Development and Validation of the Updated Pregnancy Physical Activity Questionnaire

Development and Validation of the Updated Pregnancy Physical Activity Questionnaire

A Dissertation Presented

By

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DEDICATION

To my parents, Jea and Mihi Park, who immigrated to the U.S. with little in their pockets and a lot of hope.

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ABSTRACT

DEVELOPMENT AND VALIDATION OF THE UPDATED PREGNANCY PHYSICAL ACTIVITY QUESTIONNAIRE

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Physical inactivity and sedentary behavior during pregnancy are significant public health concerns as it can increase the risk of excessive gestational weight gain, gestational diabetes mellitus, pre-eclampsia, and preterm birth. Consequently, the American College of Obstetricians and Gynecologists and the 2018 Physical Activity Guidelines Advisory Committee Scientific Report have highlighted the importance of defining specific physical activity (PA) measures. The Physical Activity Questionnaire (PPAQ) continues to be the most widely used self-reported assessment tool during pregnancy as it was validated for use during pregnancy and includes measures of PA intensity, domain, and sedentary behavior. However, it has almost been two decades

since the development of the original PPAQ. Since then, there have been significant changes to human behavior and advances in PA measurement tools. For each dissertation chapter, I used data from the PPAQ Validation Study (2019-2022, R21HD094565-01A1), a prospective cohort study of 50 eligible pregnant women enrolled in early pregnancy.

Chapter 1 developed the updated PPAQ, and then determined its validity and reliability using an accelerometer and wearable camera in a free-living setting. The PPAQ is a reliable instrument and a valid measure of a broad range of PA during pregnancy.

Chapter 2 determined the impact of the COVID-19 pandemic on PA and sedentary behavior during pregnancy using the PPAQ and the accelerometer using a cross-sectional and prospective study design. During pregnancy, significant increases in sedentary behavior and household/caregiving and decreases in transportation PA were observed after the pandemic.

Chapter 3 developed and evaluated the internal and external validity of the PPAQ-Short Form (PPAQ-SF). The internal validity of the PPAQ-SF was evaluated using the updated PPAQ and accelerometer within the PPAQ Study. The external validity of the PPAQ-SF was evaluated in an independent sample (Proyecto Mama, N=222) using the updated and original PPAQ. The PPAQ-SF produced sufficient estimates of moderate-to-vigorous-physical activity (MVPA) compared to the updated and original PPAQ.

In conclusion, the Updated PPAQ can be used as a valid and reliable measure of pregnancy PA and the PPAQ-SF can be an efficient tool to estimate MVPA.

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CHAPTER

I. UPDATE AND VALIDATION OF THE PREGNANCY PHYSICAL ACTIVITY QUESTIONNAIRE

ABSTRACT

This study aimed to update and validate the Pregnancy Physical Activity Questionnaire (PPAQ) using an accelerometer (criterion for activity intensity) and wearable camera (criterion for activity type) in a free-living setting. A prospective cohort of 50 eligible pregnant women were enrolled in early pregnancy (mean 14.9 wks gestation). In early, mid, and late pregnancy, participants completed the updated PPAQ and wore an accelerometer (ActiGraph GT3X-BT) on the non-dominant wrist and a wearable camera (Autographer) for 7 days. At the end of the 7-day period, participants repeated the PPAQ. Spearman correlations between the PPAQ and accelerometer data ranged from 0.37-0.44 for total activity, 0.17-0.53 for moderate-to-vigorous intensity activity, 0.19-0.42 for light intensity activity, and 0.23-0.45 for sedentary behavior. Spearman correlations between the PPAQ and wearable camera data ranged from 0.52-0.70 for sports/exercise, 0.26-0.30 for occupational activity, 0.03-0.29 for household/caregiving activity and -0.09-0.20 for transportation activity. Reproducibility scores ranged from 0.70-0.92 for moderate-to-vigorous intensity activity and 0.79-0.91 for sports/exercise, and were comparable across other domains of PA. The PPAQ is a reliable instrument and a valid measure of a broad range of physical activities during pregnancy.

INTRODUCTION

The American College of Obstetricians and Gynecologists (ACOG) recommends regular physical activity (PA) during pregnancy due to its positive impact on physical fitness, weight management, and psychologic well-being. Physical inactivity during pregnancy is implicated in excessive gestational weight gain, gestational diabetes mellitus (GDM), pre-eclampsia, and preterm birth (1) and consequently is an urgent public health concern. In light of these observations, ACOG has called for additional research to clarify the optimal type, frequency, and intensity of exercise during pregnancy (1). Similarly, the 2018 Physical Activity Guidelines Advisory Committee Scientific Report(2) concluded that there are limited data concerning the dose–response relationships between type of PA and important pregnancy outcomes such as GDM and preeclampsia (3).

Self-reported assessments of PA continue to be the most common method for surveillance, epidemiological, and intervention studies of pregnancy PA. Reasons for the preferred usage of self-reported assessment methods involve observing lower compliance with activity monitor wear during pregnancy, the need for a measure of long-term or habitual activity patterns, large sample sizes, and the participant burden and high cost of assessing PA with wearable activity monitors (4, 5).

However, a critical knowledge gap remains in how best to quantify PA during pregnancy using commonly administered self-report tools. According to a recent review, evidence concerning the measurement properties of pregnancy PA questionnaires is limited and predominantly of lower quality (4). Many of these tools do not measure light intensity and sedentary behavior, and do not include contemporary sedentary activities (e.g., 'screen-time' via smart phones, tablets; time texting/on social media) (4).

The Pregnancy Physical Activity Questionnaire (PPAQ) (6) was developed in 2004 as the first validated PA questionnaire for pregnancy and has since become one of the most widely used instruments for assessing pregnancy PA (4). The PPAQ has been translated and validated for use in over 13 languages and used by researchers in approximately 70 countries. In the U.S., the PPAQ is being used in the Environmental Influences on Child Health Outcomes (ECHO) study, an NIH-funded population-based longitudinal birth cohort across 35 centers (7).

Over the past two decades, advances have been made in accelerometer and direct observation (e.g., wearable cameras) calibration and validation methods that can be used to determine the validity of self-reported PA and sedentary behavior in free-living settings. Although these tools are not the gold-standard for measuring PA, they help to provide a more comprehensive understanding of the context and features of free-living behavior. Therefore, our first goal was to update the PPAQ to include contemporary sedentary behaviors and updated MET values measured in pregnancy and the general population. Our second goal was to evaluate the reproducibility and validity of the updated PPAQ in a free-living setting using a novel validation system of a wrist-worn accelerometer for PA intensity and a wearable camera for PA type. We hypothesized that the updated PPAQ measures of PA intensity (sedentary, light, moderate-to-vigorous) and type (i.e., household/caregiving, occupational, sports/exercise, and transportation) would be comparable to the objective measures.

METHODS

Study Population

Participants (N=50) were recruited in early pregnancy via flyers at prenatal care centers, health clinics, and advertisements in local papers and using paid Facebook™ advertisements. Enrollment commenced in March 2019 and follow-up continued until January 2021. Participants were screened at recruitment with a single item rating scale for level of PA (8) to ensure they represented a range of people who regularly undertake a diverse set of activities of various intensities (e.g., low active to high active participants). Women were considered ineligible for the study if they had any of the following characteristics: 1) >20 weeks gestation, 2) under 16 or over 40 years of age, 3) pregnant with twins or triplets as this is often accompanied by clinically prescribed PA restrictions, 4) musculoskeletal issues that limited ambulation, 5) chronic disease (e.g., diabetes requiring insulin, hypertension or heart disease requiring medication, chronic renal disease, emphysema) or life-threatening illnesses, or 6) lack of a telephone.

Each participant read and signed a written informed consent approved by the Institutional Review Board of the University of Massachusetts, Amherst.

Study Design

A total of three 7-day assessments were conducted in early, mid, and late pregnancy (Figure 1). At the beginning of each assessment period, the updated PPAQ (Appendix 1.1) was interviewer-administered in-person (n=40) or virtually (n=10) and participants were instructed how to wear the accelerometer and wearable camera over the following 7-days in a free-living setting. Interviewers had undergone training to correctly administer the updated PPAQ to avoid probing certain questions or responses and look out for inconsistencies in a participants' responses (e.g., overreporting on all questions). Participants were provided with a wear log to record times that the monitors were not worn (e.g., during sleep or water-based activities). Video demonstrations of how to correctly wear the monitors and links to paper-based materials were provided on a study website. At the end of each assessment period, the updated PPAQ was repeated.

Physical Activity Assessment

Pregnancy Physical Activity Questionnaire (PPAQ)

The PPAQ is a semi-quantitative instrument that measures duration and intensity of time spent in household/caregiving, occupational, transportation, and sports/exercise activities (6). Prior leisure-time sedentary behavior questions on the original PPAQ (questions #11, 12, 13) had been limited to sitting and using a computer, writing/reading/talking on the telephone while not at work, or watching TV or a video. For the purposes of the current study, we updated the PPAQ to capture the full range of contemporary sedentary behavior (e.g., 'screen-time' via smart phones and tablets; time spent texting and on social media) and clarified that the activities were done while sitting. The new wording changes were consistent with recent questions used to measure sedentary behavior in nonpregnant populations (Table 1.1) (9-11).

To classify time spent in categories of PA intensity (i.e., sedentary, light, moderate-to-vigorous), we used metabolic equivalent of task (MET) values from pregnancy studies (12, 13), (n=8 activities) and, when not available (n=25 activities), the 2011 Compendium of Physical Activity (14) MET values (Table 1.2). The selection of MET values was also guided by ACT24 (Activities Collected over Time over 24-hours), a PA assessment tool made available by the National Cancer Institute (15) and widely used for research purposes (16). For walking to go places (question #20) and walking for fun/exercise (question #23), MET values were also informed by the recent findings of Marshal et al. that pregnant women accumulate most of their walking time at cadences <50 steps/minute (17) which, according to McAvoy et al. qualifies as light intensity ambulation (18). Overall, these MET value updates led to a change in MET value for 22 of the 31 close-ended questions and a change in intensity category for four of these activities (questions # 9, 11, 14, 27).

We multiplied the number of hours spent in each reported activity by its MET level using standard cut points to define activity by intensity: sedentary (1- ≤1.5 METs), light (>1.5–<3 METs), moderate-to-vigorous (≥ 3 METs) (19) and by type: sports/exercise, household/caregiving, occupational, and transportation. Coding instructions for the updated PPAQ are presented in Appendix 1.2. We identified outliers of PPAQ assessments and excluded those that reported >20 hrs/day of total activity (n=2 assessments) or >85% hrs/day of non-sedentary activities (n=3 assessments). This decision was justified by the increased rates of sleep disturbances during pregnancy (20, 21).

Accelerometer

Participants were instructed to wear the ActiGraph GT3X-BT (Pensacola, FL) on the non-dominant wrist for three 7 day periods (early, middle, and late pregnancy) except during sleep or water-based activities. Accelerometer devices were initialized to collect data at 80 Hz using ActiLife 6 software (version 6.13.1). After each assessment period, data were exported as raw and 1-second epoch files.

Wear time was based on self-report or, if missing, using the Choi wear time algorithm (22). Assessment periods with at least 10 hours of wear time for at least 4 days were included (23). For the primary analysis, time and frequency-domain features were computed from raw acceleration data in 15-second non-overlapping epochs and used in the Staudenmayer 2015 MET intensity random forest method, a previously trained random forest models to classify accelerometer data according to intensity (24). Since there are limited methods for processing physical activity data from wrist-worn accelerometer devices, we used an additional method developed by Hildebrand et al. (25) for raw acceleration in a secondary analysis. Hildebrand et al. evaluated the associations between the wrist worn ActiGraph and indirect calorimetry to develop prediction equations to estimate PA intensity. The prediction equations predicted 93-96% of the light/sedentary values, 54-59% of the moderate values, and 89-92% of the vigorous values were correctly classified in adults (25). We calculated MET-hours/day and % wear-time hours/day spent in each intensity category for the Staudenmayer and Hildebrand et al method. Lastly, we calculated average counts per minute (CPM) for each assessment period.

Wearable Camera

Participants were instructed to wear an Autographer (OMG Life) on either a lanyard, clip, or chest harness during the 7-day period between PPAQ administrations. The Autographer is used to categorize the type and context of accelerometer-identified episodes of PA across the entire PA spectrum including sedentary and non-sedentary activities within the full range of household/caregiving, occupational, sports/exercise, and transportation activities.

Participants were instructed that they were free to remove the camera or turn the camera off at any time to protect their privacy and those of others. They were also instructed to deactivate the camera in a pre-specified list of places (e.g., restrooms, changing rooms, doctor's office, ATM or bank, and wherever requested by others). Participants were encouraged to seek verbal permission from family members, cohabitants, workplace managers, and others when wearing the camera and were provided with a prepared statement to read to anyone with concerns. After each assessment time period, participants were given the opportunity to delete any images prior to review by research staff.

