds on average than women in the control arm (p=0.18). Among women who were inactive at baseline, the intervention group lost 1.9 more pounds on average, a difference that approached statistical significance (p=0.09). Social support for physical activity increased more for women in the intervention arm than in the control arm (p=0.05). There was little difference in PA self-efficacy changes across trial arms (p=0.98).

Women in the intervention arm compared to the control arm tended to have greater decreases in depression (p=0.09), poor sleep (p=0.37), anxiety (p=0.37), and

fatigue (p=0.74), though none of these differences were statistically significant. In stratified analyses, inactive women had a significantly greater decrease in their depression score (p=0.02).

Adherence and Acceptability

Women in the intervention arm (n=30) attended 2.8 sessions per week on average over 8 weeks. The attendance had a standard deviation of 1.17 and a skewed distribution with a median of 3.5. Participants attended 3.3 sessions per week in the first half of the study, and 2.4 sessions in the second half. Five participants did not complete the entire 8 weeks, though all but one still completed end of study assessments. Women reported multiple reasons for non-completion including work, ill health, and lack of sleep.

The majority of mothers (85.7%) expressed satisfaction (extremely or somewhat satisfied) with the intervention. All mothers said they would recommend it to a friend, either certainly (96%) or maybe (4%). Mothers reported that the most significant impact from their participation was increasing their fitness levels (35.7%), being a good role model for their kids (14.2%), improving mood (10.7%), and feeling better about their body (7.1%). The most frequently (sometimes and often) used apps and YouTube videos included: Sworkit, Yoga YouTube videos, Johnson and Johnson, and Nike. All women reported feeling a benefit after sessions, e.g. “energized”, “great!” “proud”. A little less than half of the women in the intervention arm (42.9%) reported increasing their activity levels outside of the study and described these increases as: “The kids wanted to start doing more yoga (Cosmic Kids on YouTube) and dance parties as a family” and “I had more energy to do other activities throughout the day.” Most women reported that their

biggest barriers to attendance were lack of sleep, family commitments, and work commitments. Most women (78%) reported in the survey that their commitment to the group and the expectation that others would be there and rely on them being present were the main motivators to attending sessions. In open responses to why participants liked the study, most listed social support, accountability, and convenience as their favorite features as well as ones they would like further strengthened in future iterations of the program (Table 4).

Discussion

Summary of Results

The MOVE trial assessed a virtual exercise group intervention for mothers over an 8-week period, using a randomized, controlled design. The intervention was feasible and acceptable to all participants. There was a trend toward increasing moderate and vigorous minutes of physical activity for all women, although this did not reach statistical significance. As hypothesized, women in the pre-specified strata who were inactive at baseline significantly increased their MVPA minutes by an average of 56 minutes per week more in the intervention group. A corresponding statistically significant increase of 21 minutes of vigorous activity drove the increase in total MVPA minutes for this stratum of inactive women.

Feasibility and Acceptability

Digital tools were the driving force behind the feasibility and acceptability of this intervention. Recruitment, enrollment, data collection, and intervention delivery were all conducted online, which was convenient for participants and study

staff. Programs that can adapt to the individual context of their participants and ones that provide strong social support have proved effective at increasing physical activity.[60,85] The digital tools we used helped us address individual needs of participants while creating a socially supportive exercise space. Mobile apps allowed participants to choose short, and often vigorous workouts, which they could customize to their own abilities and interests. Using mobile exercise apps provided participants with a way of efficiently getting exercise without having to make major changes to their existing routines. The video conference tools helped create a supportive social group while allowing women to exercise from the convenience of their home at the time of their choosing, usually alongside their children. Most women listed the convenience and social support as features of the trial that provided motivation and enjoyment.

The participants' enthusiasm for the program was important in the early recruitment efforts, where participants shared study advertisements with multiple types of mother support group networks, and in the retention of participants who almost uniformly filled out end of study surveys, even if they no longer were able to participate in sessions. Many physical activity trials for mothers require fairly high time commitments from participants primarily through coaching and education in person, [78,108–110] remotely via telephone and texts,[111,112] or both.[113–115] Participants' time in this study went almost entirely towards exercising in their virtual groups. Participants reported a strong appreciation for the convenience and flexibility of the intervention which are particularly important features for mothers of young children who report feeling overwhelmed and unable to prioritize their own self-

care.[79,81,82,84,116] Accordingly, our retention rates of 95% were higher than the two comparable technology trials on physical activity with mothers (86% and 75%), and among the highest of physical activity trials with mothers.[78,108–112,114,115] The high feasibility and acceptability of this trial has implications for future internet-based physical activity trials targeting mothers.

Effectiveness

Randomized trials of physical activity with mothers have mixed results. Some trials have found statistically significant increases in physical activity,[108,111,113,114] while others report non-statistically significant changes.[78,115] There is great heterogeneity in the types of interventions delivered, and even inconsistency in the definition of MVPA. Some studies use a simple [moderate+vigorous=MVPA] equation while others use a vigorous enhanced equation [moderate+vigorous*2=MVPA] as used in these analyses. Two comparable randomized technology trials of physical activity with mothers that incorporated technology found statistically significant increases in MVPA minutes in the range of the increases we found in inactive women.[111,114] One trial found an increase of 92 MVPA minutes for mothers of babies 3+ months compared to our difference of 51 using the vigorous enhanced equation; and a second trial found an increase of 49 MVPA compared to our difference of 33 MVPA using the simple equation. The studies were larger and longer and they differed from the current study in that they had a large coaching component, did not include any group social support, and did not use apps or video conferencing tools. Changes in vigorous minutes were not disaggregated from MVPA minutes in either of these studies.

Secondary Findings

In addition to the increases in physical activity, we observed improvements in several secondary measures. Social support specific to physical activity increased for all mothers in this trial. Mothers have a uniquely challenging set of barriers to physical activity. Our participants reported they were motivated to show up for one another (social support), and the presence of other mothers re-enforced their own capacity to exercise consistently (self-efficacy). We observed a statistically significant decrease in depression among inactive women in the intervention arm across the trial period. The increases in physical activity and social support that we observed could both contribute to decreased depression.[78,109] These are mechanisms that could be tested individually and synergistically in future trials.

