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Changes in Physical Activity Among Postpartum Overweight and Obese Women: Results from the KAN-DO Study

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Abstract

Few studies have assessed physical activity at multiple time points in the postpartum period or used both self-reported and objective measures of assessment. The purpose of this study was to describe physical activity and sedentary behavior at two time points in a cohort of overweight or obese postpartum women using both self-reported and objective measures. In total, 132 women completed physical activity assessments at a median of 24 weeks postpartum and again approximately 10 months later. At both time points, women wore an Actical accelerometer for one week and completed the Kaiser Physical Activity Survey at both time points. Adjusted Poisson regression models were used to determine whether physical activity changed over time for the cohort. Overall counts per minute and moderate to vigorous physical activity increased from baseline to 10-months later, although the absolute levels were modest (median 6.9 to 8.8 minutes/day). A median of 64–71% at baseline and 63–67% at follow-up of their monitored time was sedentary. More intensive interventions are needed to help postpartum women integrate physical activity and reduce sedentary behavior.

Keywords

exercise; leisure activities; obesity; pregnancy; sedentary

Introduction

Most pregnant women gain in excess of recommended gestational weight gain guidelines (Viswanathan et al., 2008), established by the Institute of Medicine in 1990 (Institute of Medicine, 1990) and updated in 2009 (Institute of Medicine and National Research Council, 2009). Moreover, women often fail to lose all of the weight gained during pregnancy (Groth and David, 2008; Kinnunen et al., 2008). With weight retention, other health risks also increase, such as high blood pressure, diabetes, and cardiovascular disease (Amorim et al., 2007a; Rooney et al., 2005). However, women who return to their pre-pregnancy weight

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within approximately six months have a lower risk of being overweight ten years later (Amorim et al., 2007a). Thus, the postpartum period is described as a vulnerable time for weight gain and potentially critical for the development of obesity (Amorim et al., 2007b; Gunderson and Abrams, 2000).

A potentially modifiable behavior associated with adequate gestational weight gain and postpartum weight loss is physical activity. The health benefits of postpartum physical activity also include less anxiety, depression, lactation-induced bone loss, and urinary stress incontinence as well as improved cardiovascular fitness and sense of well-being (Larson-Meyer, 2002; Pivarnik et al., 2006; Sampselle et al., 1999; U.S. Department of Health and Human Services, 2008). The 2002 American College of Obstetricians and Gynecologists (ACOG, later "College" became "Congress") guidelines for pregnant and postpartum women state that pre-pregnancy exercise routines should be resumed gradually after giving birth, as soon as it is medically and physically safe to do so (ACOG, 2002). Another modifiable factor to consider is the time used for sedentary behavior, a distinct class of behaviors that involves sitting and low levels of energy expenditure (Marshall and Ramirez, 2011). Sedentary behavior is much less studied than physical activity among postpartum women.

Epidemiologic studies of physical activity during pregnancy and postpartum have generally relied on self-reported physical activity (Evenson et al., 2012; Borodulin et al., 2009). The advantage of more objective measures is that they minimize recall bias and allow partitioning of the intensity of physical activity (Corder et al., 2007). Moreover, few studies to date have assessed physical activity at multiple time points during postpartum. The primary purpose of this study was to describe physical activity and sedentary behavior at two time points among a cohort of overweight or obese postpartum women using both self-reported and objective measures.

Methods

Participants

Mother/ preschooler dyads took part in KAN-DO (Kids and Adults Now! Defeat Obesity), a randomized controlled trial designed to evaluate the effect of a family-based parenting intervention. The intervention promoted healthy weight in preschool age children and their postpartum mother (after the birth of a younger sibling to the index child) through a healthy diet and physical activity (Ostbye et al., 2012; Ostbye et al., 2011). Eligibility requirements for the mothers included being at least 18 years of age, residing in one of 14 counties in the Triangle and Triad regions of North Carolina, being English-speaking, and not having a health condition that precluded daily physical activity for either the mother or the preschooler. Women were recruited through birth certificate records, publicly available mailing lists, and flyers posted in clinic and community locations from 2007 to 2009. Of the 40,379 women that received information about the KAN-DO Study, 4444 (11%) were screened. Of those that were screened (n=4444), 1617 (36%) refused and 2179 (49%) were ineligible, resulting in 648 (15%) eligible women. Of those that were eligible (n=648), 152 (23%) did not attend their first scheduled appointment, 80 (12%) refused or were deemed ineligible at their first study appointment, and 16 (2%) did not complete all components of the baseline assessment. This left 400 mothers from whom we obtained written informed consent and were randomized to the intervention or control group.

Eligible participants were placed into one of 16 strata before randomization into intervention or control arms. The strata were based on study site (Durham, Greensboro), index child's age (2–3, 4–5 years), time since delivery of younger sibling (<122, >=122 days), and mother's race (Black, non-Black). Women randomized to the intervention arm received a

family-based, behavioral obesity reduction program via monthly mail and phone contacts and an in-person workshop. Women in the control arm received monthly newsletters emphasizing preschool reading. Participating mothers were 2- to 7-months postpartum at enrollment and prior to pregnancy had been overweight or obese, defined as a body mass index (BMI) of at least 25 kg/m^2.

The current analyses included only control participants who came into one of two laboratories, completed questionnaires, and wore an accelerometer at baseline (2- to 7-months postpartum) and follow-up approximately 10 months later (12- to 17-months postpartum). Women were provided $20 at completion of baseline measurements and $30 for completion of the follow-up visit, both of which included wearing the accelerometer. The Duke University Medical Center and the University of North Carolina at Greensboro Institutional Review Boards approved the study protocol and the University of North Carolina - Chapel Hill approved analyses of the data.