The wearable camera records up to 4000 'wearer's perspective' images per day (at approximately 15 second intervals; median capture rates is 3 images/minute). A minimum of 600 images/day was used as the criteria for inclusion in analyses. Episode images, in addition to the surrounding contextual images before and after the PA bout, provide visual clues as to the activity type. We aggregated images into counts of activity durations and sequences using established procedures.(26, 27) PA episodes were annotated according to type and subtype using the 21 categories and 821 subcategories from the 2011 Compendium.(14) We normalized camera data by classified recognizable hours of wear time by removing images that were too blurry or blank. We then calculated % wear-time hours/day spent in each activity type (i. e., household/caregiving, occupational, sports/exercise, transportation).

Covariates

At the baseline assessment, information on age, first day of last menstrual period, expected delivery date, parity, and race/ethnicity were collected via self-report and height and weight were measured using a stadiometer and a calibrated scale. For virtual assessments, height and weight information was collected via self-report. Early pregnancy body mass index (BMI) was calculated as kg/m^2. Gestational age (weeks) was calculated using first day of last menstrual period and/or expected delivery date.

Statistical Analyses

Validity of the Updated PPAQ with the Accelerometer and Wearable Camera

We calculated the mean and standard deviation for variables derived from the PPAQ, accelerometer, and wearable camera. To evaluate the validity of the PPAQ, we calculated Spearman correlation coefficients (not normally distributed data) between the PPAQ (the mean of the two assessments) compared to weekly summaries of the PA measurements from the accelerometer and wearable camera (28), within each measurement period. Pre and post assessments of the PPAQ were compared to the ActiGraph and Autographer and did not produce differing results compared to the mean of the two PPAQ assessments. Based on the Qualitative Attributes and Measurement Properties of Physical Activity Questionnaires (QAPAQ) (29) and the systematic review of pregnancy PA questionnaires by Sattler et al. (4), validity scores for correlations with accelerometers of ≥0.4 were deemed sufficiently valid. A cutoff of ≥0.4 was considered sufficient from prior systematic reviews (30-32) and *a priori* defined correlations. We inspected scatterplots as graphical displays of these relationships. We also calculated limits of agreement (LOA)(33) for each assessment defined as the mean change in scores of the pre-post measurement of the PPAQ versus the accelerometer and wearable camera (±1.96 * SD of this change; SD change) to assess absolute validity.

Reproducibility of the Updated PPAQ

To describe the reproducibility of the PPAQ measures, intraclass correlation coefficients were calculated as the proportion of total variance explained by between-subject variance within each measurement period. Based on QAPAQ (29) and the systematic review by Sattler et al. (4), reproducibility scores for intraclass correlations of >0.70 were deemed sufficiently reliable. Between and within subject variance components were estimated using log transformed activity data (used to reduce skewness/non-normality in data) assuming a compound symmetric covariance structure (34).

Variance Components

Within and between individual variance components for the entire PPAQ sample were calculated to assess the ability of the updated PPAQ to detect clinically significant change in total MET hrs/day and total moderate-to-vigorous hrs/day.

Sensitivity Analyses

We conducted several sensitivity analyses. Firstly, we compared total PA between the assessments conducted in colder versus warmer seasons for the PPAQ and the accelerometer. Additionally, we evaluated whether the validity of findings differed according to wear time for the wearable camera by comparing participants with < 4 and > 4 hours of wear time per day. Lastly, we evaluated the validity of the PPAQ by whether the baseline assessment was conducted in-person versus virtually.

RESULTS

We excluded four participants for not meeting PPAQ assessment requirement and one participant for not meeting the minimum wear time criteria for the accelerometer. A total of six participants did not contribute to the mid (n=3) or late pregnancy (n=3) assessments; however, due to our use of repeated measures, these participants contributed to the analyses for which they had complete data. Throughout the study, complete data for the accelerometer and the wearable camera ranged from 90-98% and 82-94%, respectively. Average wear time was 12.80 (SD 1.63) hrs/day for the accelerometer and 3.48 (SD 2.17) hrs/day for the wearable camera.

In the total sample (N=50), participants were on average 32.9 (SD 4.2) years, predominantly non-Hispanic white (80%), and nulliparous (22 [44%]) with an early pregnancy BMI of 25.1 (SD 3.6) kg/m^2 at a mean of 14.9 weeks gestation (Table 1.3). At baseline (early pregnancy), the mean MET-hrs/day of total PA were 20.73 [SD 4.96] according to the PPAQ and 21.5 [SD 9.15] according to the accelerometer (Table 1.4).

Total PA (mean MET-hrs/day) were comparable between the PPAQ and the accelerometer for overall pregnancy (20.17 vs. 21.88 MET hrs/day for PPAQ and accelerometer, respectively) and within each pregnancy assessment (Table 1.4). The majority of MET-hrs/day were spent in household/caregiving activities followed by occupational activities, transportation, and sports/exercise according to both PPAQ and wearable camera across all time periods. According to the PPAQ, a greater percentage of time was spent in occupational activity than classified by the wearable camera. This may have occurred due to participant instructions to remove the wearable camera during sensitive work settings. Compared to the accelerometer, the PPAQ overestimated sedentary MET-hrs/day and underestimated light and moderate-to-vigorous intensity MET-hrs/day across all sessions. The PPAQ and accelerometer produced consistently higher percentage of time spent in sedentary behavior compared to other intensity categories. Findings were comparable when Hildebrand et al. (25) accelerometer cutpoints were used (Table 1.5).

Validity

Correlations between the PPAQ and wearable camera were highest for sports/exercise PA (0.70 in early pregnancy to 0.52 in late pregnancy) followed by occupational activity (0.30 in early pregnancy to 0.26 in late pregnancy) (Table 1.6). While correlations were low for household/caregiving activity in early pregnancy (r=0.03), they increased to 0.29 in late pregnancy, respectively. Correlations for transportation activity were lower ranging from -0.09 to 0.20. LOA scores, as a measure of absolute validity (Table 1.7), showed significant differences in only household/caregiving measures between the PPAQ versus the wearable camera overall (LOA: -0.83, -0.07) and throughout pregnancy (early pregnancy LOA: -0.83, -0.07; mid pregnancy LOA: -0.86, -0.04); late pregnancy LOA: -0.83, -0.09).

Correlations between the PPAQ and accelerometer were highest for sedentary behavior (ranging from 0.23-0.45), total activity (ranging from 0.37-0.44) and light-intensity activity (ranging from 0.19-0.42) across all pregnancy time periods (Table 1.6). Correlations for moderate-to-vigorous intensity activity ranged from 0.17 in early and late pregnancy to 0.53 in mid pregnancy. Overall, correlations tended to be highest in early pregnancy. Findings were comparable when Hildebrand et al.(25) cutpoints were used (Table 1.5).

Reproducibility

Reproducibility between the two administrations of the PPAQ for total PA MET-hrs/day ranged from 0.55 to 0.83 (Table 1.8). In terms of activity type, reproducibility was highest for sports/exercise (0.79-0.91), household/caregiving (0.71-0.92), and occupational activity (0.70-0.91) followed by transportation (0.42-0.67). In terms of activity intensity, reproducibility was highest for moderate-to-vigorous activity (0.70-0.92) followed by light intensity activity (0.75-0.87) and sedentary behavior (0.63-0.82). The reproducibility of the ActiGraph and Autographer, respectively, have been previously published (35, 36).

Variance Components

To assess the ability of the updated PPAQ to detect clinically significant change in total MET hrs/day and total moderate-to-vigorous hrs/day, we calculated the within and between individual variance components. For total MET hrs/day, the between-person SD was 4.59 MET hrs/day and the within-person SD was 3.29 MET hrs/day. For total moderate-to-vigorous hrs/week the between-person SD was 3.29 hrs/week and the within-person standard deviation was 3.84 hrs/week.

Sensitivity

When comparing those with <=4 hours vs > 4 hours of camera wear time, there were no significant differences in PPAQ-derived mean MET-hrs/day (150.90 [95%CI]: 135.80, 158.20 [<=4 hours/day] vs. 136.53 [95%CI]:127.99, 145.08 [>4 hours/day]) and correlations (0.27 [95%CI]: -0.01, 0.55 [<=4 hours/day] vs. .38 [95%CI]: 0.19, 0.56 [>4 hours/day]). Similarly, there was no significant difference in mean MET-hrs/day between participants who attended their baseline assessment visit in person versus virtually (F =

0.1508, p>0.05). Total PA (Mean MET-hrs/day) did not significantly differ across seasons ($F = 0.8776$, $p= 0.48$) for the PPAQ and ActiGraph.

DISCUSSION

In this study of the validity and reproducibility of the updated PPAQ in a free-living setting using novel validation techniques, we found that the PPAQ had sufficient validity ($r \geq 0.40$) detecting total PA, sedentary, light, and moderate-to-vigorous intensity activities compared to the accelerometer and in detecting sports/exercise PA compared to the wearable camera. We observed sufficient reproducibility ($r \geq 0.70$) for all intensities and types of physical activities with moderate to high reproducibility for total activity, intensity, and type of activities.

Our validity scores for moderate-to-vigorous intensity activity (ranging from 0.17-0.53) were slightly lower than the corresponding scores for sports/exercise activity (ranging from 0.52-0.70). This may be due to the fact that structured exercise is recalled more reliably than other activities such as household/caregiving activities (37). Indeed, sports/exercise makes up only a portion of moderate-to-vigorous PA on the PPAQ which also queries moderate intensity household/caregiving and occupational activities. This finding may also be due to differences in the validation tools for these domains (i.e., accelerometer for moderate-to-vigorous PA vs. wearable camera for sports/exercise).

Because context of PA was validated via the wearable camera, lower validity correlations may be due to the fact that participants did not feel comfortable wearing the camera or were asked to turn the camera off in public spaces (38). We observed the lowest validity scores for transportation activities (ranging from -0.09 to 0.20). This finding may be due to the ambiguity of transportation activities being classified as transportation of, for example, sports/exercise activity. However, based on the Physical Activity and Pregnancy Questionnaire, the only other pregnancy PA questionnaire which included transportation activity, the authors observed a weak correlation between walking for transportation and pregnancy weight gain (r= - 0.117, p= 0.015) (39). This may indicate that pregnant women are either less likely to participate in this type of behavior and/or that transportation activity may not be associated with adverse health outcomes during pregnancy. For populations in which transportation activities make up a larger proportion of total PA, the Transport and Physical Activity Questionnaire has observed fair reproducibility (ranging from 0.59 to 0.61) and validity (r=0.27 with moderate-to-vigorous PA) (40).

Our reproducibility findings for the updated PPAQ (ranging from 0.55 to 0.83 for total activity) were comparable to the original PPAQ (0.78) (6). Scores for sedentary behavior (updated PPAQ 0.63 to 0.82 vs. original 0.79), moderate-to-vigorous intensity activity (updated PPAQ 0.70 to 0.92 vs. original 0.81 to 0.82), were also comparable. For PA type, sports/exercise (updated PPAQ 0.79 to 0.91 vs. original 0.83), and occupational activity (updated PPAQ 0.70 to 0.91 vs. original 0.93) were also comparable to the wearable camera.

Compared to the original PPAQ, our validity findings for the updated PPAQ (ranging from 0.37 to 0.44 for total activity) are, in general, higher (ranging from 0.08 to 0.43). Validity scores were also higher for sedentary behavior (updated PPAQ 0.23 to 0.45 vs. original -0.34 to 0.12) and light intensity activity (updated PPAQ: 0.19 to 0.42 vs original PPAQ -0.08 to 0.22) (6). Validity scores for moderate-to-vigorous PA for the updated PPAQ (0.17 to 0.53 across pregnancy) were largely overlapping with validity scores for the original (0.20 to 0.49). The original PPAQ was validated using hip-worn accelerometers, which are limited in their capacity to detect movements of the upper extremities. Given that many of the PPAQ questions are designed to capture activities like taking care of children or household chores, which involve upper extremity movements, the overall observed improvements in validity scores may in part be due to the use of the wrist-wear location and accelerometer methods calibrated from diverse activity patterns.

It is also important to compare the updated PPAQ to existing pregnancy PA questionnaires. Only the Leisure-Time Physical Activity Questionnaire (LTPAQ) (41), the Physical Activity and Pregnancy Questionnaire (42) and Q1 of MoBa (43) were developed specifically for pregnant women. However, the LTPAQ focuses on leisure-time PA only and Q1 of the MoBa focuses on exercise only. For the LTPAQ, spearman correlations ranged from 0.27-0.47 for total leisure time PA and Q1 of the MoBa showed validity scores of 0.32 for exercise. In comparison, we observed higher validity scores for sports/exercise ranging from 0.52 to 0.70. In terms of activity intensity, our scores were comparable to the scores for the Physical Activity and Pregnancy Questionnaire which observed 0.20 for light intensity activity (vs. 0.19-0.42 for the updated PPAQ), 0.15 for moderate and 0.59 for vigorous intensity activity (vs. 0.17-0.53 for moderate-to-vigorous intensity for the updated PPAQ).