Limitations

Our digital tools helped create an efficient recruiting process, however, our recruitment methods, inclusion criteria, and use of snowball sampling resulted in a sample that was not representative of the general US population. Participants were predominantly highly educated, married, white, of an older age at first child, and typically lived in large cities on the West Coast. Future trials are needed to test whether this type of intervention can be effectively delivered to a more diverse population.

We relied on a self-report measure of physical activity, which though widely used, could have introduced reporting bias. Participants and investigators were not blinded to their randomization status which could have also introduced reporting bias. Our sample size limited our ability to fully explore the differences in outcomes

by baseline activity status. In particular, the group of mothers who were physically active at baseline was quite small (n=10). While our results clearly suggest that this type of intervention is most likely to benefit mothers who are inactive, it would be premature to conclude, based on our data, that this approach does not benefit all mothers.

An important limitation of our trial is that we were not able to assess whether the intervention effect was maintained over a longer time. However, the high retention rate suggests that a trial with a longer follow-up period is feasible.

Conclusion

This study suggests that technology can be used to create an individualized physical activity intervention with social support using a scalable and cost-effective delivery mechanism for mothers. There is great excitement in the use of new technology to solve old problems, however, often new technology alone cannot overcome the barriers to behavior change. We utilized technology to deliver evidence-based components of individualization and social support in a physical activity program that was convenient and compelling for our busy participants. To our knowledge, this is the first study that examines the use of video technology paired with exercise mobile apps to create virtual exercise groups. We found that a web and mobile app group exercise intervention was a feasible and acceptable way to deliver a physical activity intervention. Furthermore, we showed our intervention increased physical activity in inactive mothers. Further studies are needed to better establish how long these changes in physical activity can be maintained and whether these findings can be reproduced in a more diverse population.

Table 3.1 Baseline characteristics of study population, n(%) unless otherwise indicated

	Control (n=34)	Intervention (n=30)
Mother's Age (years; M [SD])	36.8 (6.5)	37.3 (4.0)
Children's Age (years; M [SD])	2.5 (1.9)	2.9 (2.1)
Number of children (M [SD])	1.8 (0.8)	1.4 (0.5)
Marital Status		
Married/living as married	29 (87.9)	28 (93.3)
Never married	3 (9.1)	1 (3.3)
Separated/Divorced	1 (3.0)	1 (3.3)
Race/Ethnicity		
African American	1 (2.9)	1 (3.3)
Asian	4 (11.8)	3 (10.0)
Latina	0 (0.0)	1 (3.3)
Middle Eastern	2 (5.9)	0 (0.0)
Two or more races	5 (14.7)	4 (13.3)
White	22 (64.7)	21 (70.0)
Employment		
Full time	17 (50.0)	18 (60.0)
Not employed	9 (26.5)	4 (13.3)
Part time	7 (20.6)	6 (20.0)
Student	1 (2.9)	2 (6.7)
Education Level		
Some college	1 (2.9)	1 (3.3)
Bachelor degree	9 (26.5)	10 (33.3)
Post college degree	24 (70.6)	19 (63.3)
Currently breastfeeding	15 (44.1)	12 (40.0)
Physical Activity (minutes per week; M [SD])		
Moderate-to-Vigorous Activity	59.1 (80.1)	89.5 (112.5)
Vigorous Activity	13.5 (29.6)	24 (44.8)
Moderate Activity	32.1 (38.2)	41.5 (50.3)
BMI (kg/cm2), M [SD])	24.1 (3.3)	25.6 (4.6)
PA Self Efficacy (score; M [SD])	3.5 (0.7)	3.6 (0.7)
PA Social Support (score; M [SD])	2 (0.6)	2.1 (0.8)

Table 3.1 Baseline characteristics of study population, n(%) unless otherwise indicated

	Control (n=34)	Intervention (n=30)
PROMIS Measures (score; M [SD])		
Depression	48.2 (6.8)	48.7 (7.6)
Sleep	57.7 (7.6)	57 (6.9)
Fatigue	60 (8.7)	59.4 (6.0)
Anxiety	50.4 (9.2)	51.9 (7.9)

1- Race/Ethnicity – 2+ Races are as follows (n): Latina/White (2), Latina/Middle Eastern (1), Middle Eastern/White (1), Asian/White (2), American Indian/White (1)
2- We used stratified randomization (time and baseline activity status) which resulted in intervention and control groups of unequal sizes

Table 3.2 Changes in physical activity measures over eight weeks across randomization arms

	8 Week Change[2] (95% CI)		Difference[12] (95% CI)	p value[3]
Physical Activity (minutes/week)	Control	Intervention	Across Arms	
All Mothers (n=61)				
MVPA[4]	-9.5 (-45.2, 26.1)	37.4 (-0.1, 74.9)	46.9 (-5.3, 99.2)	0.08
Vigorous	0.4 (-13.5, 14.2)	14.8 (0.2, 29.4)	14.4 (-6, 34.8)	0.16
Moderate	-9.3 (-21.9, 3.3)	6.8 (-6.5, 20.1)	16.1 (-2.4, 34.5)	0.09
Inactive Mothers (n=51)				
MVPA[4]	3.2 (-32.9, 39.2)	50.1 (10.4, 89.9)	55.8 (10.8, 100.7)	0.02
Vigorous	2.1 (-11.9, 16.0)	16.5 (1.1, 31.9)	21.0 (5.2, 36.8)	0.01
Moderate	0.6 (-12.2, 13.3)	16.7 (3.1, 30.3)	11.8 (-8.7, 32.2)	0.25
Active Mothers (n=10)				
MVPA[4]	-74.5 (-139.2, -9.8)	-27.5 (-87.4, 32.3)	-39.3 (-368.4, 289.7)	0.77
Vigorous	-8.4 (-32.2, 15.4)	6.0 (-15.9, 27.9)	1.7 (-159.7, 163.1)	0.98
Moderate	-59.8 (-77.7, -41.8)	-43.7 (-61.2, -26.1)	27.9 (-60.9, 116.7)	0.46

1 Difference of the within-group change for intervention vs control

2 Adjusted for baseline of outcome and time

3 Statistically significant at $p<0.05$

4 MVPA - moderate and vigorous minutes of physical activity per week

Table 3.3 Changes in secondary outcome measures over eight weeks across randomization arms