Physical Activity Measurement

Self-reported Physical Activity Questionnaire—Approximately two weeks prior to the baseline and follow-up clinic visits, women were asked to complete a self-administered questionnaire. A modified version of the Kaiser Physical Activity Survey (KPAS) (Ainsworth et al., 2000b), created from the original Baecke questionnaire (Baecke et al., 1983), assessed physical activity. The questionnaire can be found online (http://www.unc.edu/~kevenson/_KANDO_PAQ.pdf). According to a comprehensive review (Evenson et al., 2012), it is one of the few physical activity questionnaires with evidence of both validity and reliability among pregnant women (Schmidt et al., 2006). We modified the recall period from “the past year” to “the past month” to avoid including the time prior to birth and to detect changes in physical activity. To reduce missing items, the survey was reviewed by a staff member when the participant turned it in (Sternfeld et al., 1999).

The questionnaire assessed physical activity in four domains, with an index score ranging from 1 (least active) to 5 (most active) for each domain.

1. The *household/caregiving index* included 11 items on child and elder care, meal preparation, cleaning, home repair, shopping, gardening, and outdoor work.
2. The *occupational index* included a screening question regarding whether the participant worked, and 7 work-related items on sitting, standing, walking, lifting heavy loads, sweating from exertion, being tired after work, and comparison to others their own age regarding their work. Women who did not work were assigned a value of 1.
3. The *active living index* included four items on walking, bicycling, active transportation, and TV/video watching. The TV item (and an additional item on computer time that was not used with the KPAS) came from the 2003–2006 National Health and Nutrition Examination Survey (NHANES) questionnaires (National Center for Health Statistics, 2006), with evidence for test-retest reliability among adults (Evenson and McGinn, 2005).
4. The *sports index* included three global five-level questions on playing sports or exercise, sweating during sports or exercise, and assessing the mother’s recreational activity compared to others their own age that each contributed one-quarter of the score. The final one-quarter of the score comprised nine items on the three most frequent sports or exercises the mother engaged in during the past month. Time for each activity was assessed in hours/week and rescaled as follows: <1 hour/week (0.04), 1–<2 hours/week (0.17), 2–<3 hours/week (0.42), 3–<4

hours/week (0.67), and >=4 hours/week (0.92). Metabolic unit (MET) values, assigned from an expanded version of the compendium (Ainsworth et al., 2000a) (http://www.cpc.unc.edu/projects/pin/design_pin3/docs_3/PIN-MET-Table-080207.pdf), were used to represent absolute intensity. One MET equals approximately 1 kilocalorie * kilogram^{-1} * hour^{-1} or the oxygen consumption at rest. The MET values were rescaled as follows: <4 METS (0.76), 4–6 METS (1.26), and >6 METS (1.76). The rescaled time was multiple by the rescaled intensity values, and then summed over all activities. If the participant did not engage in sports or exercise in the past month, the sum was assigned a value of 0. The sports score was calculated by multiplying 4.35 by the sum and rescaled as follows: 0 (1), 0.01–<4 (2), 4–<8 (3), 8–<12 (4), and >=12 (5). The sports index was calculated by adding together the three global questions with the sports score, and then dividing the sum by 4.

A total score was calculated by adding the components of the KPAS, each of which contributed equally to the final score: [(household/caregiving index*0.25) + (occupational index*0.25) + (active living index*0.25) + (sports index*0.25)] * 4. For each index, the items were added together, such that the higher frequency, greater activity, or less TV watching were assigned higher values. A weighted activity index was also created, as described elsewhere, to reflect the greater proportion of energy expenditure attributable to household/caregiving as opposed to sports during pregnancy (Schmidt et al., 2006): [(household/caregiving index*0.5) + (occupational index*0.2) + (active living index*0.25) + (sports index*0.05)] * 4.

Accelerometer—At the conclusion of the laboratory visit, women were asked to wear an Actical (versions B-1 or C) accelerometer for one week. The Actical (Respironics Co. Inc., Bend, Oregon) is an omnidirectional monitor that is small (28x27x10 mm), light-weight (17 grams), and sensitive to movement in all directions. When worn upright on a belt above the iliac crest, the Actical is most sensitive to vertical movements consistent with ambulation (Pfeiffer et al., 2006; Puyau et al., 2002). Prior studies showed that the Actical was technically reliable (Esliger and Tremblay, 2006; Welk et al., 2004).

The monitor was programmed to capture accelerations in counts beginning at midnight of the next day in one-minute epochs. The women were told to undertake usual activities for 7 days while wearing the monitor and to remove it only for bathing, sleeping, and swimming. They were also provided written instructions and a phone number to call if any questions should arise. The monitor was returned to the laboratories using a padded pre-paid envelope, where the data were downloaded, and the monitor was reinitialized for reuse.

We defined non-wear time for the Actical counts as a period of 60 minutes or more of zeros. Spurious counts, such as consecutive nonzero minutes lasting more than 60 minutes, were flagged, assessed, and set to missing if deemed to be invalid. A valid day for inclusion was defined as at least six hours of wear time. To be included in the analysis, each participant needed to contribute at least four valid days of accelerometer data, including one weekend day and two weekdays. We first analyzed the raw data using counts/minute. Next, we defined moderate activity at a cutpoint of 1535 to 3961 counts/minute, and vigorous activity of at least 3962 counts per minute (Colley et al., 2011). Sedentary time was defined as <=50 counts/minute and <100 counts/minute (Oliver et al., 2010; Wong et al., 2011).