In terms of questionnaires not developed for the pregnant population but that have been evaluated in pregnant women, poor validity has been observed for the International Physical Activity Questionnaire (IPAQ) (44), the IPAQ-short form (IPAQ-SF) (45), and the Global Physical Activity Questionnaire (GPAQ) reporting correlations of r=0.07-0.54 and ICC: -0.05–0.08 (46).

There are several advantages of the PPAQ as compared to existing pregnancy PA questionnaires. First, the PPAQ remains the only questionnaire that uses pregnancy-specific METs when available. Second, the PPAQ is the only tool to be concurrently validated against the accelerometer and wearable camera to assess both activity intensity and context. Prior pregnancy PA questionnaires relied upon accelerometers alone or consumer-grade devices such as pedometers, logbooks, or other PA questionnaires (4, 5). Those studies that used accelerometers placed the accelerometer on waist and hip and therefore were limited in detecting movements involving the upper extremities (6).

While we did not observe significant differences in the validity of total PA between the PPAQ and ActiGraph by season, it is important to note that we do not dismiss the possibility of differences in PPAQ validity in colder versus warmer months. Our study encompassed participants from diverse geographical locations across the U.S., raising the consideration that the use of certain months to indicate seasons might not have been universally applicable to detect differences. Additionally, even though we found no difference in the validity of the PPAQ using the pre- and post-assessments compared to the mean of the two assessments, results are unlikely to be overstated because the PPAQ instructions ask users to recall their current trimester's usual activity unlike other questionnaires such as the IPAQ (44) whose recall period is the prior week.

Strengths of the updated PPAQ include the assessment of total PA, sedentary behavior, the type of PA including household/caregiving activity, and the fact that it was developed using a novel, data-driven approach among pregnant women (6). Other strengths include the prospective design to capture many seasons and the use of a free-living setting for validation.

Our study also had several limitations. The validity results are impacted by limitations in the objective measures as well as in the PPAQ measures. For example, cutpoints used to categorize accelerometer data into intensity levels vary substantially according to subject characteristics and the activities performed during the generation of calibration equations. In addition, because wearable cameras are a novel validation tool, there are no references for a minimal acceptable number of wear-time hours. In our study, the average wear time for the wearable camera was low (approximately 3.5 hours/day), and the number of usable images for determining the type of PA was reduced because we removed unusable photos. It is difficult to predict the impact of limited wear time and the poor quality of camera data. One reason is because women who worked from home during the COVID-19 pandemic often removed the camera due to privacy issues. Additionally, although women were provided with multiple harnesses to best wear the camera, participants who engaged in high intensity aerobic activity found the camera cumbersome to wear and therefore removed it during these periods. Lastly, due to the COVID-19 pandemic, it was difficult to distinguish what was defined as occupational versus household/caregiving activity, since they were often completed simultaneously. In spite of these limitations, the wearable camera, unlike the accelerometer, is unique in its ability to provide information on context of PA. Additionally, because errors associated with the accelerometer, wearable camera and PPAQ are largely independent, our correlation coefficients are likely not overstated (28).

Despite the instructions that users could self- or interviewer-administer the PPAQ, the PPAQ was interviewer-administered in this study to ensure consistency and accuracy. Therefore, it is possible that validity findings may differ if the PPAQ is self-administered. Lastly, because our sample was mainly homogeneous (90% Non-Hispanic White) differences in PA responses of activity domain and/or intensity during pregnancy due to racial/ethnic background could result in differing validity of the Updated PPAQ for minorities.

Reactivity, defined as a change in behavioral pattern due to the knowledge that PA is being monitored, may have occurred. However, a national sample of U.S. adolescents and adults did not observe sufficient evidence of accelerometer reactivity (47). In addition, because both objective measures and the PPAQ could lead to such change in behavior, and as the analysis is within-subject, the impact of reactivity on the validity findings is reduced.

While we used MET values for pregnant women when available, the majority of MET values in the PA Compendium were not developed in pregnant women. However, because all 3 instruments (i.e., PPAQ, wearable camera, accelerometer) rely upon the same intensity categories, the accuracy of Compendium values will not affect comparisons between them (i.e., the validity scores). Future studies among pregnant women designed to measure the metabolic intensity of physical activities in the field are warranted.

Because recruitment and follow-up spanned a 2-year period, each trimester of pregnancy spanned different seasons. This reduces the concern that validity scores for sports/exercise may be affected by weather. In addition, occupational and household/caregiving activities tend to be consistent across seasons. In our sensitivity analyses, results did not significantly vary across seasons.

Activities were selected for inclusion in the original PPAQ based upon their ability to discriminate between subjects; consistent with the primary objective of a questionnaire to classify subjects into activity rankings (e.g., quartiles of activity) and to avoid unnecessarily lengthy questionnaires (6). For the same reason, the PPAQ should not be used to calculate absolute energy expenditure during pregnancy. Our findings demonstrate that the updated PPAQ is sensitive to differences in PA levels and patterns between women and therefore will help investigators avoid misclassifying active pregnant women as sedentary when the alternative may be true.

CONCLUSION

The updated PPAQ provides equivalent and reliable estimates of PA and sedentary behavior in free-living pregnant women compared to existing tools. The updated PPAQ can be used for: 1) surveillance studies assessing compliance with PA guidelines, 2) etiologic studies of PA and maternal-fetal outcomes designed to identify the optimal dose of pregnancy PA for the prevention of these disorders, and 3) to determine the impact of physical activity intervention studies.

Table 1.1 Modifications to the sedentary questions from the Pregnancy Physical Activity Questionnaire (PPAQ), n=50; PPAQ Novel Validation Study, 2019-2021.

Original PPAQ				Updated PPAQ		
Question	**Wording**	**Intensity Category**	**METs**	**Wording**	**Intensity Category***	**METs**
11	Sitting and using a computer or writing, while not at work	light (1.5-<3)	1.8	Sitting and using a screen (computer/iPad/smartphone) and playing video games, while NOT at work	sedentary (1-≤1.5)	1.3
12	Watching TV or a video	sedentary (<1.5)	1	Sitting and watching TV or video	sedentary (1-≤1.5)	1.3
13	Sitting and reading, talking on the phone, while not at work	sedentary (<1.5)	1.1	Sitting and reading, listening to music/podcast, talking, or on the phone, while NOT at work	sedentary (1-≤1.5)	1.4

*Verbal clarification to share with respondent: "includes Facebook or surfing the Internet, texting, or email."

Table 1.2 Modifications to assigned MET value, n=50; PPAQ Novel Validation Study, 2019-2021.

Question	Wording	Original PPAQ MET score	Updated PPAQ MET score	Change in MET score	Change in Intensity Category*	Source
4	Preparing meals (cook, set table, wash dishes):	2.5	2.0	yes	no	2011 Compendium and ACT24
5	Dressing, bathing, feeding children while you are SITTING:	2.0	2.0	no	n/a	2011 Compendium
6	Dressing, bathing, feeding children while you are STANDING	3.0	3.0	no	n/a	2011 Compendium
7	Playing with children while you are SITTING OR STANDING	2.7	2.2	yes	no	2011 Compendium
8	Playing with children while you are WALKING OR RUNNING	4.0	3.5	yes	no	2011 Compendium
9	Carrying children	3.0	2.1	yes	from moderate to light	2011 Compendium
10	Taking care of an older adult	4.0	4.0	no	n/a	2011 Compendium
11	Sitting and using a screen (computer/iPad/smartphone) and playing video games, while NOT at work	1.8	1.3	yes	from light to sedentary	Campbell, 2012
12	Sitting and watching TV or video	1.0	1.3	yes	no	2011 Compendium
13	Sitting and reading, listening to music/podcast, talking, or on the phone, while NOT at work	1.1	1.4	yes	no	2011 Compendium
14	Playing with pets	3.2	2.6	yes	from moderate to light	2011 Compendium
15	Light cleaning (make beds, laundry, iron, put things away)	2.3	2.8	yes	no	Chasan-Taber, 2007
16	Shopping for food, clothes, or other items	2.3	2.3	no	n/a	2011 Compendium
17	Heavier cleaning (vacuum, mop, sweep, wash windows)	2.8	2.8	no	n/a	Mid point between 2011 Compendium and Chasan-Taber 2007
18	Mowing lawn while on a riding mower	2.8	2.5	yes	no	2011 Compendium
19	Mowing lawn using a walking mower, raking, gardening	4.4	3.8	yes	no	2011 Compendium
20	Walking SLOWLY to go places (such as to the bus, work, visiting) NOT for fun or exercise	2.5	2.8	yes	no	Campbell, 2012; Marshall, 2018

Table 1.2., continued.

Question	Wording	Original PPAQ MET score	Updated PPAQ MET score	Change in MET score	Change in Intensity Category*	Source
21	Walking quickly to go places (such as to the bus, work, or school) NOT for fun or exercise	4.0	4.1	yes	no	Campbell, 2012
22	Driving or riding in a car or bus	1.5	1.5	no	n/a	2011 Compendium
23	Walking SLOWLY for fun or exercise	3.2	2.8	yes	no	Campbell, 2012; Marshall, 2018
24	Walking more QUICKLY for fun or exercise	4.6	4.1	yes	no	Campbell, 2012
25	Walking QUICKLY UP HILLS for fun or exercise	6.5	6.5	no	n/a	Campbell, 2012
26	Jogging	7.0	7.0	no	n/a	2011 Compendium
27	Exercise class (prenatal if pregnant)	3.5	2.3	yes	from moderate to light	2011 Compendium
28	Swimming	6.0	6.0	no	n/a	2011 Compendium
29	Dancing	4.5	5.0	yes	no	2011 Compendium
30	Doing other things for fun or exercise	see compendium	see compendium			2011 Compendium
31	Doing other things for fun or exercise	see compendium	see compendium			2011 Compendium
32	Sitting at work or in class	1.6	1.5	yes	no	2011 Compendium
33	Standing or SLOWLY walking at work while carrying things (heavier than a 1 gallon milk jug)	3.0	3.8	yes	no	2011 Compendium
34	Standing or SLOWLY walking at work NOT carrying anything	2.2	2.0	yes	no	2011 Compendium
35	Walking QUICKLY at work while CARRYING things (heavier than a 1 gallon milk jug)	4.0	4.8	yes	no	2011 Compendium
36	Walking quickly at work NOT carrying anything	3.3	4.3	yes	no	2011 Compendium

*Cutpoints for intensity categories: sedentary (1 - ≤1.5 METs), light (>1.5 – <3.0 METs), moderate to vigorous (MVPA; ≥3.0 METs).

Table 1.3 Participant Characteristics, n=50; PPAQ Novel Validation Study, 2019-2021.

Characteristics	**Overall Sample**
N	50
Age (years [SD])	32.9 (4.2)
Body mass index (kg/m^2 [SD])	25.1 (3.6)
Parity (N, [%])	
Nulliparous	22 (44%)
1-2	20 (40%)
≥ 3	8 (16%)
Mean gestational age (weeks [SD])	
Early pregnancy assessment	14.9 (3.8)
Mid pregnancy assessment	26.0 (3.0)
Late pregnancy assessment	35.9 (1.6)
Race/ethnicity (%)	
Asian	3 (6%)
Black	1 (2%)
Hispanic	3 (6%)
Multi-race	3 (6%)
Non-Hispanic White	40 (80%)

Table 1.4 Physical Activity as Measured via the PPAQ, ActiGraph, and Wearable Camera according to Pregnancy Time Period; PPAQ Novel Validation Study, 2019-2021.

Measures	**PPAQ**		**ActiGraph**				**Wearable**
	MET-hrs/day	**% waking day (SD)**	**MET-hrs/day**	**% wear-time hrs/day**	**Minutes/day**	**Counts per minute**	**% wear-time hrs/day**
Overall Pregnancy (n = 50)							
Total PA (mean [SD])	20.17 (5.69)		21.88 (8.63)		280.4 (77.1)		
Counts per minute (mean [SD])						2651.59 (701.58)	
PA Type (mean [SD])							
Household/Caregiving	7.46 (5.00)	30 (18)					80 (25)
Occupational	6.41 (4.36)	35 (20)					9 (20)
Sports/Exercise	1.34 (1.21)	4 (3)					6 (13)
Transportation	1.76 (1.41)	8 (6)					5 (11)
PA Intensity (mean [SD])							
Sedentary	8.19 (3.21)	56 (19)	5.31 (1.68)	64 (9)	487.6 (92.8)		
Light	8.14 (4.38)	34 (17)	11.09 (4.11)	29 (7)	221.6 (61.2)		
Moderate - Vigorous	3.84 (2.85)	9 (7)	5.48 (2.84)	8 (4)	58.8 (27.6)		
Early Pregnancy (n = 50)							
Total PA (mean [SD])	20.73 (4.96)		21.52 (9.15)		274.3 (76.1)		
Counts per minute (mean [SD])						2621.13 (703.42)	
PA Type (mean [SD])							
Household/Caregiving	7.30 (4.73)	28 (17)					78 (26)
Occupational	6.98 (3.76)	38 (19)					11 (21)
Sports/Exercise	1.40 (1.18)	4 (3)					6 (13)
Transportation	2.11 (1.54)	9 (6)					5 (10)
PA Intensity (mean [SD])							
Sedentary	8.46 (2.93)	57 (19)	5.66 (1.8)	64 (9)	495.6 (90.6)		
Light	8.18 (4.50)	33 (16)	9.93 (4.31)	27 (7)	210.2 (58.4)		
Moderate - Vigorous	4.09 (2.34)	10 (7)	5.93 (3.04)	8 (4)	64.2 (29.1)		

Table 1.4 continued.