	All Mothers (n=61)		Inactive Mothers (n=51)		Active Mothers (n=10)	
Measures	Difference[1] (95% CI)	p value	Difference[1] (95% CI)	p value	Difference[1] (95% CI)	p value
Weight loss (lbs)	-1.4 (-3.6, 0.7)	0.18	-1.9 (-4, 0.3)	0.09	-0.3 (-20, 19.3)	0.96
PA Social Support[a]	0.3 (0, 0.5)	0.05	0.2 (-0.1, 0.5)	0.18	1.1 (-0.6, 2.8)	0.15
PA Self Efficacy[a]	0.0 (-0.2, 0.2)	0.98	0 (-0.3, 0.2)	0.76	0.0 (-0.7, 0.6)	0.94
PROMIS Measures						
Depression[b]	-2.8 (-5.9, 0.4)	0.09	-4.1 (-7.3, -0.8)	0.02	3.6 (-10.3, 17.5)	0.53
Sleep disturbance[b]	-1.2 (-3.7, 1.4)	0.37	-1.2 (-3.9, 1.6)	0.40	0.3 (-12.7, 13.2)	0.96
Fatigue[b]	-0.6 (-4.5, 3.3)	0.74	-0.9 (-5.1, 3.2)	0.65	-0.6 (-21, 19.8)	0.94
Anxiety [b]	-1.0 (-4.5, 2.5)	0.74	-1.4 (-5.4, 2.7)	0.50	0.3 (-11, 11.5)	0.96

1-Adjusted for baseline value of outcome and time slot

2-MVPA - moderate and vigorous minutes of physical activity per week

a- Higher scores indicate a more optimal outcome

b- Lower scores indicate a more optimal outcome

*- Statistically significant at $p<0.05$

Table 3.4 Satisfaction with MOVE - qualitative assessments

Things we liked best
That is got me doing SOMETHING physical which I really, really needed.
I liked having the time set out for me to do the workout and having other people "keeping me company". That was a HUGE motivator.
Creating a structured time for myself and following through.
Loved the group motivation
Working Out from home, having accountability, the "come as you are" mentality, the other gals were great!
I discovered that 15 minutes of morning exercise made my body feel better immediately and often for the rest of the day.
The workouts. You really can notice results with 15 minutes per day.
The "live" nature of the sessions.
Knowing that there were other moms in the same boat as me.
Having a program to participate in created more support from [my] partner around exercise.
Things we would change
Some way to help push yourself to increasingly challenging programs in a measured way
The social support element built in a bit more. It was helpful to exercise alongside people, but I didn't feel that I got to know them.
More workout options.
Offer more flexibility in the time
Better introductions when a new person starts
It would be nice to be able to join a later group if we can't make our regularly scheduled group.

Figure 3.1 Flow diagram for study participants

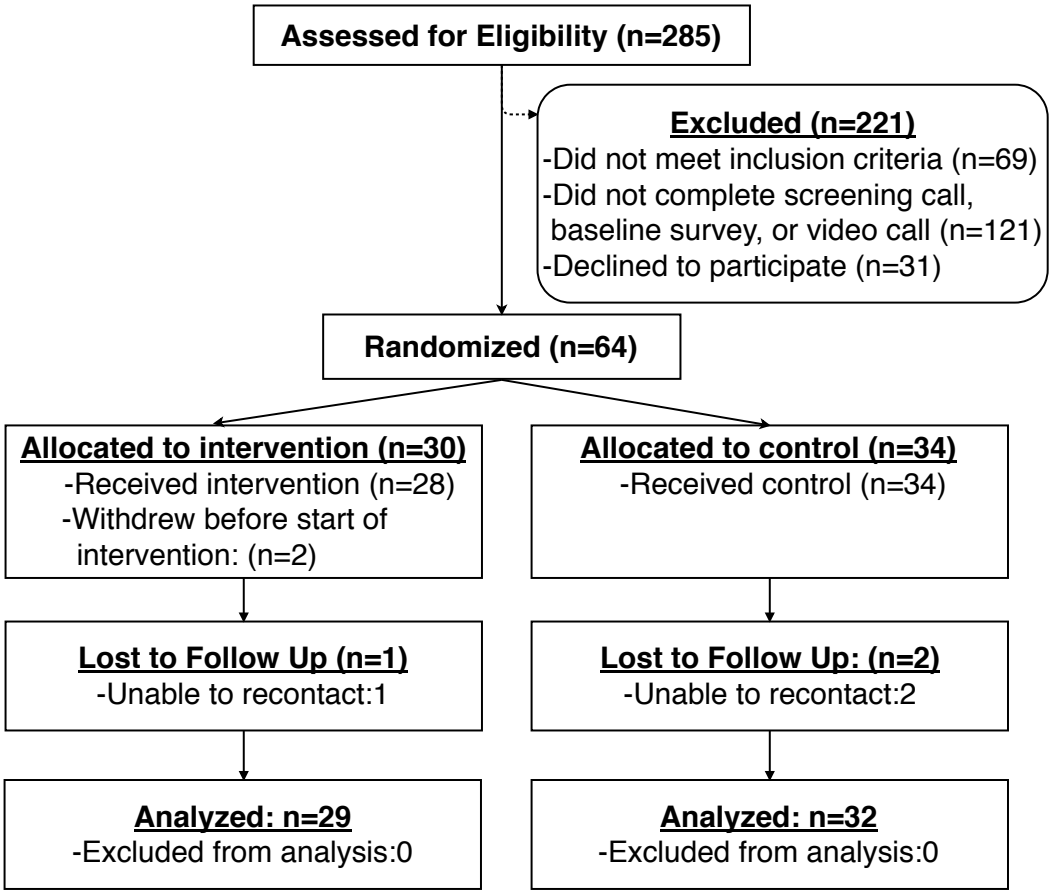
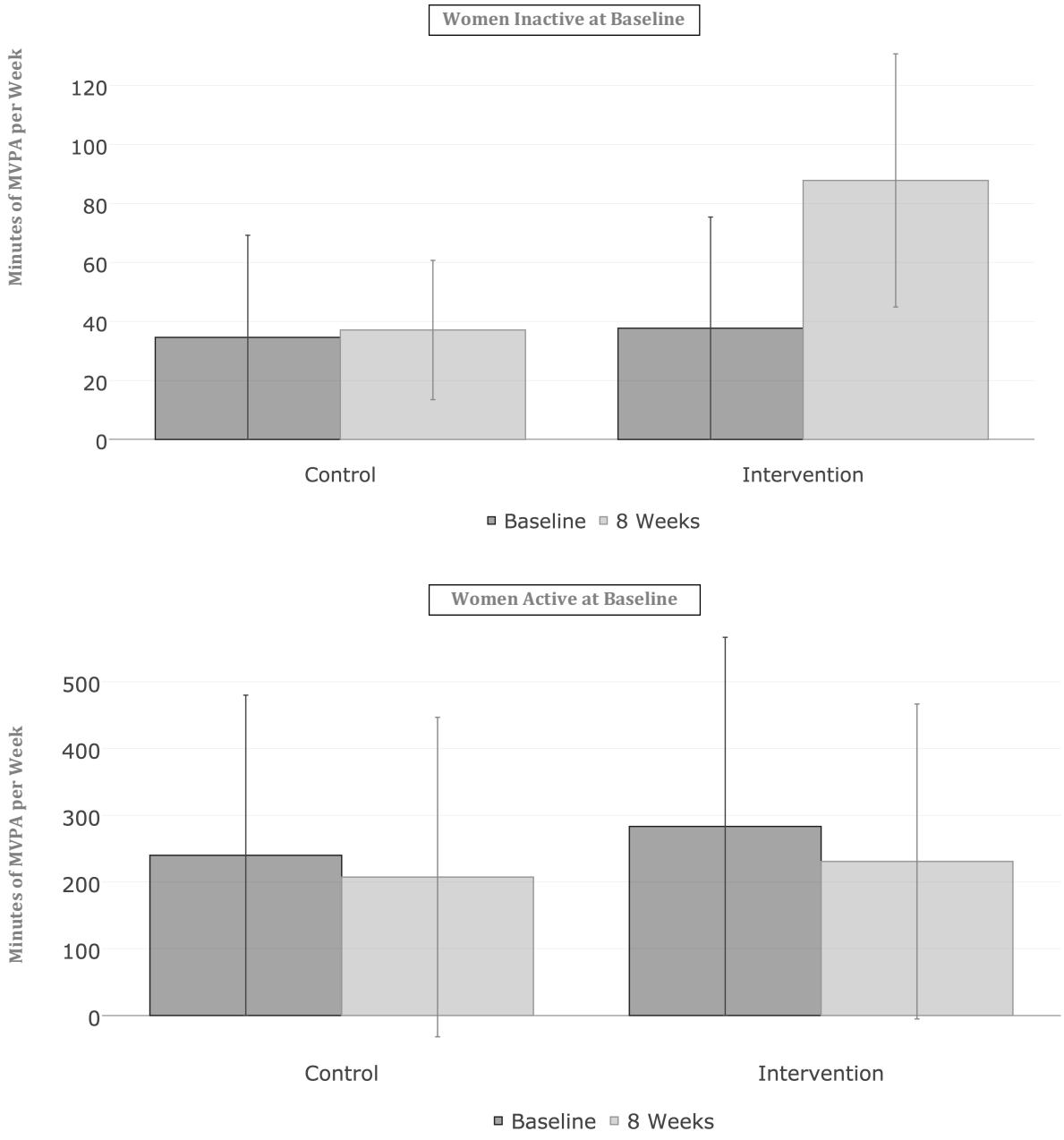