Covariate Measurement

On the baseline and follow-up questionnaires, women were asked about their age, race (Black, White, Asian, Native American/ Pacific Islander, Other), ethnicity (Hispanic, non-Hispanic), overall general health, marital status, breastfeeding, parity, current pregnancy

status, work status, and number of children in the home. Weight was assessed using a Tanita BWB-800S digital scale and height was measured using a SECA 214 portable stadiometer, both in street clothing with shoes removed. BMI values in kg/m^2 were grouped into categories at both time periods: normal weight (<25.0), overweight (25.0–<30.0), obese class I (30.0–<35.0), obese class II (35.0–<40.0), and obese class III (>=40.0) (National Institutes of Health and National Heart Lung and Blood Institute, 1998).

Statistical Analysis

In total, 400 postpartum women were randomized in the KAN-DO Study and 200 each were assigned to the intervention and control arms (Ostbye et al., 2012; Ostbye et al., 2011). Our present analytic sample included only the control group, to avoid contamination by the KAN-DO intervention, and further excluded 48 women who did not have complete follow-up data (n=25 were never reached after 6 attempts, n=15 were scheduled but did not come to their appointment, n=5 refused contact, n=3 refused to wear the accelerometer), 12 women without valid accelerometer data at both visits (5 accelerometers were lost or broken, 3 wore it fewer than 3 valid days and including at least one weekend day, 3 accelerometers malfunctioned, and 1 accelerometer was set incorrectly), and 8 women who became pregnant before the follow-up visit, for a final analysis sample size of 132.

Chi-square tests were used to compare those included in the analysis sample to those excluded. The relative percentages, means, and medians with interquartile ranges (IQR) of physical activity were reported separately at both time periods. Due to the skewed nature of the physical activity outcomes, adjusted Poisson models (for self-reported data) and negative binomial models (for accelerometer data) with generalized estimating equation (GEE) for repeated measures, using a compound symmetry working correlation, were used to test whether the change in physical activity across the two time points was significantly different (Liang and Zeger, 1986; Zeger and Liang, 1986). The goodness-of-fit statistics of all models indicated over-dispersion; therefore, the Pearson scaling adjustment was applied.

The significance level was set at $p<0.05$ and these models provided an adjusted p value for the differences in physical activity measured across time. Due to the use of multiple models (i.e., one model for each measure of physical activity) and the lack of a single exposure variable, we did not develop criteria to identify and retain confounders in multivariable models. Rather, we controlled for a set of covariates identified in the literature often associated with postpartum physical activity. Thus, we adjusted for age (continuous), education (less than college graduate, college graduate or higher), race/ethnicity (non-Hispanic White, other), and site (Durham, Greensboro), as well as the time varying covariates of marital status (married, not married), general health (excellent/very good, good, fair/poor), work status (employed full-time, employed part-time, not employed), and BMI (continuous). In addition, for the models using accelerometry we controlled for wear time at both time periods (continuous). All statistical analyses were conducted using SAS version 9.3 (Cary, NC). Box and whisker plots of physical activity were constructed using R (R Development Core Team, 2010).

Results

Description of Sample

Women completed measures at baseline and follow-up, with the median time since giving birth of 24 weeks (interquartile range 21–26, with 90% of women ranging from 15–27 weeks) and 65 weeks (interquartile range 62–68, with 90% of women ranging from 56–70 weeks), respectively. The median length of time from the baseline assessment to follow-up was 10 months.

Among the analytic sample of 132 postpartum women, half (50.0%) were between the ages of 30 and 35 years, with a median age of 34 years (Table 1). The sample included 81.1% non-Hispanic White and 15.2% non-Hispanic Black women. Almost all participants reported good, very good, or excellent general health. At baseline, 41.7% were classified as overweight, with the remainder classified as obese. Approximately 10-months later, seven women (5.3%) were considered normal weight, with 40.5% overweight and 54.2% obese.

We compared control participants included in the analyses (n=132) to those not included (n=68) (data not shown). Using baseline visit measures, those not included were more likely to be younger, non-Hispanic Black or Other race/ethnic group, have less education, have a higher parity, and not be married. No significant differences were observed for site, general health, weight categories, or working status.

Self-reported Physical Activity

During the 10-month postpartum period, household/caregiving and sport indices increased significantly (Table 2). The active living index increased modestly. The occupational index did not change significantly, both for the whole sample and only among those that worked. Over the postpartum period, television watching declined, with no change in time spent on the computer outside of work.

Objectively-Measured Physical Activity

The median accelerometer wear time was 13.3 hours/day at baseline (interquartile range 11.8–14.4) and 12.7 hours/day at follow-up (interquartile range 11.6–13.9). The median number of valid days of accelerometry data was 7 at both time periods. Overall counts per minute increased from baseline to 10-months later (Table 3 and Online Figure 1). Specifically, moderate and moderate to vigorous physical activity (MVPA) increased over time (Online Figure 2), although the absolute values were small. For example, MVPA increased from a median of 6.9 minutes/day to 8.8 minutes/day. No significant change was observed in vigorous activity, and the absolute values were very small at both time periods (median 0 minutes/day at baseline and 0.1 minutes at follow-up). Sedentary time significantly declined during the postpartum period when defined as <100 counts/minute (Table 3 and Online Figure 3). Overall, approximately two-thirds of the women's time was sedentary at baseline (median 63.6% to 71.4%), and this proportion decreased over the 10-month period (median 62.5% to 66.7%).

Discussion

We examined physical activity and sedentary behavior during two time points in the postpartum period for women who were initially overweight or obese using both self-reported and objective measures. The KPAS questionnaire provided rank-based scores for four physical activity modes. It is challenging to compare the results to samples that have not used the KPAS. Comparing to two samples of pregnant women (Chasan-Taber et al., 2007; Schmidt et al., 2006), our sample had relatively similar household/caregiving, active living, and sports scores, but lower occupational scores. During the 10-month follow-up period, household/caregiving and sport indices increased, as did the total score.