Measures	PPAQ		ActiGraph				Wearable
	MET-hrs/day	**% waking day (SD)**	**MET-hrs/day**	**% wear-time hrs/day**	**Minutes/day**	**Counts per minute**	**% wear-time hrs/day**
Mid Pregnancy (n = 47)							
Total PA (mean [SD])	20.7 (5.98)		22.86 (8.74)		292.1 (80.6)		
Counts per minute (mean [SD])						2710.92 (741.95)	
PA Type (mean [SD])							
Household/Caregiving	7.58 (5.01)	30 (19)					80 (27)
Occupational	6.67 (5.29)	34 (21)					9 (20)
Sports/Exercise	1.39 (1.28)	3 (3)					6 (16)
Transportation	1.79 (1.21)	8 (7)					6 (16)
PA Intensity (mean [SD])							
Sedentary	8.27 (3.43)	56 (19)	5.10 (1.63)	63 (9)	492.2 (91.2)		
Light	7.98 (3.95)	34 (17)	12.19 (4.26)	30 (8)	232.6 (65.9)		
Moderate - Vigorous	4.46 (3.61)	10 (7)	5.57 (2.84)	7 (4)	59.5 (26.2)		
Late Pregnancy (n = 44)							
Total PA (mean [SD])	18.96 (6.06)		21.27 (7.47)		275.0 (74.8)		
Counts per minute (mean [SD])						2623.49 (667.89)	
PA Type (mean [SD])							
Household/Caregiving	7.51 (5.39)	31 (19)					82 (23)
Occupational	5.48 (3.82)	32 (21)					8 (20)
Sports/Exercise	1.22 (1.18)	4 (4)					5 (11)
Transportation	1.32 (1.34)	6 (5)					5 (8)
PA Intensity (mean [SD])							
Sedentary	7.80 (3.29)	56 (19)	5.16 (1.58)	63 (9)	473.9 (97.6)		
Light	8.27 (4.75)	36 (18)	11.24 (3.41)	30 (7)	223.0 (58.3)		
Moderate - Vigorous	2.89 (2.19)	7 (5)	4.88 (2.48)	7 (4)	52.1 (27.1)		

Table 1.5 Mean Physical Activity and Spearman Validity Coefficients as Measured via the PPAQ and ActiGraph (Hildebrand) according to Intensity Level and Pregnancy Time Period; PPAQ Novel Validation Study, 2019-2021.

Measures	PPAQ	ActiGraph	Correlation		
	Mean (SD)	Mean (SD)	Correlation Coefficient	95%CI	
PA Intensity (% wear-time hrs/day)					
Overall Pregnancy					
Sedentary	56.37 (18.74)	76.81 (10.81)			
Light	34.49 (16.77)	18.41 (7.82)			
Moderate-Vigorous	9.14 (6.76)	4.78 (4.86)			
Early Pregnancy					
Sedentary	56.87 (18.61)	74.92 (12.64)	0.40	0.14	0.62
Light	33.31 (16.23)	19.44 (9.13)	0.35	0.08	0.58
Moderate-Vigorous	9.82 (7.23)	5.64 (5.36)	0.12	-0.17	0.39
Mid Pregnancy					
Sedentary	55.75 (18.79)	77.84 (9.03)	0.20	-0.10	0.47
Light	34.01 (16.53)	17.64 (6.67)	0.19	-0.11	0.46
Moderate-Vigorous	10.23 (7.15)	4.51 (4.29)	0.23	-0.07	0.49
Late Pregnancy					
Sedentary	56.45 (19.24)	77.83 (10.26)	0.26	-0.05	0.52
Light	36.36 (17.82)	18.06 (7.39)	0.33	0.03	0.57
Moderate-Vigorous	7.19 (5.30)	4.11 (4.77)	0.01	-0.29	0.31

Table 1.6 Spearman Validity Coefficients between the PPAQ, ActiGraph, and Wearable Camera according to Pregnancy Time Period, n=50; PPAQ Novel Validation Study, 2019-2021.

	Early Pregnancy						**Mid Pregnancy**						**Late Pregnancy**					
	ActiGraph			**Camera**			**ActiGraph**			**Camera**			**ActiGraph**			**Camera**		
Measures	**ρ**	**95% CI**		**ρ**	**95% CI**		**ρ**	**95% CI**		**ρ**	**95% CI**		**ρ**	**95% CI**		**ρ**	**95% CI**	
Total PA (MET-hrs/day)	0.37	0.10	0.59	-	-	-	0.44	0.17	0.65	-	-	-	0.41	0.12	0.63	-	-	-
PA Type (% wear-time hrs/day)																		
Household/Caregiving	-	-	-	0.03	-0.26	0.31	-	-	-	0.17	-0.13	0.45	-	-	-	0.29	-0.02	0.55
Occupational	-	-	-	0.30	0.02	0.54	-	-	-	0.26	-0.04	0.52	-	-	-	0.26	-0.05	0.52
Sports/Exercise	-	-	-	0.70	0.52	0.82	-	-	-	0.63	0.41	0.78	-	-	-	0.52	0.25	0.71
Transportation	-	-	-	0.20	-0.09	0.46	-	-	-	-0.01	-0.31	0.30	-	-	-	0.11	-0.20	0.41
PA Intensity (MET-hrs/day)																		
Sedentary	0.31	0.02	0.54	-	-	-	0.23	-0.07	0.49	-	-	-	0.35	0.06	0.59	-	-	-
Light	0.25	-0.04	0.50	-	-	-	0.19	-0.11	0.46	-	-	-	0.27	-0.03	0.53	-	-	-
Moderate - Vigorous	0.22	-0.07	0.47	-	-	-	0.53	0.28	0.71	-	-	-	0.30	-0.01	0.55	-	-	-
PA Intensity (% wear-time hrs/day)																		
Sedentary	0.45	0.18	0.65	-	-	-	0.35	0.06	0.58	-	-	-	0.38	0.09	0.61	-	-	-
Light	0.42	0.16	0.63	-	-	-	0.31	0.01	0.55	-	-	-	0.40	0.11	0.62	-	-	-
Moderate - Vigorous	0.17	-0.12	0.44	-	-	-	0.42	0.14	0.63	-	-	-	0.17	-0.13	0.45	-	-	-

ρ calculated from Spearman Correlation

Table 1.7 Limits of Agreement between Physical Activity as Measured via the PPAQ vs. the ActiGraph and Wearable Camera according to Pregnancy Time Period, n=50; PPAQ Novel Validation Study, 2019-2021.

Measures	PPAQ vs Actigraph		PPAQ vs Camera	
	Lower bound	Upper bound	Lower bound	Upper bound
Overall Pregnancy				
Total PA (MET-hrs/day)	-14.16924	11.09124		
PA Type (mean [SD])				
Household/Caregiving			-0.82926	-0.07074
Occupational			-0.1188	0.5868
Sports/Exercise			-0.15912	0.12312
Transportation			-0.12294	0.17694
PA Intensity (MET-hrs/day)				
Sedentary	-1.72098	6.90498		
Light	-10.14318	4.83318		
Moderate - Vigorous	-6.49458	3.54258		
PA Intensity (% wear-time hrs/day)				
Sedentary	-0.31896	0.17496		
Light	-0.16668	0.25668		
Moderate - Vigorous	-0.08802	0.10602		
Early Pregnancy				
Total PA (MET-hrs/day)	-13.15602	11.73402		
PA Type (mean [SD])				
Household/Caregiving			-0.82926	-0.07074
Occupational			-0.1098	0.5958
Sports/Exercise			-0.15912	0.12312
Transportation			-0.10512	0.17712
PA Intensity (MET-hrs/day)				
Sedentary	-1.65186	6.69186		
Light	-9.34542	6.19542		
Moderate - Vigorous	-6.40116	3.08916		
PA Intensity (% wear-time hrs/day)				
Sedentary	-0.30996	0.18396		
Light	-0.14886	0.25686		
Moderate - Vigorous	-0.07902	0.11502		

Table 1.7 continued.

Measures	PPAQ vs Actigraph		PPAQ vs Camera	
	Lower bound	Upper bound	Lower bound	Upper bound
Mid Pregnancy				
Total PA (MET-hrs/day)	-14.92704	11.03904		
PA Type (mean [SD])				
Household/Caregiving			-0.85572	-0.04428
Occupational			-0.13662	0.58662
Sports/Exercise			-0.19458	0.14058
Transportation			-0.18486	0.22086
PA Intensity (MET-hrs/day)				
Sedentary	-1.60992	7.31592		
Light	-11.03022	3.45222		
Moderate - Vigorous	-6.6879	4.6899		
PA Intensity (% wear-time hrs/day)				
Sedentary	-0.30996	0.18396		
Light	-0.1845	0.2565		
Moderate - Vigorous	-0.07002	0.12402		
Late Pregnancy				
Total PA (MET-hrs/day)	-14.01246	9.85446		
PA Type (mean [SD])				
Household/Caregiving			-0.82944	-0.08856
Occupational			-0.14562	0.57762
Sports/Exercise			-0.1413	0.1233
Transportation			-0.10566	0.12366
PA Intensity (MET-hrs/day)				
Sedentary	-1.91934	6.67134		
Light	-9.87012	4.52412		
Moderate - Vigorous	-5.90994	2.32794		
PA Intensity (% wear-time hrs/day)				
Sedentary	-0.30996	0.18396		
Light	-0.1665	0.2745		
Moderate - Vigorous	-0.07938	0.07938		

Table 1.8 Reproducibility (Intraclass Correlation Coefficients) of the PPAQ according to Pregnancy Time Period; PPAQ Novel Validation Study, 2019-2021.

	Early Pregnancy (n = 50)			**Mid Pregnancy (n = 47)**			**Late Pregnancy (n = 44)**		
	ICC	**95% CI**		**ICC**	**95% CI**		**ICC**	**95% CI**	
Total PA (MET-hrs/day)	0.55	0.31	0.71	0.81	0.68	0.89	0.83	0.70	0.90
PA Type									
Household/Caregiving	0.71	0.53	0.82	0.83	0.72	0.90	0.92	0.85	0.95
Occupational	0.70	0.53	0.82	0.91	0.85	0.95	0.80	0.66	0.89
Sports/Exercise	0.79	0.66	0.88	0.79	0.65	0.88	0.91	0.84	0.95
Transportation	0.67	0.50	0.80	0.42	0.14	0.63	0.64	0.42	0.79
PA Intensity									
Sedentary	0.63	0.43	0.78	0.82	0.70	0.89	0.76	0.60	0.86
Light	0.75	0.59	0.85	0.77	0.65	0.87	0.87	0.77	0.92
Moderate - Vigorous	0.70	0.53	0.82	0.81	0.69	0.90	0.92	0.86	0.96

Figure 1.1 Pregnancy Physical Activity Study (PPAQ) Study Timeline

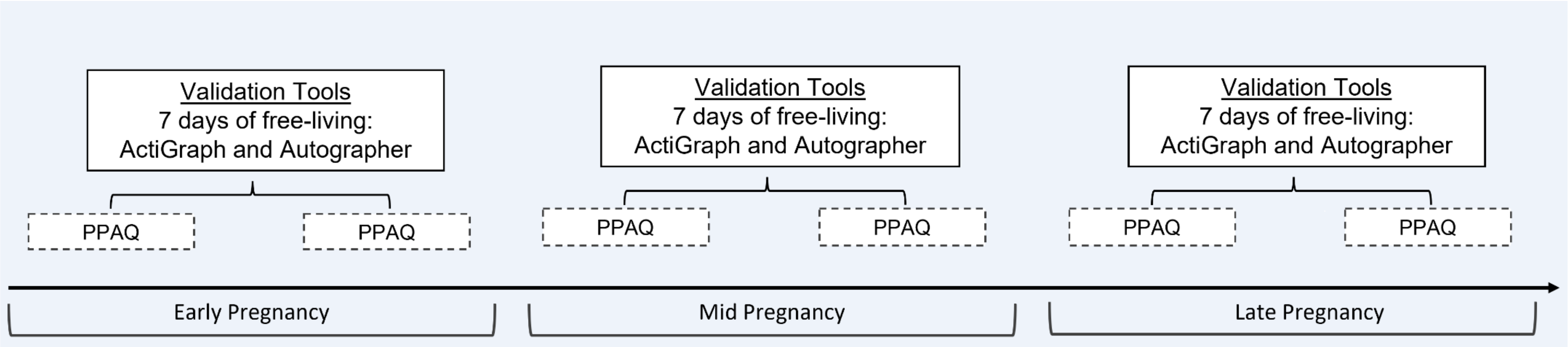

Figure 1: Pregnancy Physical Activity Study (PPAQ) Study Timeline

Appendix 1.1 Updated Pregnancy Physical Activity Questionnaire

Updated Pregnancy Physical Activity Questionnaire

Your answers are confidential and will be used only for research purposes.