Figure 3.2 Change in moderate-to-vigorous physical activity minutes per week over eight weeks across randomization arms for women inactive and active at baseline



References

1. Engberg E, Alen M, Kukkonen-Harjula K, Peltonen JE, Tikkanen HO, Pekkarinen H. Life events and change in leisure time physical activity: a systematic review. *Sports Med*. 2012;42(5):433-447. doi:10.2165/11597610-000000000-00000.
2. Bellows-Riecken KH, Rhodes RE. A birth of inactivity? A review of physical activity and parenthood. *Prev Med (Baltim)*. 2008;46(2):99-110. doi:10.1016/j.ypmed.2007.08.003.
3. Allender S, Hutchinson L, Foster C. Life-change events and participation in physical activity: a systematic review. *Health Promot Int*. 2008;23(2):160-172. doi:10.1093/heapro/dan012.
4. Grace SL, Williams A, Stewart DE. Health-Promoting Behaviors Through Pregnancy, Maternity Leave, and Return to Work: Effects of Role Spillover and Other Correlates. *Women Health*. 2006;43(2):37-41. doi:10.1300/J013v43n02.
5. Devine CM, Bove CF, Olson CM. Continuity and change in women's weight orientations and lifestyle practices through pregnancy and the postpartum period: The influence of life course trajectories and transitional events. *Soc Sci Med*. 2000;50:567-582. doi:10.1016/S0277-9536(99)00314-7.
6. Albright C, Maddock JE, Nigg CR. Physical activity before pregnancy and following childbirth in a multiethnic sample of healthy women in Hawaii. *Women Health*. 2005;42(3):95-110.
7. Pereira MA, Rifas-Shiman SL, Kleinman KP, Rich-Edwards JW, Peterson KE, Gillman MW. Predictors of change in physical activity during and after pregnancy: Project Viva. *Am J Prev Med*. 2007;32(4):312-319. doi:10.1016/j.amepre.2006.12.017.
8. Bell S, Lee C. Emerging adulthood and patterns of physical activity among young Australian women. *Int J Behav Med*. 2005;12(4):227-235. doi:10.1207/s15327558ijbm1204_3.
9. Brown WJ, Trost SG. Life transitions and changing physical activity patterns in young women. *Am J Prev Med*. 2003;25(2):140-143. doi:10.1016/S0749-3797(03)00119-3.
10. Sallis JF, Greenlee L, McKenzie TL, et al. Changes and Tracking of Physical Activity Across Seven Years in Mexican-American and European-American Mothers. *Women Health*. 2001;34(4)(911724993):37-41. doi:10.1300/J013v34n04.
11. Brown WJ, Heesch KC, Miller YD. Life events and changing physical activity patterns in women at different life stages. *Ann Behav Med*. 2009;37(3):294-305. doi:10.1007/s12160-009-9099-2.
12. Burke V, Beilin LJ, Dunbar D, Kevan M. Changes in health-related behaviours and cardiovascular risk factors in young adults: Associations with living with a partner. *Prev Med (Baltim)*. 2004;39(4):722-730. doi:10.1016/j.ypmed.2004.02.038.
13. Hull EE, Rofey DL, Robertson RJ, Nagle EF, Otto AD, Aaron DJ. Influence of marriage and parenthood on physical activity: A 2-year prospective analysis. *J*