The self-reported increase in physical activity was supported by the accelerometer results, which showed small increases in moderate and MVPA, although the absolute amounts of change were small. These increases during the postpartum period were in agreement with the findings of another study of postpartum women that included accelerometry-determined physical activity assessments (Evenson and Wen, 2010). However, the findings in our sample of overweight and obese women were lower than values obtained from the

aforementioned study of postpartum women, who achieved 17 minutes/day of MVPA at 3-months postpartum and 18 minutes/day of MVPA at 12-months postpartum, in contrast to our sample with only 6 to 8 minutes/day. Moreover, the absolute levels in our study were much lower than what was observed in a nationally representative sample from 2003–04, in which women 20 to 29 years achieved 24 minutes/day of MVPA and women 30 to 39 years achieved 21 minutes/day of MVPA (Troiano et al., 2008). While the accelerometer used in the two cited studies (Evenson and Wen, 2010; Troiano et al., 2008) was different from the one used in this study (ActiGraph vs. Actical), this difference did not fully account for the contrasting findings.

The 2008 US Guidelines for Americans recommend that healthy postpartum women who are not already highly active or doing vigorous-intensity physical activity should obtain at least 150 minutes of moderate intensity aerobic activity spread throughout the week (U.S. Department of Health and Human Services, 2008). At both time periods, most women fell far short of this recommendation. Moreover, for adults to obtain substantial health benefits, the guidelines also recommend at least 75 minutes of vigorous intensity physical activity or a combination of moderate and vigorous intensity activity (U.S. Department of Health and Human Services, 2008). The postpartum women in this study engaged in very little vigorous intensity activity.

Among the sample of overweight and obese postpartum women, approximately two-thirds of monitored time was spent in sedentary pursuits at both time periods, and we found a small decline in sedentary time at follow-up. Other studies of postpartum women have found large amounts of sedentary time (Durham et al., 2011) and small declines in sedentary time during the postpartum period (Evenson and Wen, 2010). This is of concern, given that others have found long-term risks of high levels of sedentary time, independent of physical activity (Beunza et al., 2007; Healy et al., 2008; Thorp et al., 2010).

In the US, postpartum medical care often ends around 6 weeks after delivery, and, assuming the woman attends the appointment, she may or may not receive advice on physical activity (Ferrari et al., 2010; Krans et al., 2005; Moran et al., 1997). Thus, postpartum women may not be aware of the benefits and importance of resuming physical activity. Many have noted that the postpartum period may be an opportune time to target interventions to engage more women in physical activity, especially with the high proportion of women retaining gestational weight or gaining further weight (Larson-Meyer, 2002; Siega-Riz et al., 2009). Results from qualitative studies have indicated numerous barriers to physical activity, including physical discomfort, parenting duties, tiredness, lack of time, not prioritizing health over other competing responsibilities, lack of spousal/partner support, social isolation, lack of childcare, family responsibilities, financial, neighborhood safety, and weather (Albright et al., 2005; Carter-Edwards et al., 2009; Chang et al., 2008; Evenson et al., 2009; Groth and David, 2008; Kieffer et al., 2002; Price et al., 2012; Setse et al., 2008; Thornton et al., 2006). These physical activity barriers should be addressed most generally, and specific additional barriers may be identified, in particular, for overweight and obese postpartum women to overcome (Chang et al., 2008). On a positive note, findings from qualitative studies also have indicated a number of enabling factors for physical activity that may enhance participation, including a focus on the benefits (i.e., stress relief, increased energy), weight loss, social support, and returning to work (often corresponding with child care provision) (Chang et al., 2008; Evenson et al., 2009; Groth and David, 2008; Price et al., 2012; Thornton et al., 2006).

Limitations and Strengths

The representativeness of the present sample was limited, as they constituted a small subsample from the initial sample of recruited women, thus increasing the likelihood of

selection and participation bias and potentially reducing the accuracy and generalizability of results. Women in the initial randomized trial were more likely to be married and better educated than women in the recruitment area (Ostbye et al., 2011). The analytic sample also included only those who attended both visits and therefore were more compliant with the study procedures. While this study focused only on overweight and obese postpartum women, this group is at high risk for future obesity complications.

These findings were based on a control group from a randomized controlled behavioral intervention trial among postpartum women who had another child aged three to five years, primarily targeting weight maintenance in children of healthy weight and weight reduction in overweight children. This contrasted with studies of observational cohorts which had no intervention. Thus, our study may have a stronger social desirability bias, as women recruited into an intervention study may be more motivated and behave differently than women enrolled in a cohort study.

We also cannot rule out the potential for reactivity, such as changing behavior due to wearing the accelerometer and completing multiple measures of physical activity. Cutpoints to define various intensity levels of physical activity were only an estimate. For example, for sedentary time we used a cutpoint of <=50 counts/minute and <100 counts/minute (Oliver et al., 2010; Wong et al., 2011). Disagreement on this definition is apparent in the literature, as other studies have suggested 0 or <=20 counts/minute (Oliver et al., 2010) or <=35 counts/15-seconds for sedentary time (Crouter et al., 2011). Similarly, for this age group, other moderate, vigorous, or MVPA cutpoints have been used (Giffuni et al., 2012; Heil, 2006; Welk et al., 2004). For this reason, we also reported total counts that were not affected by cutpoint definitions. The use of cutpoints may decline in the future as methods are developed to analyze raw, continuous accelerometer data (Staudenmayer et al., 2009).