Example: During this trimester, when you are NOT at work, how much time do you usually spend:

If you take care of your mom for 2 hours each day, then your answer should look like this… →

E1. Taking care of an older adult.

- O None
- O Less than 1/2 hour per day
- O 1/2 to almost 1 hour per day
- O 1 to almost 2 hours per day
- ● 2 to almost 3 hours per day
- O 3 or more hours per day

It is very important that you tell us about yourself honestly. There are no right or wrong answers. We just want to know about the things you are doing during this trimester.

1. Today's Date: ☐☐ / ☐☐ / ☐☐☐☐
Month Day Year

2. What was the first day of your last period? ☐☐ / ☐☐ / ☐☐☐☐
Month Day Year

3. When is your due date? ☐☐ / ☐☐ / ☐☐☐☐
Month Day Year

HOUSEHOLD/CAREGIVING ACTIVITY

During this trimester, when you are NOT at work, how much time do you usually spend:

4. Preparing meals (cook, set table, wash dishes)

- O None
- O Less than 1/2 hour per day
- O 1/2 to almost 1 hour per day
- O 1 to almost 2 hours per day
- O 2 to almost 3 hours per day
- O 3 or more hours per day

5. Dressing, bathing, feeding children while you are <u>SITTING</u>

- O None
- O Less than 1/2 hour per day
- O 1/2 to almost 1 hour per day
- O 1 to almost 2 hours per day
- O 2 to almost 3 hours per day
- O 3 or more hours per day

6. Dressing, bathing, feeding children while you are <u>STANDING</u>

- O None
- O Less than 1/2 hour per day
- O 1/2 to almost 1 hour per day
- O 1 to almost 2 hours per day
- O 2 to almost 3 hours per day
- O 3 or more hours per day

7. Playing with children while you are <u>SITTING OR STANDING</u>

- O None
- O Less than 1/2 hour per day
- O 1/2 to almost 1 hour per day
- O 1 to almost 2 hours per day
- O 2 to almost 3 hours per day
- O 3 or more hours per day

Updated PPAQ 1

Appendix 1.1 continued.

8. Playing with children while you are <u>WALKING OR RUNNING</u>
   - O None
   - O Less than 1/2 hour per day
   - O 1/2 to almost 1 hour per day
   - O 1 to almost 2 hours per day
   - O 2 to almost 3 hours per day
   - O 3 or more hours per day

9. Carrying children
   - O None
   - O Less than 1/2 hour per day
   - O 1/2 to almost 1 hour per day
   - O 1 to almost 2 hours per day
   - O 2 to almost 3 hours per day
   - O 3 or more hours per day

10. Taking care of an older adult
   - O None
   - O Less than 1/2 hour per day
   - O 1/2 to almost 1 hour per day
   - O 1 to almost 2 hours per day
   - O 2 to almost 3 hours per day
   - O 3 or more hours per day

11. <u>Sitting</u> and using a screen (computer/iPad/smartphone) and playing video games, while <u>NOT</u> at work
   - O None
   - O Less than 1/2 hour per day
   - O 1/2 to almost 1 hour per day
   - O 1 to almost 2 hours per day
   - O 2 to almost 3 hours per day
   - O 3 or more hours per day

12. <u>Sitting</u> and watching TV or video
   - O None
   - O Less than 1/2 hour per day
   - O 1/2 to almost 2 hours per day
   - O 2 to almost 4 hours per day
   - O 4 to almost 6 hours per day
   - O 6 or more hours per day

13. <u>Sitting</u> and reading, listening to music/podcast, talking, or on the phone, while <u>NOT</u> at work
   - O None
   - O Less than 1/2 hour per day
   - O 1/2 to almost 2 hours per day
   - O 2 to almost 4 hours per day
   - O 4 to almost 6 hours per day
   - O 6 or more hours per day

14. Playing with pets
   - O None
   - O Less than 1/2 hour per day
   - O 1/2 to almost 1 hour per day
   - O 1 to almost 2 hours per day
   - O 2 to almost 3 hours per day
   - O 3 or more hours per day

15. Light cleaning (make bed, laundry, iron, put things away)
   - O None
   - O Less than 1/2 hour per day
   - O 1/2 to almost 1 hour per day
   - O 1 to almost 2 hours per day
   - O 2 to almost 3 hours per day
   - O 3 or more hours per day

16. Shopping for food, clothes, or other items
   - O None
   - O Less than 1/2 hour per day
   - O 1/2 to almost 1 hour per day
   - O 1 to almost 2 hours per day
   - O 2 to almost 3 hours per day
   - O 3 or more hours per day

17. Heavy cleaning (vacuum, mop, sweep, wash windows)
   - O None
   - O Less than 1/2 hour per <u>week</u>
   - O 1/2 to almost 1 hour per <u>week</u>
   - O 1 to almost 2 hours per <u>week</u>
   - O 2 to almost 3 hours per <u>week</u>
   - O 3 or more hours per <u>week</u>

18. Mowing lawn while on a riding mower
   - O None
   - O Less than 1/2 hour per <u>week</u>
   - O 1/2 to almost 1 hour per <u>week</u>
   - O 1 to almost 2 hours per <u>week</u>
   - O 2 to almost 3 hours per <u>week</u>
   - O 3 or more hours per week

19. Mowing lawn using a walking mower, raking, gardening
   - O None
   - O Less than 1/2 hour per <u>week</u>
   - O 1/2 to almost 1 hour per <u>week</u>
   - O 1 to almost 2 hours per <u>week</u>
   - O 2 to almost 3 hours per <u>week</u>
   - O 3 or more hours per <u>week</u>

Updated PPAQ 2

Appendix 1.1 continued.

GOING PLACES

During this trimester, how much time do you usually spend:

20. Walking SLOWLY to go places (such as to the bus, work, visiting) NOT for fun or exercise

- O None
- O Less than 1/2 hour per day
- O 1/2 to almost 1 hour per day
- O 1 to almost 2 hours per day
- O 2 to almost 3 hours per day
- O 3 or more hours per day

21. Walking QUICKLY to go places (such as to the bus, work, visiting) NOT for fun or exercise

- O None
- O Less than 1/2 hour per day
- O 1/2 to almost 1 hour per day
- O 1 to almost 2 hours per day
- O 2 to almost 3 hours per day
- O 3 or more hours per day

22. Driving or riding in a car or bus

- O None
- O Less than 1/2 hour per day
- O 1/2 to almost 1 hour per day
- O 1 to almost 2 hours per day
- O 2 to almost 3 hours per day
- O 3 or more hours per day

FOR FUN OR EXERCISE

During this trimester, when you are NOT at work, how much time do you usually spend:

23. Walking SLOWLY for fun or exercise

- O None
- O Less than 1/2 hour per week
- O 1/2 to almost 1 hour per week
- O 1 to almost 2 hours per week
- O 2 to almost 3 hours per week
- O 3 or more hours per week

24. Walking MORE QUICKLY for fun or exercise

- O None
- O Less than 1/2 hour per week
- O 1/2 to almost 1 hour per week
- O 1 to almost 2 hours per week
- O 2 to almost 3 hours per week
- O 3 or more hours per week

25. Walking QUICKLY UP HILLS for fun or exercise

- O None
- O Less than 1/2 hour per week
- O 1/2 to almost 1 hour per week
- O 1 to almost 2 hours per week
- O 2 to almost 3 hours per week
- O 3 or more hours per week

26. Jogging

- O None
- O Less than 1/2 hour per week
- O 1/2 to almost 1 hour per week
- O 1 to almost 2 hours per week
- O 2 to almost 3 hours per week
- O 3 or more hours per week

27. Prenatal exercise class

- O None
- O Less than 1/2 hour per week
- O 1/2 to almost 1 hour per week
- O 1 to almost 2 hours per week
- O 2 to almost 3 hours per week
- O 3 or more hours per week

28. Swimming

- O None
- O Less than 1/2 hour per week
- O 1/2 to almost 1 hour per week
- O 1 to almost 2 hours per week
- O 2 to almost 3 hours per week
- O 3 or more hours per week

Updated PPAQ 3

Appendix 1.1 continued.

29. Dancing

- O None
- O Less than 1/2 hour per **week**
- O 1/2 to almost 1 hour per **week**
- O 1 to almost 2 hours per **week**
- O 2 to almost 3 hours per **week**
- O 3 or more hours per **week**

30. Doing other things for fun or exercise. Please tell us what they are:

____

Name of Activity

- O None
- O Less than 1/2 hour per **week**
- O 1/2 to almost 1 hour per **week**
- O 1 to almost 2 hours per **week**
- O 2 to almost 3 hours per **week**
- O 3 or more hours per **week**

31. Doing other things for fun or exercise. Please tell us what they are:

____

Name of Activity

- O None
- O Less than 1/2 hour per **week**
- O 1/2 to almost 1 hour per **week**
- O 1 to almost 2 hours per **week**
- O 2 to almost 3 hours per **week**
- O 3 or more hours per **week**

Do you attend school or work, either for wages or as a volunteer?

- O No (skip the remainder of the survey)
- O Yes (please fill out the remaining questions)

AT WORK

During this trimester, how much time do you usually spend:

32. Sitting at work or in class

- O None
- O Less than 1/2 hour per day
- O 1/2 to almost 2 hours per day
- O 2 to almost 4 hours per day
- O 4 to almost 6 hours per day
- O 6 or more hours per day

33. Standing or SLOWLY walking at work while carrying things (heavier than a 1 gallon milk jug)

- O None
- O Less than 1/2 hour per day
- O 1/2 to almost 2 hours per day
- O 2 to almost 4 hours per day
- O 4 to almost 6 hours per day
- O 6 or more hours per day

34. Standing or SLOWLY walking at work NOT carrying anything

- O None
- O Less than 1/2 hour per day
- O 1/2 to almost 2 hours per day
- O 2 to almost 4 hours per day
- O 4 to almost 6 hours per day
- O 6 or more hours per day

35. Walking QUICKLY at work while carrying things (heavier than a 1 gallon milk jug)

- O None
- O Less than 1/2 hour per day
- O 1/2 to almost 2 hours per day
- O 2 to almost 4 hours per day
- O 4 to almost 6 hours per day
- O 6 or more hours per day

36. Walking QUICKLY at work NOT carrying anything

- O None
- O Less than 1/2 hour per day
- O 1/2 to almost 2 hours per day
- O 2 to almost 4 hours per day
- O 4 to almost 6 hours per day
- O 6 or more hours per day

Thank You!

Updated PPAQ 4

Appendix 1.2 Instructions for the Updated Pregnancy Physical Activity Questionnaire

Updated PREGNANCY PHYSICAL ACTIVITY QUESTIONNAIRE

OVERVIEW:

This document provides instructions for the Updated Pregnancy Physical Activity Questionnaire (PPAQ).

The PPAQ is an updated version of the PPAQ originally developed in 2004 . Major updates are the inclusion of contemporary sedentary behaviors and the use of the most recent Compendium MET values. To ensure accurate measures, please use the appropriate instructions when using the Updated PPAQ and the 2004 PPAQ.

PURPOSE

The PPAQ is designed to rank individuals according to their physical activity rather than to estimate their absolute energy expenditure. The activities on the PPAQ were selected because they were the most important contributors to between-person variation in pregnancy physical activity (Chasan-Taber 2007).

INSTRUCTIONS:

The PPAQ is self- and/or researcher-administered questionnaire. The time frame of recall is the current trimester of pregnancy. Specific instructions are listed on the questionnaire.

Individuals are asked to select the category that best approximates the amount of time spent in 33 activities (questions #4-36) including household/caregiving, occupational, sports/exercise, transportation, and sedentary behavior during the current trimester. At the end of the sports/exercise section of the questionnaire, an open-ended section allows the respondent to add activities not already listed (#30, 31).

Component(s) assessed in PPAQ	
Total activity	Light intensity and above
Intensity domains	Sedentary activity, light-intensity, moderate-intensity, vigorous-intensity activity
Activity domains	Household/caregiving, occupational, sports/exercise, transportation

PRIMARY SOURCE OF INFORMATION:

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Examples of coding the PPAQ will be displayed throughout the instructions in shaded boxes.

Updated Pregnancy Physical Activity Questionnaire 1

Appendix 1.2 continued.

CALCULATIONS

To calculate an estimate of weekly energy expenditure (MET-h-week^{-1}) for each activity, multiply the duration (hours/week) by the intensity.

Duration

The lowest bound of each response option is used to estimate hours/week, due to the tendency for over-reporting of physical activity. Using the table below, find the Hours/Week score assigned to the response for each question.