Phys Act Health. 2010;7(5):577-583. doi:10.1123/jpah.7.5.577.
14. Twisk J, Snel J, Kemper HC, van Mechelen W. Daily uplifts and positive life events ; relation with coronary heart disease risk factors in young adults. *J Psychosom Res*. 2015;46(3):229-240.
15. Treuth MS, Butte NF, Puyau M. Pregnancy-related changes in physical activity, fitness, and strength. *Med Sci Sports Exerc*. 2005;37(5):832-837. doi:10.1249/01.MSS.0000161749.38453.02.
16. Sidney S, Jacobs DR, Haskell WL, et al. Comparison of two methods of assessing physical activity in the Coronary Artery Risk Development in Young Adults (CARDIA) Study. *Am J Epidemiol*. 1991;133(12):1231-1245.
17. Jacobs DR, Ainsworth BE, Hartman TJ, Leon AS. A simultaneous evaluation of 10 commonly used physical activity questionnaires. *Med Sci Sports Exerc*. 1993;25(1):81-91.
18. Jacobs DRJ, Hahn LP, Haskell WL, Pirie P, Sidney S. Validity and Reliability of Short Physical Activity History: Cardia and the Minnesota Heart Health Program. *J Cardiopulm Rehabil*. 1989;9:448-459.
19. Hankinson AL, Daviglus ML, Bouchard C, et al. Maintaining a high physical activity level over 20 years and weight gain. *JAMA*. 2010;304(23):2603-2610. doi:10.1001/jama.2010.1843.
20. Parker ED, Schmitz KH, Jacobs DR, Dengel DR, Schreiner PJ. Physical activity in young adults and incident hypertension over 15 years of follow-up: The CARDIA study. *Am J Public Health*. 2007;97(4):703-709. doi:10.2105/AJPH.2004.055889.
21. Robins JM, Hernán MA, Brumback B. Marginal structural models and causal inference in epidemiology. *Epidemiology*. 2000;11(5):550-560.
22. Bellows-Riecken KH, Rhodes RE. A birth of inactivity? A review of physical activity and parenthood. *Prev Med (Baltim)*. 2008;46(2):99-110. doi:10.1016/j.ypmed.2007.08.003.
23. American Diabetes Association. Gestational diabetes mellitus. *Diabetes Care*. 2004;27 Suppl 1(suppl 1):S88-90. doi:10.2337/diacare.27.2007.s88.
24. Ferrara A, Kahn HS, Quesenberry CP, Riley C, Hedderson MM. An increase in the incidence of gestational diabetes mellitus: Northern California, 1991-2000. *Obstet Gynecol*. 2004;103(3):526-533. doi:10.1097/01.AOG.0000113623.18286.20.
25. Bardenheier BH, Imperatore G, Gilboa SM, et al. Trends in Gestational Diabetes Among Hospital Deliveries in 19 U.S. States, 2000-2010. *Am J Prev Med*. 2015;49(1):12-19. doi:10.1016/j.amepre.2015.01.026.
26. Wendland EM, Torloni MR, Falavigna M, et al. Gestational diabetes and pregnancy outcomes--a systematic review of the World Health Organization (WHO) and the International Association of Diabetes in Pregnancy Study Groups (IADPSG) diagnostic criteria. *BMC Pregnancy Childbirth*. 2012;12:23. doi:10.1186/1471-2393-12-23.
27. Bellamy L, Casas J-P, Hingorani AD, Williams D. Type 2 diabetes mellitus after gestational diabetes: a systematic review and meta-analysis. *Lancet (London, England)*. 2009;373(9677):1773-1779. doi:10.1016/S0140-6736(09)60731-5.

28. Kim C, Newton KM, Knopp RH. Gestational diabetes and the incidence of type 2 diabetes: a systematic review. *Diabetes Care*. 2002;25(10):1862-1868.
29. Jones EJ, Roche CC, Appel SJ. A review of the health beliefs and lifestyle behaviors of women with previous gestational diabetes. *J Obstet Gynecol neonatal Nurs JOGNN*. 38(5):516-526. doi:10.1111/j.1552-6909.2009.01051.x.
30. Petrylak DP, Tangen CM, Hussain MHA, et al. Docetaxel and estramustine compared with mitoxantrone and prednisone for advanced refractory prostate cancer. *N Engl J Med*. 2004;351(15):1513-1520. doi:10.1056/NEJMoa041318.
31. Devsam BU, Bogossian FE, Peacock AS. An interpretive review of women's experiences of gestational diabetes mellitus: Proposing a framework to enhance midwifery assessment. *Women and Birth*. 2013;26(2):e69-e76. doi:10.1016/j.wombi.2012.12.003.
32. Ratner RE, Christophi CA, Metzger BE, et al. Prevention of diabetes in women with a history of gestational diabetes: effects of metformin and lifestyle interventions. *J Clin Endocrinol Metab*. 2008;93(12):4774-4779. doi:10.1210/jc.2008-0772.
33. Engberg E, Alen M, Kukkonen-Harjula K, Peltonen JE, Tikkanen HO, Pekkarinen H. Life events and change in leisure time physical activity: a systematic review. *Sports Med*. 2012;42(5):433-447. doi:10.2165/11597610-000000000-00000.
34. Keller C, Fleury J. Factors related to physical activity in Hispanic women. *J Cardiovasc Nurs*. 2006;21(2):142-145.
35. Ainsworth BE, Keller C, Herrmann S, et al. Physical activity and sedentary behaviors in postpartum Latinas: Madres para la Salud. *Med Sci Sports Exerc*. 2013;45(7):1298-1306. doi:10.1249/MSS.0b013e3182863de5.
36. Tortolero SRR, Mâsse LCC, Fulton JEE, Torres I, Kohl HWW. Assessing physical activity among minority women: focus group results. *Womens Health Issues*. 1999;9(3):135-142.
37. Voorhees CC, Rohm Young D. Personal, social, and physical environmental correlates of physical activity levels in urban Latinas. *Am J Prev Med*. 2003;25(3 Suppl 1):61-68. doi:10.1016/S0749-3797(03)00166-1.
38. Bandy M. *The WIC Program in California (PPIC Publication)*.; 2015.
39. Athavale P, Thomas M, Delgadillo-Duenas AT, et al. Linking High Risk Postpartum Women with a Technology Enabled Health Coaching Program to Reduce Diabetes Risk and Improve Wellbeing: Program Description, Case Studies, and Recommendations for Community Health Coaching Programs. *J Diabetes Res*. 2016;2016:1-16. doi:10.1155/2016/4353956.
40. Handley MA, Harleman E, Gonzalez-Mendez E, et al. Applying the COM-B model to creation of an IT-enabled health coaching and resource linkage program for low-income Latina moms with recent gestational diabetes: the STAR MAMA program. *Implement Sci*. 2016;11(1):73. doi:10.1186/s13012-016-0426-2.
41. Ferrara A, Hedderson MM, Albright CL, et al. A pragmatic cluster randomized clinical trial of diabetes prevention strategies for women with gestational