In the 2003–04 NHANES data, 60% of women 20 to 39 years achieved at least 4 of 7 valid days (>=10 hours/day) of wear time (Troiano et al., 2008). Our minimal criterion for wear time was less stringent, defined as at least 3 of 7 valid days (including 1 weekend day and 2 week-days; >=6 hours/day) of wear time. While all but three women in the cohort exceeded this minimal criterion, it was likely that sedentary time may have been even higher with longer wear times.

Moderate or vigorous physical activity could have also been missed when the accelerometer was not being worn, and because the monitor had to be removed when in the water, water activities (e.g., swimming, water aerobics) were missed. However, the questionnaire would have captured these activities. For this reason, we controlled for wear time in the longitudinal analyses of the accelerometer. As accelerometer technology develops to be less intrusive, wear time and compliance may improve. Notable strengths of this study included measurement of physical activity using both self-reported and objective assessments at two time points, and adjustment for important covariates.

Conclusion

Among our sample of overweight and obese postpartum women, the amount of MVPA was limited and improved only modestly 10-months after the first measurement. In contrast, approximately two-thirds of the monitored day was spent in sedentary time, which was reduced 10 months later. Most women in our sample did not meet recommendations for physical activity, such as from ACOG (ACOG, 2002) or the US government (U.S. Department of Health and Human Services, 2008). More intensive interventions are needed to help overweight and obese women integrate physical activity and reduce sedentary time after the birth of a baby.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

ACOG. Exercise during pregnancy and the postpartum period. ACOG Committee Opinion No. 267. Obstet Gynecol. 2002; 99:171–173. [PubMed: 11777528]

Ainsworth B, Haskell W, Whitt M, Irwin M, Swartz A, Strath S, O'Brien W, Bassett D Jr, Schmitz K, Emplaincourt P, Jacobs D Jr, Leon A. Compendium of physical activities: an update of activity codes and MET intensities. Med Sci Sport Exer. 2000a; 32:S498–S516.

Ainsworth B, Sternfeld B, Richardson M, Jackson K. Evaluation of the Kaiser Physical Activity Survey in women. Med Sci Sports Exerc. 2000b; 32:1327–1338. [PubMed: 10912901]

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; 42:95–110. [PubMed: 16901890]

Amorim A, Linne Y, Lourenco P. Diet or exercise, or both, for weight reduction in women after childbirth (Review). Cochrane Database of Systematic Reviews. 2007a; 3:Art. No. CD005627. 1–32.10.1002/14651858.CD005627.pub2

Amorim AR, Rossner S, Neovius M, Lourenco PM, Linne Y. Does excess pregnancy weight gain constitute a major risk for increasing long-term BMI? Obesity. 2007b; 15:1278–1286. [PubMed: 17495204]

Baecke J, Burema J, Frijters J, et al. Obesity in young Dutch adults, I: socio-demographic variables and body mass index. Intl J Obes. 1983; 7:1–12.

Beunza JJ, Martinez-Gonzalez MA, Ebrahim S, Bes-Rastrollo M, Nunez J, Martinez JA, Alonso A. Sedentary behaviors and the risk of incident hypertension: the SUN Cohort. Am J Hypertens. 2007; 20:1156–1162. [PubMed: 17954361]

Borodulin K, Evenson K, Herring A. Physical activity patterns during pregnancy through postpartum. BMC Womens Health. 2009; 9(32):1–7. Available at http://www.biomedcentral.com/1472-6874/1479/1432. [PubMed: 19178703]

Carter-Edwards L, Ostbye T, Bastian LA, Yarnall K, Krause KM, Simmons TJ. Barriers to adopting a healthy lifestyle: insight from postpartum women. BMC Res Notes. 2009; 2:161. [PubMed: 19686601]

Chang MW, Nitzke S, Guilford E, Adair CH, Hazard DL. Motivators and barriers to healthful eating and physical activity among low-income overweight and obese mothers. J Am Diet Assoc. 2008; 108:1023–1028. [PubMed: 18502238]

Chasan-Taber L, Schmidt MD, Pekow P, Sternfeld B, Manson J, Markenson G. Correlates of physical activity in pregnancy among Latina women. Maternal Child Health J. 2007; 11:353–363.

Colley R, Garriguet D, Janssen I, Craig C, Clarke J, Tremblay M. Physical activity of Canadian adults: Accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. Statistics Canada no. 82–003-XPE. Health Reports. 2011; 22:7–14. [PubMed: 21510585]

Corder K, Brage S, Ekelund E. Accelerometers and pedometers: methodology and clinical application. Curr Opin Clin Nutr Metab Care. 2007; 10:597–603. [PubMed: 17693743]

Crouter SE, Dellavalle DM, Horton M, Haas JD, Frongillo EA, Bassett DR Jr. Validity of the Actical for estimating free-living physical activity. Eur J Appl Physiol. 2011; 111:1381–1389. [PubMed: 21153659]

Durham HA, Morey MC, Lovelady CA, Namenek Brouwer RJ, Krause KM, Ostbye T. Postpartum physical activity in overweight and obese women. J Phys Act Health. 2011; 8:988–993. [PubMed: 21885890]

Esliger D, Tremblay M. Technical reliability assessment of three accelerometer models in a mechanical setup. Med Sci Sports Exerc. 2006; 38:2173–2181. [PubMed: 17146326]

Evenson K, Chasan-Taber L, Symons Downs D, Pearce E. Review of self-reported physical activity assessments for pregnancy: Summary of the evidence for validity and reliability. Paediatr Perinat Epidemiol. 2012; 26:479–494. [PubMed: 22882792]

Evenson K, McGinn A. Test-retest reliability of adult surveillance measures for physical activity and inactivity. Am J Prev Med. 2005; 28:470–478. [PubMed: 15894151]

Evenson K, Wen F. Measuring physical activity in pregnant women using a structured one-week recall questionnaire: evidence for validity and reliability. Intl J Behavioral Nutr Phys Act. 2010; 7:21. Available at http://www.ijbnpa.org/content/27/21/21.