Question #	Duration Category	Hours/Week
4, 5, 6, 7, 8, 9, 10, 11, 14, 15, 16, 20, 21, 22	None	0
	Less than ½ hour per day	0.84
	½ to almost 1 hour per day	3.5
	1 to almost 2 hours per day	7
	2 to almost 3 hours per day	14
	3 or more hours per day	21
12, 13, 32, 33, 34, 35, 36	None	0
	Less than ½ hour per day	0.84
	½ to almost 2 hour per day	3.5
	2 to almost 4 hours per day	14
	4 to almost 6 hours per day	28
	6 or more hours per day	42
17, 18, 19, 23, 24, 25, 26, 27, 28, 29, 30, 31	None	0
	Less than ½ hour per week	0.12
	½ to almost 1 hour per week	0.5
	1 to almost 2 hours per week	1
	2 to almost 3 hours per week	2
	3 or more hours per week	3

Example 1: If participant answered ½ to almost 1 hour per day for question 4 (i.e., preparing meals) the hours/week estimate is:

3.5 hours/week

Example 2: If participant answered 3 or more hours per week for question 25 (i.e., walking quickly up hills) the hours/week estimate is:

3 hours/week

Updated Pregnancy Physical Activity Questionnaire 2

Appendix 1.2 continued.

Intensity

To estimate intensity, field-based measurements in pregnant women (Campbell 2012, Chasan-Taber 2007) are used to represent activity intensity for walking and light-to moderate-intensity household tasks, and Compendium-based MET values (Ainsworth 2011) are used to estimate the intensity of the remainder of the PPAQ activities.

The specific MET values assigned to each question are shown in the Table below. For questions 30 and 31, see Compendium. To calculate MET-hours/week, multiply the Hours/Week spent in each activity by its intensity.

Question #	4	5	6	7	8	9	10	11	12	13	14
MET Value	2.0	2.0	3.0	2.2	3.5	2.1	4.0	1.3	1.3	1.4	2.6

Question #	15	16	17	18	19	20	21	22	23	24	25
MET Value	2.8	2.3	2.8	2.5	3.8	2.8	4.1	1.5	2.8	4.1	6.5

Question #	26	27	28	29	30	31	32	33	34	35	36
MET Value	7.0	2.3	6.0	5.0	*	*	1.5	3.8	2.0	4.8	4.3

*For the open-ended questions (#30,31), use following cut-points to determine if the activity is sedentary (1 - ≤1.5 METS), light (>1.5 - <3.0 METS), moderate (3.0 – 5.9 METS), or vigorous (≥6.0 METS).

Example 1 continued:

3.5 hours/week * 3.3 METs = 11.55 MET-hours/week

Example 2 continued:

3 hours/week * 5.2 METs = 15.6 MET-hours/week

Appendix 1.2 continued.

CLASSIFICATION OF PHYSICAL ACTIVITY	
Total activity	sum of MET-hours/week for all questions
Light-intensity and above	sum of MET-hours/week for questions #4, 5, 6, 7, 8, 9, 10, 14, 15, 16, 17, 18, 19, 20, 21, 23, 24, 25, 26, 27, 28, 29, 33, 34, 35, 36, and questions #30, 31 if 1.6 - ≥6.0 METS
Intensity domains	
Sedentary activity	sum of MET-hours/week for questions #11, 12, 13, 22, 32 and questions #30, 31 (if 1 - 1.5 METs)
Light-intensity activity	sum of MET-hours/week for questions #4, 5, 7, 9, 14, 15, 16, 17, 18, 20, 23, 27, 34, and questions #30, 31 (if 1.6 – 2.9 METs)
Moderate-intensity activity	sum of MET-hours/week for questions #6, 8,10, 19, 21, 24, 29, 33, 35, 36, and questions #30, 31 (if 3.0 - 5.9 METs)
Vigorous-intensity activity	sum of MET-hours/week for questions #25, 26, 28, and questions #30, 31 (if ≥6.0 METs)
Activity domains	
Household/caregiving activity	sum of MET-hours/week for questions #4, 5, 6, 7, 8, 9, 10, 14, 15, 16, 17, 18, 19
Occupational activity	sum of MET-hours/week for questions #32, 33, 34, 35, 36.
Sports/exercise activity	sum of MET-hours/week for questions #23, 24, 25, 26, 27, 28, 29, 30, 31.
Transportation activity	sum of MET-hours/week for questions #20, 21, 22

Updated Pregnancy Physical Activity Questionnaire 4

Appendix 1.2 continued.

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CHAPTER

II. THE IMPACT OF THE COVID-19 PANDEMIC ON PHYSICAL ACTIVITY AND SEDENTARY BEHAVIOR DURING PREGNANCY: A PROSPECTIVE STUDY

ABSTRACT

Prior studies evaluating the impact of the COVID-19 pandemic on pregnancy physical activity (PA) have largely been limited to internet-based surveys not validated for use in pregnancy. This study used data from the Pregnancy PA Questionnaire Validation study conducted from 2019-2021. A prospective cohort of 50 pregnant women completed the Pregnancy PA Questionnaire (PPAQ), validated for use in early, mid, and late pregnancy and wore an ActiGraph GT3X-BT for seven days. COVID-19 impact was defined using a fixed date of onset (March 13, 2020) and a self-reported date of impact. Multivariable linear mixed effects regression models adjusted for age, early pregnancy BMI, gestational age, and parity were used to estimate the change in PA with COVID-19 impact during each stage of pregnancy and among participants who had pre- and post-pandemic sessions. During early pregnancy, significant increases in sedentary behavior by 14.2 MET hrs/wk (95%CI: 2.3, 26.0) were observed after the onset of the pandemic compared to sessions completed pre-pandemic using the fixed impact date. Using the fixed date, transportation activity decreased by -8.1 (-14.5, -1.6) during middle pregnancy. During mid and late pregnancy, significant increases in household/caregiving PA were observed after the onset of the pandemic compared to sessions completed pre-pandemic using the self-reported impact date by 34.4 MET hrs/wk (95%CI: 8.5, 60.3) and 25.9 MET hrs/wk

(95%CI: 0.9, 50.9), respectively. After the onset of the pandemic, transportation PA significantly decreased using the fixed (-19.7 (-27.4, -13.7) and self-reported -16.7 (-24.7, -8.8) measure of impact. Proactive approaches for the promotion of pregnancy PA during pandemic-related restrictions or confinement are critically needed.

INTRODUCTION

The rise in physical inactivity and sedentary time has been a consistent public health concern, as it remains one of the leading risk factors for noncommunicable disease mortality and morbidity. Despite the known benefits of obtaining adequate physical activity (PA), women obtain less PA than men (48). Physical inactivity during pregnancy is an urgent public health concern and is implicated in excessive gestational weight gain, gestational diabetes, pre-eclampsia, and preterm birth (49). The American College of Obstetricians and Gynecologists (ACOG) recommends regular PA during pregnancy due to its positive impact on physical fitness, weight management, prevention of gestational diabetes mellitus (GDM), and psychologic well-being (1). Commonly cited barriers contributing to the lack of exercise include caretaking and work responsibilities. In addition, during pregnancy, women may experience pregnancy-related changes in physiology and behaviors which pose an additional challenge to obtaining adequate PA levels (50). The beneficial impact of PA on anxiety and depression (51, 52) is particularly critical in managing psychological stress associated with pandemic lockdown restrictions.

As of 2022, the COVID-19 pandemic has led to more than 634 million confirmed cases and 6.6 million deaths worldwide (53). In addition to the negative health consequences among those infected by the SARS-CoV-2 coronavirus, lockdowns were instituted across many nations in an effort to impede the spread of the virus. These lockdowns have been shown to adversely impact mental health, diet, sleep, financial stability, and social relationships, resulting in unexpected and sudden shifts in human behavior (54, 55). For example, studies show that, for many adults, PA decreased throughout the pandemic due to pandemic-related restrictions leading to disruptions in the daily routine (e.g., commute, gym closures, work-from-home, loss of job/hours) (56).

However, few studies have evaluated the impact of the pandemic on PA levels among pregnant women (57-65) and, with the exception of two studies (58, 64), were internet-based surveys administered to convenience samples. All of the studies, with the exception of one (60), used self-reported measures of PA and sedentary behavior which were not validated for use during pregnancy. Finally, the one prospective cohort study used a consumer-grade, as opposed to a research-grade, monitor to measure PA (i.e., Samsung smartwatch)(64). Studies were largely conducted internationally including Denmark, the UK, Japan, China, Finland, Spain, and the United Arab Emirates, with only one (63) conducted in the US.

Therefore, our aim was to prospectively examine the impact of the COVID-19 pandemic on patterns of PA and sedentary behavior in pregnant women in the US using an objective research-grade accelerometer and a self-reported questionnaire validated for use in pregnancy. Using a combination of PA assessment methods is important as objective measures do not provide information on the context of PA, which is important for public health recommendations. The hypothesis was that pandemic-related restrictions would be associated with lower levels of PA and higher levels of sedentary behavior. We hypothesized that we would observe differences in PA type before and after the onset of the pandemic.

METHODS

Study Population

Participants were part of an observational cohort study designed to use novel validation techniques to re-validate the Pregnancy Physical Activity Questionnaire (PPAQ) (NIH/NICHD 1R21HD094565). Enrollment commenced in March 2019 and follow-up continued until January 2021. Participants (N=50) were recruited in early pregnancy via flyers at prenatal care centers, health clinics, and advertisements in local papers and using paid Facebook™ advertisements.

Participants were screened at recruitment with a single item rating scale for level of PA(8) to ensure they represented a range of people who regularly undertake a diverse set of activities of various intensities (e.g., low active to high active participants). Women were considered ineligible for the study if they had any of the following characteristics: 1) >20 weeks gestation, 2) under 16 or over 40 years of age, 3) pregnant with twins or triplets as this is often accompanied by clinically prescribed PA restrictions, 4) musculoskeletal issues that limited ambulation, 5) chronic disease (e.g., diabetes requiring insulin, hypertension or heart disease requiring medication, chronic renal disease, emphysema) or life-threatening illnesses, or 6) lack of a telephone.

This research was performed in accordance with the Declaration of Helsinki and was approved by approved by the Institutional Review Board of the University of Massachusetts, Amherst (reference number: 118-0811). Each participant read and signed a written informed consent.

Study Design

A total of three 7-day assessments were conducted in early, mid, and late pregnancy. Women were recruited in early pregnancy (i.e., 8-20 weeks gestation). The late pregnancy assessment was scheduled 4 to 5 weeks prior to the expected delivery date (i.e., 35-36 weeks gestation) and the middle pregnancy assessment was scheduled halfway between the early and late pregnancy assessment. Participants were given the option of an in-person or virtual assessment. At the beginning of each assessment period, the PPAQ was administered, and women were instructed in use of the ActiGraph to be worn for the following 7-days. Participants were instructed on how to complete a wear log, which recorded times that ActiGraph was not worn (e.g., during sleeping or water-based activities). Video demonstrations of how to correctly wear the monitors, as well as links to paper-based materials were provided for all participants on a study website. At the end of each assessment period, the PPAQ was repeated.

We evaluated the impact of the pandemic on PA during each pregnancy assessment (i.e., early, middle, and late pregnancy). A secondary analysis, limited to women whose enrollment periods spanned the pre and post COVID-19 pandemic onset dates, was also conducted.

Physical Activity Assessment

PA was assessed via objective measures (ActiGraph) and self-report (the PPAQ) during the three assessment time periods (i.e., early, middle, and late pregnancy).

ActiGraph-GT3X-BT Activity Monitor

Participants were instructed to wear the ActiGraph GT3X-BT (ActiGraph) on the non-dominant wrist for 7 consecutive days except during sleeping or water-based activities (e.g., showering, swimming). ActiGraph devices were initialized to collect data at 80 Hz using ActiLife 6 software (version 6.13.1: ActiGraph, Pensacola, FL). After each assessment period, data were exported as raw and 1-second epoch files.

Wear time was based on self-report or, if missing, using the Choi wear time algorithm (22). Only assessment periods with at least 10 hours of wear time for at least 4 days were included in analyses (23). For overall activity metrics, total vector magnitude counts per day was computed using days with valid wear time. For time spent in different behaviors, time and frequency-domain features were computed from raw acceleration data in 15-second non-overlapping epochs and used in previously trained random forest models to classify sedentary and locomotion (walking/running) behaviors (24). Although this method was developed for devices worn on the dominant wrist, no valid methods for determining locomotion behaviors for wrist methods has been developed. Since a prior step count comparison study(66) found that monitors worn on the dominant wrist yielded higher steps compared to monitors worn on the non-dominant wrist, this limitation was considered in the discussion.

Counts and cut-points were not used to define sedentary behavior and PA because existing cut-point methods are specific to hip-worn ActiGraph accelerometers. In contrast, we used wrist worn accelerometers in our study, as is done in large scale surveillance studies such as NHANES (67) and the UK BioBank (68). We then used machine learning methods to translate activity patterns from the raw wrist data into more interpretable units (i.e., sedentary behavior and locomotion time) (24).