diabetes: design and rationale of the Gestational Diabetes' Effects on Moms (GEM) study. *BMC Pregnancy Childbirth*. 2014;14(1):21. doi:10.1186/1471-2393-14-21.
42. Mujahid MS, Diez Roux A V., Morenoff JD, Raghunathan T. Assessing the measurement properties of neighborhood scales: from psychometrics to ecometrics. *Am J Epidemiol*. 2007;165(8):858-867. doi:10.1093/aje/kwm040.
43. Kaiser B, Razurel C. Determinants of postpartum physical activity, dietary habits and weight loss after gestational diabetes mellitus. *J Nurs Manag*. 2013;21(1):58-69. doi:10.1111/jonm.12006.
44. Sallis JF, Grossman RM, Pinski RB, Patterson TL, Nader PR. The development of scales to measure social support for diet and exercise behaviors. *Prev Med (Baltim)*. 1987;16(6):825-836.
45. Sandelowski M. Using Qualitative Research. *Qual Health Res*. 2004;14(10):1366-1386. doi:10.1177/1049732304269672.
46. Corbin J, Strauss A. *Basics of Qualitative Research- Techniques and Procedures for Developing Grounded Theory*. Thousand Oaks; 1998.
47. Michie S, van Stralen MM, West R. The behaviour change wheel: A new method for characterising and designing behaviour change interventions. *Implement Sci*. 2011;6(1):42. doi:10.1186/1748-5908-6-42.
48. Kim C, McEwen LN, Piette JD, Goewey J, Ferrara A, Walker EA. Risk perception for diabetes among women with histories of gestational diabetes mellitus. *Diabetes Care*. 2007;30(9):2281-2286. doi:10.2337/dc07-0618.
49. Shilts MK, Horowitz M, Townsend MS. Goal setting as a strategy for dietary and physical activity behavior change: a review of the literature. *Am J Health Promot*. 2004;19(2):81-93.
50. Langford CP, Bowsher J, Maloney JP, Lillis PP. Social support: a conceptual analysis. *J Adv Nurs*. 1997;25(1):95-100.
51. Thornton PL, Kieffer EC, Salabarría-Peña Y, et al. Weight, diet, and physical activity-related beliefs and practices among pregnant and postpartum latino women: The role of social support. *Matern Child Health J*. 2006;10(1):95-104. doi:10.1007/s10995-005-0025-3.
52. Kieffer EC, Willis SK, Arellano N, Guzman R. Perspectives of Pregnant and Postpartum Latino Women on Diabetes, Physical Activity, and Health. *Heal Educ Behav*. 2002;29(5):542-556. doi:10.1177/109019802237023.
53. Kieffer EC, Sinco B, Kim C. Health Behaviors Among Women of Reproductive Age With and Without a History of Gestational Diabetes Mellitus. *Diabetes Care*. 2006;29(8):1788-1793. doi:10.2337/dc06-0199.
54. Lie MLS, Hayes L, Lewis-Barned NJ, May C, White M, Bell R. Preventing Type 2 diabetes after gestational diabetes: women's experiences and implications for diabetes prevention interventions. *Diabet Med*. 2013;30(8):986-993. doi:10.1111/dme.12206.
55. Jones EJ, Appel SJ. Type 2 Diabetes: Fueling the Surge of Cardiovascular Disease in Women. *Nurs Womens Health*. 2008;12(6):500-514. doi:10.1111/j.1751-486X.2008.00384.x.
56. Symons Downs D, Ulbrecht JS. Understanding exercise beliefs and behaviors in women with gestational diabetes mellitus. *Diabetes Care*. 2006;29(2):236-