Evenson KR, Aytur SA, Borodulin K. Physical activity beliefs, barriers, and enablers among postpartum women. J Women Health. 2009; 18:1925–1934.

Ferrari R, Siega-Riz A, Evenson K, Moos M, Melvin C, Herring A. Provider advice about weight loss and physical activity in the postpartum period. J Women Health. 2010; 19:397–406.

Giffuni J, McMurray R, Schwartz T, Berry D. Actical accelerometry cut-points for quantifying levels of exertion: Comparing normal and overweight adults. Intl J Exercise Sci. 2012:170–182.

Groth SW, David T. New mothers' views of weight and exercise. MCN Am J Matern Child Nurs. 2008; 33:364–370. [PubMed: 18997572]

Gunderson E, Abrams B. Epidemiology of gestational weight gain and body weight changes after pregnancy. Epidemiol Rev. 2000; 22:261–274. [PubMed: 11218377]

Healy GN, Wijndaele K, Dunstan DW, Shaw JE, Salmon J, Zimmet PZ, Owen N. Objectively measured sedentary time, physical activity, and metabolic risk: the Australian Diabetes, Obesity and Lifestyle Study (AusDiab). Diabetes Care. 2008; 31:369–371. [PubMed: 18000181]

Heil DP. Predicting activity energy expenditure using the Actical activity monitor. Res Q Exerc Sport. 2006; 77:64–80. [PubMed: 16646354]

Institute of Medicine. Committee on Nutritional Status During Pregnancy and Lactation, Food and Nutrition Board. National Academy Press; Washington D.C: 1990. Nutrition during pregnancy: Part I, Weight gain; Part II Nutrient supplements.

Rasmussen, K.; Yaktine, A., editors. Institute of Medicine, National Research Council. Weight gain during pregnancy: Reexamining the guidelines. National Academies Press; Washington, D.C: 2009.

Kieffer E, Willis S, Arellano N, Guzman R. Perspectives of pregnant and postpartum Latino women on diabetes, physical activity, and health. Health Educ Behav. 2002; 29:542–556. [PubMed: 12238699]

Kinnunen T, Aittasalo M, Koponen P, Ojala K, Mansikkamaki K, Weiderpass E, Fogelholm M, Luoto R. Feasibility of a controlled trial aiming to prevent excessive pregnancy-related weight gain in primary health care. BMC Preg Childbirth. 2008; 8:1–8. available at http://www.biomedcentral.com/1471-2393/1478/1437.

Krans EE, Gearhart JG, Dubbert PM, Klar PM, Miller AL, Replogle WH. Pregnant women's beliefs and influences regarding exercise during pregnancy. J Mississippi State Med Assn. 2005; 46:67–73.

Larson-Meyer DE. Effect of postpartum exercise on mothers and their offspring: a review of the literature. Obes Res. 2002; 10:841–853. [PubMed: 12181395]

Liang K, Zeger S. Longitudinal data analysis using generalized linear models. Biometrika. 1986; 73:13–22.

Marshall S, Ramirez E. Reducing sedentary behavior: A new paradigm in physical activity promotion. AM J Lifestyle Med. 2011:1–13. Online February 16, 2011. 10.1177/1559827610395487

Moran C, Holt V, Martin D. What do women want to know after childbirth. Birth. 1997; 24:27–34. [PubMed: 9271964]

National Center for Health Statistics. Documentation, codebook, and frequencies. MEC exam component: physical activity monitor examination data. 2006. Accessed at http://www.cdc.gov/nchs/data/nhanes/nhanes_03_04/paxraw_c.pdf NHANES 2003–04

National Institutes of Health National Heart Lung Blood Institute. Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults: The evidence report. Obes Res. 1998; 6:S51–S209.

Oliver M, Schofield GM, Badland HM, Shepherd J. Utility of accelerometer thresholds for classifying sitting in office workers. Prev Med. 2010; 51:357–360. [PubMed: 20816693]

Ostbye T, Krause KM, Stroo M, Lovelady CA, Evenson KR, Peterson BL, Bastian LA, Swamy GK, West DG, Brouwer RJ, Zucker NL. Parent-focused change to prevent obesity in preschoolers: results from the KAN-DO study. Prev Med. 2012; 55:188–195. [PubMed: 22705016]

Ostbye T, Zucker NL, Krause KM, Lovelady CA, Evenson KR, Peterson BL, Bastian LA, Swamy GK, West DG, Brouwer RJ. Kids and adults now! Defeat Obesity (KAN-DO): rationale, design and baseline characteristics. Contemporary Clin Trial. 2011; 32:461–469.

Pfeiffer K, McIver K, Dowda M, Almeida M, Pate R. Validation and calibration of the Actical accelerometer in preschool children. Med Sci Sports Exerc. 2006; 38:152–157. [PubMed: 16394968]

Pivarnik JM, Chambliss H, Clapp J III, Dugan S, Hatch M, Lovelady C, Mottola MF, Williams M. Impact of physical activity during pregnancy and postpartum on chronic disease risk. Med Sci Sports Exerc. 2006; 38:989–1006. [PubMed: 16672855]

Price SN, McDonald J, Oken E, Haines J, Gillman MW, Taveras EM. Content analysis of motivational counseling calls targeting obesity-related behaviors among postpartum women. Maternal Child Health J. 2012; 16:439–447.