Pregnancy Physical Activity Questionnaire (PPAQ)

The Pregnancy Physical Activity Questionnaire (PPAQ) was used to measure pregnancy PA (6). The PPAQ is a semi-quantitative instrument that measures the duration and intensity of time spent in household/caregiving, occupational, transportation (i.e., driving and walking to go places), and sports/exercise activities. Intraclass correlation coefficients used to measure reproducibility of the PPAQ were 0.78 for total activity, 0.82 for moderate activity, 0.81 for vigorous activity, and ranged from 0.83 for sports/exercise to 0.93 for occupational activity domains. Spearman correlations between the PPAQ and 3 published accelerometer cutpoints used to classify ActiGraph data ranged from 0.08 to 0.43 for total activity, 0.25 to 0.34 for vigorous-intensity activity, 0.20 to 0.49 for moderate-intensity activity, -0.08 to 0.22 for light-intensity activity, and -0.34 to 0.12 for sedentary behavior (6). These validity findings were comparable to those for prior PA questionnaires in pregnant (4) and non-pregnant populations (31).

Participants were asked to complete the PPAQ twice at each of the three assessment periods (i.e., early, middle, and late pregnancy). The PPAQ was modified to capture the full range of contemporary sedentary behavior (e.g., ‘screen-time’ via smart phones and tablets; time spent texting and on social media). The number of minutes spent in each reported activity was multiplied by its metabolic equivalent of task (MET) level to estimate average weekly MET-hours/week. MET intensity scores were based on the 2011 Compendium of Physical Activities (14) except for walking and light housework activities for which field-based measures among pregnant women (12, 13) were used. Activities were classified by PA domain (e.g., sports/exercise, household/caregiving, occupational, and transportation), and PA intensity (e.g., vigorous, moderate, light, and sedentary). Consistent with the ACOG guidelines(1) as well as the 2019 Canadian Guidelines for physical activity in pregnancy(69), meeting ACOG guidelines was defined as obtaining at least 150 minutes of moderate-vigorous intensity sports/exercise activity per week (i.e., the equivalent of >7.5 MET-hrs/week)(1).

Assessment of COVID-19 Impact

The impact of the COVID-19 pandemic was defined in two ways. First, the fixed date of March 13, 2020 was used. This date, which represents the timeframe in which states and businesses considered stay-at-home mandates, was selected to be consistent with prior studies that used a mid-March timeframe (11,16). PA before March 13, 2020 was therefore defined as "not impacted by COVID-19" and PA after March 13, 2020 was defined as "impacted by COVID-19."

Secondly, the self-reported COVID-19 impact date was used. Specifically, at each assessment conducted after mid-March of 2020, women were asked, "Has your lifestyle or daily routine been impacted by the COVID-19 pandemic?" For those that responded 'yes', we asked participants to provide a date of impact (e.g., started work from home). PA before the self-reported COVID-19 impact date was therefore defined as "not impacted by COVID-19" and PA after the self-reported COVID-19 impact date was defined as "impacted by COVID-19."

Covariates

Information on age, first day of last menstrual period, expected delivery date, and parity were collected via self-report at the beginning of each assessment period. During the early pregnancy in-person assessment, the researcher measured height and weight using a stadiometer and a calibrated scale, respectively; for virtual assessments this information was collected via self-report. Body mass index was calculated as kg/m^2. Gestational age (weeks) was calculated using first day of last menstrual period and/or expected delivery date.

Statistical Analysis

Linear mixed effects regression models were used to evaluate the impact of COVID-19 on PA and sedentary behavior at each of the three assessment timepoints (i.e., early, middle, and late pregnancy). Established risk factors for PA and sedentary behavior in models (i.e., age, early pregnancy BMI, gestational age, parity) were included as covariates. Models with ActiGraph PA outcomes were further adjusted for wear time minutes. Chi-square likelihood ratio tests were used to identify whether COVID-19 had a statistically significant impact on PA and sedentary behavior outcomes using an alpha level of 0.05.

A secondary prospective analysis among women whose enrollment period spanned the pre and post COVID-19 pandemic onset dates was then conducted. This analysis, therefore, excluded women whose follow-up ended before the COVID-19 impact date or who were enrolled after the COVID-19 impact date. Sociodemographic and medical history characteristics of this prospective subsample were compared to the excluded sample using 2-sample t-tests for quantitative characteristics and Chi-square tests for categorical characteristics. Linear mixed effects regression models with random intercept for participants were used to evaluate the impact of COVID-19 on PA and sedentary behavior.

All analyses were conducted using R (version 3.6.1).

RESULTS

Among the overall sample (N=50), women were on average 32.9 ± 4.2 years, non-Hispanic white (80%), and overweight (25.1 ± 3.6 kg/m^2) (Table 2.1) with 90-100% reporting attending school or working during follow-up. Three and six women had missing PPAQ data at the middle and late pregnancy assessment time points, respectively. One woman was excluded from the ActiGraph analyses for not meeting the criteria of 10 hours of wear time for at least 4 days in the early, middle, and late pregnancy assessment periods. Mean gestational age was 14.7 ± 3.8 in early, 26.3 ± 3 in middle, and 36 ± 1.3 weeks in late pregnancy.

Firstly, the impact of the onset of the pandemic within each assessment period (i.e., early, mid, and late pregnancy) was evaluated. Using the fixed COVID-19 impact date and PPAQ measures assessed in early pregnancy, we observed higher sedentary behavior (14.2 MET-hrs/wk, 95% CI: 2.3, 26.0) after the onset of the pandemic as compared to measures completed pre-pandemic (Table 2.2). However, no other significant differences in PPAQ (i.e., meeting ACOG guidelines, household/caregiving, sports/exercise, occupational, transportation, light-intensity, moderate, or vigorous activity) or ActiGraph (i.e., locomotion, steps/day, sedentary time) measured PA was observed between assessments held prior to or after the fixed COVID-19 impact date.

Using the self-reported COVID-19 impact date, compared to the pre-pandemic time period, greater household/caregiving activity was observed in middle and late pregnancy assessments held after the onset of the pandemic (34.4 MET-hrs/wk, 95% CI 8.5, 60.3 and 25.9 MET-hrs/wk, 95% CI: 0.9, 50.9, respectively) as compared to assessments held pre-pandemic. A difference of approximately 35 MET-hrs/wk would be equivalent to, for example, 7-9 hours per week in raking/gardening or other moderate intensity household activity. In addition, compared to the pre-pandemic time period, less occupational activity was observed in middle and late pregnancy assessments held after the onset of the pandemic (-34.5 MET-hrs/wk, 95% CI: -61.9, -7.0 and -30.6 MET-hrs/wk, 95% CI: -51.4, -9.8). This would be equivalent to, for example, to 7-8 fewer hours per week walking quickly at work. In terms of ActiGraph measures, less locomotion (walking/running) was observed in middle pregnancy assessments (-8.0 hrs/wk, 95% CI: -15.7, -0.3) held after the onset of the pandemic as compared to assessments held pre-pandemic in adjusted analyses (Table 2.3). Other PPAQ and ActiGraph-measured PA outcomes did not significantly differ among women who participated prior to or after the self-reported COVID-19 impact date.

A secondary analysis to evaluate the prospective impact of the COVID-19 pandemic was conducted. Women whose follow-up ended entirely prior to the COVID-19 impact date or whose enrollment started after the COVID-19 impact date were excluded from this prospective analysis leaving a final sample size of n=20. Women in this subgroup did not significantly differ from the excluded sample in terms of any sociodemographic or medical history characteristics (all $p > 0.05$).

Compared to the pre-pandemic time period defined by the fixed COVID-19 impact date, locomotion (-6.2 hrs/week, 95% CI: -11.5, -1.5) and percent of time in locomotion (-0.7%, 95% CI: -1.3, -0.1) as measured by the ActiGraph significantly decreased after the onset of the pandemic adjusting for age, early pregnancy BMI, gestational age, parity, and wear time (**Table 4**). This would be equivalent to, for example, a decrease of almost 6 hours per week in walking to go places. Similarly, using the PPAQ measures, statistically significant decreases in transportation activity (-19.7 MET-hrs/wk, 95% CI: - 27.4, -13.7) and increases in household/caregiving activity (19.2 MET-hrs/wk, 95% CI: 1.8, 38.0) were observed after the onset of the pandemic (Table 2.4) as compared to the pre-pandemic time period. This would be equivalent to, for example, 5 hours per week in raking/gardening or other moderate intensity household activity. Similar reductions in transportation activity (-16.7 MET-hrs/wk, 95% CI: -24.7, -8.8) were observed using the self-reported COVID-19 impact date. An impact of the pandemic on other PPAQ measures (i.e., meeting ACOG guidelines, household/caregiving, sports/exercise, occupational, light-intensity, moderate, or vigorous activity) was not observed.

DISCUSSION

In this analysis of the impact of the COVID-19 pandemic on PA during pregnancy using both objective and self-reported measures of PA and sedentary behavior, it was found that locomotion and transportation PA decreased, and household/caregiving PA increased after the onset of the COVID-19 pandemic using the fixed COVID-19 impact date of March 13, 2020. Additionally, higher levels of sedentary behavior in early pregnancy assessments conducted after the fixed COVID-19 impact date as compared to assessments conducted pre-pandemic were observed. No impact of the pandemic on steps/day, total vector magnitude, occupational, sports/exercise activity, or meeting ACOG guidelines.

Consistent with our findings, the majority of the prior cross-sectional studies found that the COVID-19 pandemic negatively impacted PA during pregnancy(57-59, 62, 65). For instance, Hillyard et al. conducted an internet based survey among 724 pregnant participants with gestational diabetes mellitus in the UK (59). Using a single-item PA measure, the authors found that while almost half (47%) reported meeting PA guidelines pre COVID-19, this dropped to 23% during the COVID-19 pandemic while sedentary time increased for 79% of participants. In contrast, in the only study to use a validated measure of pregnancy PA and sedentary behavior (i.e., the Japanese PPAQ), Hori et al. conducted an internet based survey among 168 pregnant women in their second and third trimesters in Japan (60). The authors found no significant differences in PA (i.e., total PA, intensity and type of activity, and inactivity) between women who reported being affected by the pandemic as compared to those who were unaffected.

Our prospective findings are similar to the one prior prospective study that examined PA patterns in pregnant women before and during the COVID-19 pandemic. In this study among 38 Finnish pregnant women (64), the authors found that device-estimated step counts, using a Samsung smartwatch, decreased ($p = 0.001$) and inactive time increased ($p = 0.014$) after the COVID-19 national restrictions.. In terms of prospective studies conducted prior to the pandemic, A recent study using the National Institute of Child Health and Human Development Fetal Growth Studies (N=2,947) (70), found that median total PA declined by 47%, from 297 to 157 MET-hours/wk throughout pregnancy. This decline was largely driven by decreases in household and occupational activity. Throughout pregnancy, sedentary time decreased from baseline (14% of reported MET-hrs/wk) by 26% (35 to 26 MET-hrs/week). Although there was no impact of the COVID-19 pandemic on sedentary behavior in our prospective analyses, a decrease in locomotion and transportation PA and increase in household PA was observed which highlight the implications of lockdown.

Differences in findings between our study and prior studies may have occurred due to the differences in the tools used to measure PA. For example, prior research has shown large variability between step estimates from research-grade (ActiGraph) and consumer-grade (e.g., Samsung, Fitbit) devices (71, 72). For self-reported measures, the detailed PPAQ was used, as did one prior cross-sectional study by Hori et al. (60). In contrast, the one prior prospective study relied upon a single-item Likert-scale PA (0-100) question. Lastly, studies varied in their measures of COVID-19 impact with the majority relying upon the self-reported impact of COVID-19.

Our study had several strengths including the use of a research grade wearable device (ActiGraph) and a questionnaire validated for use in pregnancy to measure PA according to multiple domains of type and intensity. The use of both a fixed COVID-19 impact date as well as a self-reported impact date) took into account individual-level variability in how women perceived being affected by the COVID-19 pandemic were also study strengths. Finally, our secondary prospective analysis allowed us to assess the temporal association of the COVID-19 pandemic on PA during pregnancy, although the sample size for this analysis was small and findings should be interpreted with caution.

Our study also had several limitations. First, self-reported information on PA is subject to error. A recent systematic review of physical activity questionnaires for pregnancy recommended the PPAQ to assess PA in pregnancy concluding that it has sufficient reliability in assessing total physical activity and vigorous physical activity. However, the authors noted that the PPAQ revealed insufficient construct validity in assessing these scores, but that the evidence for this was of low-to moderate quality (4). The review article, therefore, called for future research on the validity of comparison instruments in pregnancy followed by consensus on validation reference criteria. Such error, if it occurred, would tend to bias our results toward the null.

On a related issue/topic, while the PPAQ asked participants if they attended school or work, either for wages or as a volunteer during pregnancy, we did not have more detail on the percent working from home nor regarding which careers could be accommodated via work at home during the pandemic.