240.
57. Evans MK, Patrick LJ, Wellington CM. Health Behaviours of Postpartum Women with a History of Gestational Diabetes. *Can J Diabetes*. 2010;34(3):227-232. doi:10.1016/S1499-2671(10)43011-7.
58. Wilbur J, Chandler PJ, Dancy B, Lee H. Correlates of physical activity in urban Midwestern Latinas. *Am J Prev Med*. 2003;25(3 Suppl 1):69-76. doi:10.1016/S0749-3797(03)00167-3.
59. Nicaise V, Marshall S, Ainsworth BE. Domain-specific physical activity and self-report bias among low-income Latinas living in San Diego County. *J Phys Act Health*. 2011;8(7):881-890.
60. Bauman AE, Reis RS, Sallis JF, Wells JC, Loos RJF, Martin BW. Correlates of physical activity: Why are some people physically active and others not? *Lancet*. 2012;380(9838):258-271. doi:10.1016/S0140-6736(12)60735-1.
61. Handley M, MacGregor K, Schillinger D, Sharifi C, Wong S, Bodenheimer T. Using action plans to help primary care patients adopt healthy behaviors: a descriptive study. *J Am Board Fam Med*. 2006;19(3):224-231. doi:10.3122/jabfm.19.3.224.
62. Kahn E, Ramsey L, Brownson R, et al. The effectiveness of interventions to increase physical activity - A systematic review. *Am J Prev Med*. 2002;22(4):73-107. doi:10.1016/S0749-3797(02)00434-8.
63. Orozco L, Am B, M RF, et al. Exercise or exercise and diet for preventing type 2 diabetes mellitus (Review). 2008;(3):3-5. doi:10.1002/14651858.CD003054.pub3.Copyright.
64. Callaghan P. Exercise: A neglected intervention in mental health care? *J Psychiatr Ment Health Nurs*. 2004;11(4):476-483. doi:10.1111/j.1365-2850.2004.00751.x.
65. Bauman AE. Updating the evidence that physical activity is good for health: an epidemiological review 2000–2003. *J Sci Med Sport*. 2004;7(1):6-19. doi:10.1016/S1440-2440(04)80273-1.
66. Fox KR. The influence of physical activity on mental well-being. *Public Health Nutr*. 1999;2(3A):411-418.
67. Impact of physical activity during pregnancy and postpartum on chronic disease risk. *Med Sci Sports Exerc*. 2006;38(5):989-1006. doi:10.1249/01.mss.0000218147.51025.8a.
68. Trost SG, Sallis JF, Pate RR, Freedson PS, Taylor WC, Dowda M. Evaluating a model of parental influence on youth physical activity. *Am J Prev Med*. 2003;25(4):277-282. doi:10.1016/S0749-3797(03)00217-4.
69. Hesketh KR, Goodfellow L, Ekelund U, et al. Activity levels in mothers and their preschool children. *Pediatrics*. 2014;133(4):e973-80. doi:10.1542/peds.2013-3153.
70. Verloigne M, Van Lippevelde W, Maes L, Brug J, De Bourdeaudhuij I. Family- and school-based correlates of energy balance-related behaviours in 10-12-year-old children: a systematic review within the ENERGY (EuropeaN Energy balance Research to prevent excessive weight Gain among Youth) project. *Public Heal Nutr*. 2012;15(8):1380-1395. doi:10.1017/s1368980011003168.
71. Centers for Disease Control and Prevention (CDC). Adult participation in

aerobic and muscle-strengthening physical activities--United States, 2011. *MMWR Morb Mortal Wkly Rep*. 2013;62(17):326-330.
72. Orozco LJ, Buchleitner AM, Gimenez-Perez G, Roqué I Figuls M, Richter B, Mauricio D. Exercise or exercise and diet for preventing type 2 diabetes mellitus. *Cochrane database Syst Rev*. 2008;(3):CD003054. doi:10.1002/14651858.CD003054.pub3.
73. Fox KR. The influence of physical activity on mental well-being. *Public Health Nutr*. 2007;2(3a):411-418. doi:10.1017/S1368980099000567.
74. USDHHS. *2008 Physical Activity Guidelines for Americans*. Washington DC; 2008.
75. Engberg E, Alen M, Kukkonen-Harjula K, Peltonen JE, Tikkanen HO, Pekkarinen H. Life events and change in leisure time physical activity: a systematic review. *Sports Med*. 2012;42(5):433-447. doi:10.2165/11597610-000000000-00000.
76. Allender S, Hutchinson L, Foster C. Life-change events and participation in physical activity: a systematic review. *Health Promot Int*. 2008;23(2):160-172. doi:10.1093/heapro/dan012.
77. Archer E, Lavie CJ, McDonald SM, et al. Maternal inactivity: 45-year trends in mothers' use of time. *Mayo Clin Proc*. 2013;88(12):1368-1377. doi:10.1016/j.mayocp.2013.09.009.
78. Norman E, Sherburn M, Osborne RH, Galea MP. An exercise and education program improves well-being of new mothers: a randomized controlled trial. *Phys Ther*. 2010;90(3):348-355. doi:10.2522/ptj.20090139.
79. Currie J. Motherhood, stress and the exercise experience: freedom or constraint? *Leis Stud*. 2004;23(3):225-242. doi:10.1080/0261436042000251987.
80. Lewis B, Ridge D. Mothers reframing physical activity: Family oriented politicism, transgression and contested expertise in Australia. *Soc Sci Med*. 2005;60(10):2295-2306. doi:10.1016/j.socscimed.2004.10.011.
81. Hamilton K, White KM. Understanding parental physical activity: Meanings, habits, and social role influence. *Psychol Sport Exerc*. 2010;11(4):275-285. doi:10.1016/j.psychsport.2010.02.006.
82. Barkin JL, Wisner KL. The role of maternal self-care in new motherhood. *Midwifery*. 2013;29(9):1050-1055. doi:10.1016/j.midw.2012.10.001.
83. Brown PR, Brown WJ, Miller YD, Hansen V. Perceived Constraints and Social Support for Active Leisure Among Mothers With Young Children. *Leis Sci*. 2001;23(3):131-144. doi:10.1080/014904001316896837.
84. Verhoef MJ, Love EJ. Women and exercise participation: The mixed blessings of motherhood. *Health Care Women Int*. 2009;15(4):297-306. doi:10.1080/07399339409516122.
85. Kahn EB, Ramsey LT, Brownson RC, et al. The Effectiveness of Interventions to Increase Physical Activity: A Systematic Review. *Am J Prev Med*. 2010;22(2):73-107. doi:10.1016/S0749-3797(02)00434-8.
86. Griffiths F, Lindenmeyer A, Powell J, Lowe P, Thorogood M. Why are health care interventions delivered over the internet? A systematic review of the published literature. *J Med Internet Res*. 2006;8(2). doi:10.2196/jmir.8.2.e10.