Puyau M, Adolph A, Vohra F, Butts N. Validation and calibration of physical activity monitors in children. Obesity Res. 2002; 10:150–157.

R Development Core Team. R: A language and environment for statistical computing. R Foundation for Statistical Computing; Vienna, Austria: 2010.

Rooney BL, Schauberger CW, Mathiason MA. Impact of perinatal weight change on long-term obesity and obesity-related illnesses. Obstet Gynecol. 2005; 106:1349–1356. [PubMed: 16319262]

Sampselle C, Seng J, Yeo S, Killion C, Oakley D. Physical activity and postpartum well-being. J Obstet Gynecol Neonatal Nurs. 1999; 28:41–49.

Schmidt MD, Freedson PS, Pekow P, Roberts D, Sternfeld B, Chasan-Taber L. Validation of the Kaiser Physical Activity Survey in pregnant women. Med Sci Sports Exerc. 2006; 38:42–50. [PubMed: 16394952]

Setse R, Grogan R, Cooper LA, Strobino D, Powe NR, Nicholson W. Weight loss programs for urban-based, postpartum African-American women: perceived barriers and preferred components. Maternal Child Health J. 2008; 12:119–127.

Siega-Riz AM, Viswanathan M, Moos MK, Deierlein A, Mumford S, Knaack J, Thieda P, Lux LJ, Lohr KN. A systematic review of outcomes of maternal weight gain according to the Institute of Medicine recommendations: birthweight, fetal growth, and postpartum weight retention. Am J Obstet Gynecol. 2009; 201:339 e331–314. [PubMed: 19788965]

Staudenmayer J, Pober D, Crouter S, Bassett D, Freedson P. An artificial neural network to estimate physical activity energy expenditure and identify physical activity type from an accelerometer. J Appl Physiol. 2009; 107:1300–1307. [PubMed: 19644028]

Sternfeld B, Ainsworth B, Quesenberry C Jr. Physical activity patterns in a diverse population of women. Prev Med. 1999; 28:313–323. [PubMed: 10072751]

Thornton P, Kieffer E, Salabarria-Pena Y, Odoms-Young A, Willis S, Kim H, Salinas M. Weight, diet, and physical activity-related beliefs and practices among pregnant and postpartum Latino women: the role of social support. Maternal Child Health J. 2006; 10:95–104.

Thorp AA, Healy GN, Owen N, Salmon J, Ball K, Shaw JE, Zimmet PZ, Dunstan DW. Deleterious associations of sitting time and television viewing time with cardiometabolic risk biomarkers: Australian Diabetes, Obesity and Lifestyle (AusDiab) study 2004–2005. Diabetes Care. 2010; 33:327–334. [PubMed: 19918003]

Troiano R, Berrigan D, Dodd K, Masse L, Tilert T, McDowell M. Physical activity in the United States measured by accelerometer. Med Sci Sports Exerc. 2008; 40:181–188. [PubMed: 18091006]

U.S. Department of Health and Human Services. ODPHP Publication No U0036. Washington, D.C: 2008. 2008 Physical Activity Guidelines for Americans; p. 1-61.Accessed at http://www.health.gov/paguidelines/

Viswanathan, M.; Siega-Riz, A.; Moos, M.; Deierlein, A.; Mumford, S.; Knaack, J.; Thieda, P.; Lux, L.; Lohr, K. Prepared by RTI International-University of North Carolina Evidence-based Practice Center under Contract No 290–02–0016. Agency for Healthcare Research and Quality (AHRQ); Rockville, MD: 2008. Outcomes of maternal weight gain, evidence report/technology assessment No. 168.

Welk G, Schaben J, Morrow J Jr. Reliability of accelerometry-based activity monitors: A generalizability study. Med Sci Sports Exerc. 2004; 36:1637–1645. [PubMed: 15354049]

Wong SL, Colley R, Connor Gorber S, Tremblay M. Actical accelerometer sedentary activity thresholds for adults. J Phys Act Health. 2011; 8:587–591. [PubMed: 21597132]

Zeger S, Liang K. Longitudinal data analysis for discrete and continuous outcomes. Biometrics. 1986; 42:121–130. [PubMed: 3719049]

Table 1

Descriptive characteristics of participants in the control arm of the KAN-DO Study (n=132)

	Baseline (2–7 months postpartum)		Follow-up (12–17 months postpartum)	
	n	%	n	%
Age in years				
<30	21	15.9	n/a	
30–35	66	50.0	n/a	
>=36	45	34.1	n/a	
Race/ethnicity				
Non-hispanic White	107	81.1	n/a	
Non-hispanic Black	20	15.2	n/a	
Other or Hispanic	5	3.8	n/a	
Education in years				
High school graduate or less	9	6.8	n/a	
Some college	25	18.9	n/a	
College degree	63	47.7	n/a	
Graduate school	35	26.5	n/a	
Parity				
2	91	68.9	n/a	
>=3	41	31.1	n/a	
Site				
Durham	91	68.9	n/a	
Greensboro	41	31.1	n/a	
Marital status				
Not married	8	6.1	10	7.6
Married	124	93.9	122	92.4
General health				
Excellent	10	7.6	17	13.0
Very Good	47	35.6	52	39.7
Good	67	50.8	54	41.2
Fair/Poor	8	6.1	8	6.1
Body mass index (kg/m^2)				
Normal weight	0	0.0	7	5.3
Overweight (25.0 to <30.0)	55	41.7	53	40.5
Obese class I (30.0–34.9)	41	31.1	33	25.2
Obese class II (35.0–39.9)	26	19.7	30	22.9
Obese class III (>=40.0)	10	7.6	8	6.1
missing			1	
Working status				
Not employed	65	49.2	56	42.8
Employed (full- or part-time)	67	50.8	75	57.3