87. Mobile Fact sheet. *Internet Sci Tech*. 2015. http://www.pewinternet.org/fact-sheet/mobile/. Accessed September 5, 2017.
88. Krebs P, Duncan DT. Health App Use Among US Mobile Phone Owners: A National Survey. *JMIR mHealth uHealth*. 2015;3(4):e101. doi:10.2196/mhealth.4924.
89. Conroy DE, Yang C-H, Maher JP. Behavior change techniques in top-ranked mobile apps for physical activity. *Am J Prev Med*. 2014;46(6):649-652. doi:10.1016/j.amepre.2014.01.010.
90. Cowan LT, Van Wagenen SA, Brown BA, et al. Apps of steel: are exercise apps providing consumers with realistic expectations?: a content analysis of exercise apps for presence of behavior change theory. *Health Educ Behav*. 2013;40(2):133-139. doi:10.1177/1090198112452126.
91. Modave F, Bian J, Leavitt T, Bromwell J, Harris Iii C, Vincent H. Low Quality of Free Coaching Apps With Respect to the American College of Sports Medicine Guidelines: A Review of Current Mobile Apps. *JMIR mHealth uHealth*. 2015;3(3):e77. doi:10.2196/mhealth.4669.
92. Pagoto S, Bennett GG. How behavioral science can advance digital health. *Transl Behav Med*. 2013;3(3):271-276. doi:10.1007/s13142-013-0234-z.
93. Duggan M, Lenhart A, Lampe C, Ellison NB. Parents and social media. 2015;(July). http://www.pewinternet.org/2015/07/16/parents-and-social-media/.
94. Davies CA, Spence JC, Vandelanotte C, Caperchione CM, Mummery W. Meta-analysis of internet-delivered interventions to increase physical activity levels. *Int J Behav Nutr Phys Act*. 2012;9(1):52. doi:10.1186/1479-5868-9-52.
95. Foster C, Richards J, Thorogood M, Hillsdon M. Remote and web 2.0 interventions for promoting physical activity. *Cochrane database Syst Rev*. 2013;9(9):CD010395.
96. Free C, Phillips G, Galli L, et al. The Effectiveness of Mobile-Health Technology-Based Health Behaviour Change or Disease Management Interventions for Health Care Consumers: A Systematic Review. *PLoS Med*. 2013;10(1). doi:10.1371/journal.pmed.1001362.
97. Muntaner A, Vidal-Conti J, Palou P. Increasing physical activity through mobile device interventions: A systematic review. *Health Informatics J*. 2015:1460458214567004-. doi:10.1177/1460458214567004.
98. Alley S, Jennings C, Plotnikoff RC, Vandelanotte C. Web-based video-coaching to assist an automated computer-tailored physical activity intervention for inactive adults: A randomized controlled trial. *J Med Internet Res*. 2016;18(8):1-15. doi:10.2196/jmir.5664.
99. Chisholm DM, Collis ML, Kulak LL, Davenport W, Gruber N (1975). Physical activity readiness. *B C Med J*. 1975;17(2):375-378.
100. Johnson & Johnson Health & Wellness Solutions. 7 Minute Workout. https://7minuteworkout.jnj.com/ [http://www.webcitation.org/6rRZlSLhP]. Accessed June 23, 2017.
101. AIWH. *The Active Australia Survey: A Guide and Manual for Implementation, Analysis and Reporting*. Canberra; 2003.
102. Armstrong T, Bauman A, Davies J. *Physical Activity Patterns of Australian*

Adults. Results of the 1999 National Physical Activity Survey. Canberra; 2000.
103. Brown WJ, Burton NW, Marshall AL, Miller YD. Reliability and validity of a modified self-administered version of the Active Australia physical activity survey in a sample of mid-age women. *Aust N Z J Public Health*. 2008;32(6):535-541. doi:10.1111/j.1753-6405.2008.00305.x.
104. Reeves MM, Marshall AL, Owen N, Winkler EAH, Eakin EG. Measuring physical activity change in broad-reach intervention trials. *J Phys Act Health*. 2010;7(2):194-202.
105. Albright CL, Steffen AD, Novotny R, et al. Baseline results from Hawaii's Nā Mikimiki Project: a physical activity intervention tailored to multiethnic postpartum women. *Women Health*. 2012;52(3):265-291. doi:10.1080/03630242.2012.662935.
106. Sallis JF, Pinski RB, Grossman RM, Patterson TL, Nader PR. The development of self-efficacy scales for healthrelated diet and exercise behaviors. *Health Educ Res*. 1988;3(3):283-292. doi:10.1093/her/3.3.283.
107. Cella D, Riley W, Stone A, et al. The patient-reported outcomes measurement information system (PROMIS) developed and tested its first wave of adult self-reported health outcome item banks: 2005-2008. *J Clin Epidemiol*. 2010;63(11):1179-1194. doi:10.1016/j.jclinepi.2010.04.011.
108. Miller YD, Trost SG, Brown WJ. Mediators of physical activity behavior change among women with young children. *Am J Prev Med*. 2002;23(2 Suppl):98-103. doi:10.1016/S0749-3797(02)00484-1.
109. Armstrong K, Edwards H. The effects of exercise and social support on mothers reporting depressive symptoms: A pilot randomized controlled trial. *Int J Ment Health Nurs*. 2003;12(2):130-138. doi:10.1046/j.1440-0979.2003.00229.x.
110. Cramp AG, Brawley LR. Moms in motion: a group-mediated cognitive-behavioral physical activity intervention. *Int J Behav Nutr Phys Act*. 2006;3(23):23. doi:10.1186/1479-5868-3-23.
111. Albright CL, Steffen AD, Wilkens LR, et al. Effectiveness of a 12-month randomized clinical trial to increase physical activity in multiethnic postpartum women: Results from Hawaii's Nā Mikimiki Project. *Prev Med (Baltim)*. 2014;69(4):214-223. doi:10.1016/j.ypmed.2014.09.019.
112. Chang MW, Nitzke S, Brown R. Design and Outcomes of a Mothers In Motion Behavioral Intervention Pilot Study. *J Nutr Educ Behav*. 2010;42(3 SUPPL.):S11-S21. doi:10.1016/j.jneb.2010.01.010.
113. Fahrenwald NL, Atwood JR, Walker SN, Johnson DR, Berg K. A randomized pilot test of "Moms on the Move": a physical activity intervention for WIC mothers. *Ann Behav Med*. 2004;27(2):82-90. doi:10.1207/s15324796abm2702_2.
114. Fjeldsoe BS, Miller YD, Graves N, Barnett AG, Marshall AL. Randomized Controlled Trial of an Improved Version of MobileMums, an Intervention for Increasing Physical Activity in Women with Young Children. *Ann Behav Med*. 2015;49(4):487-499. doi:10.1007/s12160-014-9675-y.
115. Østbye T, Krause KM, Lovelady CA, et al. Active Mothers Postpartum. A Randomized Controlled Weight-Loss Intervention Trial. *Am J Prev Med*.

2009;37(3):173-180. doi:10.1016/j.amepre.2009.05.016.
116. Harrington M, Dawson D, Bolla P. Objective and subjective constraints on women's enjoyment of leisure. *Loisir Soc*. 1992;15(1):203-221. doi:10.1080/07053436.1992.10715414.

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