Table 2

Self-reported physical activity at baseline and follow-up among control participants of the KAN-DO Study (n=132)

	Baseline (2–7 months postpartum)			Follow-up (12–17 months postpartum)			p value*
	Mean	Median	IQR	Mean	Median	IQR	
KPAS*							
Household / caregiving index	2.6	2.5	2.4–2.7	2.6	2.6	2.4–2.9	0.005
Occupational index	1.8	1.4	1.0–2.6	1.9	1.9	1.0–2.7	0.14
** Occupational index among workers only (n=81)	2.4	2.3	1.7–3.1	2.5	2.4	1.9–3.3	0.69
Sports index	2.3	2.0	1.3–3.3	2.5	2.5	1.5–3.5	0.007
*** Sports index among those who exercise only (n=107)	2.5	2.3	1.5–3.5	2.8	2.8	2.0–3.8	0.1
Active living index	2.3	2.3	2.0–2.8	2.4	2.5	2.0–2.8	0.07
Total activity	9.0	8.8	7.6–10.3	9.6	9.5	8.2–11.0	0.0003
Weighted total activity	9.4	9.3	8.7–10.2	9.8	9.7	8.8–10.9	0.0001
	n	%		n	%		
Watch TV or videos							0.002
<1 hour/week	4.0	3.0		6.0	4.6		
>=1 hour/week but <1 hour/day	19.0	14.4		27.0	20.5		
>=1 hour/day but <2 hours/day	44.0	33.3		48.0	36.4		
>=2 hours/day but <4 hours/day	45.0	34.1		41.0	31.1		
>=4 hours/day	20.0	15.2		10.0	7.6		
Use a computer or play computer games outside of work							0.92
<1 hour/week	13.0	9.9		13.0	9.9		
>=1 hour/week but <1 hour/day	46.0	34.9		47.0	35.6		
>=1 hour/day but <2 hours/day	42.0	31.8		43.0	32.6		
>=2 hours/day but <4 hours/day	23.0	17.4		19.0	14.4		
>=4 hours/day	8.0	6.1		10.0	7.6		

* p-value is based on the cohort from GEE models adjusted for age (at baseline), education (at baseline, high school or less/some college, college graduate or more), race/ethnicity (non-Hispanic White, Other), site (Durham, Greensboro), marital status (time varying: married, not married), general health (time varying: excellent/very good, good, fair/poor), work status (time varying: employed full-time, employed part-time, not employed), and body mass index (time varying: continuous)

** among those who worked at either baseline or follow-up.

***among those who reported any sports or exercises at either baseline or follow-up.

GEE=generalized estimating equation; IQR=interquartile range; KPAS=Kaiser Physical Activity Survey; MET=metabolic equivalent

Note: The household/caregiving, occupational, sports, and active living indices ranged from 1 to 5, with the higher number indicating more physical activity from those modes.

Table 3

Accelerometry at baseline and follow-up among the control participants of the KAN-DO Study (n=132)

	Baseline (2–7 months postpartum)			Follow-up (12–17 months postpartum)			p value*
	Mean	Median	IQR	Mean	Median	IQR	
Counts/minute	138	133.3	102.8–166.2	171	154.4	120.2–195.3	<.0001
Absolute values (minutes per day):							
Moderate (1535–3959 counts/min)	7.2	6.2	2.3–10.2	10.3	8.2	4.0–14.2	<.0001
Vigorous (>=3960 counts/min)	1.2	0.0	0.0–0.5	2.3	0.1	0.0–1.3	0.085
Moderate to vigorous physical activity (>=1535 counts/min)	8.4	6.9	2.3–11.3	12.5	8.8	4.1–17.9	<.0001
Light (51-1534 counts/min)	272.3	265.9	222.5–318.0	275.3	275.4	223.9–319.4	0.0001
Light (101-1534 counts/min)	212.4	210.8	170.9–251.5	236.9	233.6	190.0–283.1	<.0001
Sedentary behavior (<=50 counts/min)	503.4	494.4	455.4–550.5	488.3	480.0	422.9–535.1	0.41
Sedentary behavior (<100 counts/min)	563.6	557.6	512.1–615.4	508.1	508.5	455.7–556.0	<.0001
Relative values (% time per day):							
Moderate (1535-3959 counts/min)	0.9	0.8	0.3–1.3	1.3	1.1	0.5–1.8	<.0001
Vigorous (>=3960 counts/min)	0.1	0.0	0.0–0.1	0.3	0.0	0.0–0.2	0.03
Moderate to vigorous physical activity (>=1535 counts/min)	1.0	0.9	0.3–1.5	1.6	1.1	0.5–2.3	<.0001
Light (51-1534 counts/min)	34.2	34.3	29.4–38.9	35.9	36.2	30.8–41.1	0.0001
Light (101-1534 counts/min)	26.7	26.6	22.6–30.5	30.9	30.9	26.2–35.3	<.0001
Sedentary behavior (<=50 counts/min)	63.7	63.6	58.7–69.2	63.5	62.5	56.5–71.0	0.62
Sedentary behavior (<100 counts/min)	71.2	71.4	67.2–75.7	66.2	66.7	61.4–70.8	<.0001

*p-value is based on the cohort from GEE models adjusted for age (at baseline), education (at baseline, high school or less/some college, college graduate or more), race/ethnicity (non-Hispanic White, Other), site (Durham, Greensboro), marital status (time varying: married, not married), general health (time varying: excellent/very good, good, fair/poor), work status (time varying: employed full time, employed part-time, not employed), body mass index (time varying: continuous), and average total daily Actical wearing hours (time varying)

GEE=general estimating equation; IQR = interquartile range