Secondly, the use of a fixed date (March 13, 2020) to define the onset of COVID-19 may not be individually applicable to all participants. However, the similar associations in our findings using either the fixed or self-reported COVID-19 impact date suggests that this source of bias may be minimal. Third, PA tends to decrease as the pregnancy progresses (73), and our results, and those of prior studies, may partly be explained by normal changes during pregnancy rather than by a change due to the COVID-19 pandemic. However, the consistency of our cross-sectional findings conducted within each stage of pregnancy (early, mid, and late) with our prospective subanalysis, although limited by a small sample size, help to reduce this concern. Lastly, our participants were largely non-Hispanic white women. Therefore, findings may not be generalizable to all pregnant women in the US. For example, studies show that factors related to the COVID-19 pandemic such as employment loss during the onset of the pandemic differentially affected people of color (74).

In summary, the current study adds to the growing body of research on the impact of the COVID-19 pandemic on PA and sedentary behavior during pregnancy. In the current study, locomotion, transportation, occupational PA, and sedentary behavior were negatively impacted by the COVID-19 pandemic and household/caregiving activity increased. Reduced levels of pregnancy PA are of concern as this may increase the risk of pregnancy complications such as preeclampsia, gestational diabetes mellitus, and increased gestational weight gain. Furthermore, the mental health impact of a pandemic and its associated restrictions will likely be further exacerbated by increases in stress and anxiety which have been associated with low levels of PA (54). Future studies should investigate whether such negative lifestyle changes persist over time.

Our findings also have implications for the promotion of PA during pandemic-related restrictions. For example, when pandemic lockdowns are initiated, prenatal health care providers should be instructed to address barriers and facilitators to PA and sedentary behavior in their counseling sessions. Resources to help pregnant women maintain healthy lifestyles during pandemics should be tailored for specific racial/ethnic subgroups and take into account diversity in socioeconomic status and access to resources. These may include increased accessibility of online PA classes, provided by instructors qualified in prenatal exercise, as well as resources on how to be active at home, with limited space and equipment.

Table 2.1 Characteristics of the Study Sample

Characteristics	**Overall Sample**
N	50
Covariates	
Age (years)	32.9 ± 4.2
Prepregnancy body mass index (kg/m^2)	25.1 ± 3.6
Parity (prior pregnancies)	1.1 ± 1.4
Mean gestational age (wks)	
Early pregnancy	14.9 ± 3.8
Middle pregnancy	26.0 ± 3.0
Late pregnancy	35.9 ± 1.6
Non-Hispanic White (%)	80%
Wear Time (hrs/day)	13.5 ± 1.6
PPAQ Measures (MET-hrs/wk)	
Meeting ACOG guidelines* (%)	47%
Total physical activity	153 ±49.5
Type	
Household/Caregiving	61.0 ± 40.6
Sport/Exercise	9.6 ± 8.9
Occupational	45.6 ± 36
Transportational	14.5 ± 12.9
Intensity	
Light	36.3 ± 25.5
Moderate	62.0 ± 34.9
Vigorous	2.3 ± 5.5
Sedentary	52.4 ± 24.3
ActiGraph Measures	
Total vector magnitude (1000 counts/day)	2154.7 ± 738.9
Sedentary Time	
min/day	516.6 ± 116.6
% time	63.5 ± 11.6
Locomotion (Walking/Running)	
min/day	12.6 ± 13.9
% time	1.6 ± 1.7

*American College of Obstetricians and Gynecologists of ≥7.5 MET hours/week of moderate-vigorous intensity sports and exercise.

Table 2.2 Cross-Sectional Association of COVID-19 on Pregnancy Physical Activity and Sedentary Behavior Using a Fixed Impact Date.

Variable	Early Pregnancy		Mid Pregnancy		Late Pregnancy	
	β (95% CI)[a]	p-value	β (95% CI)[a]	p-value	β (95% CI)[a]	p-value
ActiGraph Measures						
Total vector magnitude (1000 counts/day)	-91.8 (-458.4, 274.8)	0.62	106.2 (-269.5, 483.4)	0.57	-149.7 (-530.1, 242.9)	0.48
Sedentary Time						
min/day	17.8 (-27.0, 62.6)	0.43	5.1 (-42.9, 53.1)	0.84	16.3 (-33.5, 65.0)	0.54
% time	1.9 (-3.5, 7.4)	0.48	0.6 (-5.5, 6.7)	0.85	1.5 (-4.8, 7.6)	0.66
Locomotion (Walking/Running)						
min/day	-2.2 (-7.8, 3.4)	0.43	-5.0 (-12.3, 2.3)	0.18	-5.4 (-11.3,1.0)	0.10
% time	-0.3 (-1.0, 0.5)	0.48	-0.6 (-1.4, 0.3)	0.21	-0.6 (-1.3, 0.2)	0.14
PPAQ Measures (MET-hrs/wk)						
Meeting ACOG guidelines (%)	0.1 (-2.1, 2.4)	0.90	1.6 (-2.6, 9.5)	0.40	0.6 (-3.0, 5.0)	0.72
Total physical activity	7.8 (-14.6, 30.0)	0.50	4.1 (-26.4, 34.5)	0.79	18.3 (-13.6, 52.1)	0.24
By type						
Household/Caregiving	-1.4 (-20.7, 18.0)	0.89	23.3 (-0.7, 47.3)	0.06	12.7 (-3.9, 33.3)	0.12
Sport/Exercise	5.2 (-0.5, 10.2)	0.08	-0.5 (-6.3, 5.4)	0.87	0.5 (-3.1, 3.9)	0.90
Occupational	5.3 (-10.5, 20.8)	0.52	-21.9 (-47.3, 3.6)	0.09	-12.5 (-36.1, 10.6)	0.28
Transportation	-4.5 (-11.3, 2.2)	0.18	-8.1 (-14.5, -1.6)	0.02	-2.6 (-9.0, 3.7)	0.41
By intensity						
Light	-4.0 (-19.1, 10.8)	0.57	-6.4 (-21.9, 9.1)	0.41	-0.6 (-11.2, 10.6)	0.95
Moderate	-1.8 (-16.5, 13.0)	0.81	8.2 (-11.2, 27.6)	0.40	21.6 (-1.5, 45.9)	0.07
Vigorous	0.3 (-2.4, 3.1)	0.80	-2.5 (-6.7, 1.7)	0.23	-0.6 (-2.8, 1.4)	0.52
Sedentary	14.2 (2.3, 26.0)	0.02	4.8 (-11.9, 1.5)	0.57	-1.6 (-15.1, 12.2)	0.83

*American College of Obstetricians and Gynecologists of ≥7.5 MET hours/week of moderate-vigorous intensity sports and exercise.

[a]Models adjusted for age, BMI, gestational age, and parity. ActiGraph measures were also adjusted for wear time.

Table 2.3 Cross-Sectional Association of COVID-19 on Pregnancy Physical Activity and Sedentary Behavior using a Self-Reported Impact Date

Variable	**Early Pregnancy**		**Mid Pregnancy**		**Late Pregnancy**	
	β (95% CI)[a]	p-value	β (95% CI)[a]	p-value	β (95% CI)[a]	p-value
ActiGraph Measures						
Total vector magnitude (1000 counts/day)	-159.8 (-599.2, 279.4)	0.47	30.4 (-379.9, 442.1)	0.88	-239.6 (-607.4, 127.9)	0.47
Sedentary Time						
min/day	35.8 (-17.2, 88.9)	0.18	12.6 (-39.6, 64.6)	0.63	29.0 (-17.8, 75.8)	0.22
% time	4.2 (-2.3, 10.7)	0.20	1.7 (-5.0, 8.3)	0.62	3.0 (-2.9, 8.9)	0.30
Locomotion (Walking/Running)						
min/day	-2.8 (-9.5, 3.9)	0.10	-8.0 (-15.7, -0.3)	0.04	-2.9 (-8.8, 3.0)	0.10
% time	-0.3 (-1.2, 0.5)	0.47	-0.9 (-1.8, 0.0)	0.05	-0.3 (-1.0, 0.4)	0.47
PPAQ Measures (MET-hrs/wk)						
Meeting ACOG guidelines (%)	-0.2 (-2.9, 2.5)	0.88	3.6 (-0.9, 12.8)	0.12	0.2 (-3.8, 4.2)	0.90
Total physical activity	5.6 (-20.9, 32.0)	0.67	2.7 (-31.4, 36.8)	0.88	-4.9 (-38.8, 29.1)	0.78
By type						
Household/Caregiving	2.6 (-20.9, 26.0)	0.83	34.4 (8.5, 60.3)	0.01	25.9 (0.9, 50.9)	0.04
Sport/Exercise	1.6 (-4.3, 7.5)	0.59	3.4 (-3.1, 9.8)	0.29	0.2 (-4.9, 5.3)	0.93
Occupational	1.3 (-17.8, 20.4)	0.89	-34.5 (-61.9, -7.0)	0.02	-30.6 (-51.4, -9.8)	0.01
Transportation	-0.5 (-8.9, 7.9)	0.90	-5.7 (-13.2, 1.9)	0.14	-4.9 (-11.9, 2.2)	0.17
By intensity						
Light	-8.9 (-27.3, 9.5)	0.33	-3.4 (-20.9, 14.0)	0.69	-1.0 (-16.5, 14.5)	0.90
Moderate	-0.6 (-17.9, 16.8)	0.95	8.1 (-13.7, 29.8)	0.46	2.8 (-21.1, 26.7)	0.81
Vigorous	2.1 (-1.4, 5.7)	0.23	-0.5 (-5.3, 4.3)	0.83	-0.8 (-3.6, 2.0)	0.57
Sedentary	13.0 (-1.4, 27.3)	0.08	-1.5 (-20.2, 17.2)	0.87	-5.9 (-21.2, 9.3)	0.44

*American College of Obstetricians and Gynecologists of ≥7.5 MET hours/week of moderate-vigorous intensity sports and exercise.

[a]Models adjusted for age, BMI, gestational age, and parity. ActiGraph measures were also adjusted for wear time.

Table 2.4 Prospective Impact of COVID-19 on Pregnancy Physical Activity and Sedentary Behavior.

Variable	**Fixed COVID-19 Date**		**Self-Reported COVID-19 Date**	
	β (95% CI)[a]	p-value	β (95% CI)[a]	p-value
ActiGraph Measures				
Total vector magnitude (1000 counts/day)	-36.3 (-285.8, 225.8)	0.82	10.1 (-268.1, 284.5)	0.95
Sedentary Time				
min/day	8.8 (-25.2, 42.5)	0.61	5.9 (-30.1, 43.3)	0.72
% time	1.2 (-3.0, 5.4)	0.57	0.6 (-3.8, 5.3)	0.75
Locomotion (Walking/Running)				
min/day	-6.2 (-11.5, -1.5)	0.01	-3.3 (-9.6, 1.6)	0.35
% time	-0.7 (-1.3, -0.1)	0.02	-0.3 (-1.1, 0.3)	0.29
PPAQ Measures				
Meeting ACOG guidelines* (%)	0.8 (-1.3, 2.9)	0.45	0.4 (-2.1, 2.7)	0.74
Total physical activity	3.4 (-20.8, 28.4)	0.76	-3.1 (-29.2, 26.3)	0.91
By type				
Household/Caregiving	19.2 (1.8, 38.0)	0.03	9.6 (-10.0, 31.6)	0.31
Sport/Exercise	1.2 (-3.9, 6.5)	0.62	-0.3 (-5.7, 6.2)	0.95
Occupational	-7.4 (-22.1, 5.2)	0.22	-4.5 (-20.7, 9.7)	0.48
Transportation	-19.7 (-27.4, -13.7)	<0.001	-16.7 (-24.7, -8.8)	<0.001
By intensity				
Light	-5.9 (-16.4, 4.4)	0.25	-4.9 (-16.3, 7.0)	0.43
Moderate	11.1 (-6.9, 30.0)	0.22	1.8 (-17.8, 24.4)	0.77
Vigorous	-2.2 (-6.2, 1.7)	0.25	-2.1 (-6.4, 2.5)	0.39
Sedentary	0.5 (-10.0, 11.4)	0.90	3.4 (-8.4, 15.4)	0.56

*American College of Obstetricians and Gynecologists of ≥7.5 MET hours/week of moderate-vigorous intensity sports and ex

[a]Models adjusted for age, BMI, gestational age, and parity. ActiGraph measures were also adjusted for wear time.

CHAPTER

III. VALIDITY AND RELIABILTY OF THE PREGNACY PHYSICAL ACTIVITY QUESTIONAIRE SHORT FORM (PPAQ-SF)

ABSTRACT

To develop and evaluate the validity of the Pregnancy Physical Activity Questionnaire-Short Form (PPAQ-SF). Participants (N=50) completed the updated PPAQ (long-form) before and after each weekly assessment during early, mid, and late pregnancy. During the assessments, participants wore an ActiGraph. The top ten questions with the highest relative contribution to the between-person variance in total MET-hrs/wk were selected for the PPAQ-SF. The internal validity of the PPAQ-SF was evaluated using the updated PPAQ (long-form) and ActiGraph within the internal dataset. Similarly, the external validity of the PPAQ-SF was evaluated in an independent sample (N=222) using the updated and original PPAQ (long-form). The mean (SD) of moderate-to-vigorous physical activity (MVPA) MET-hrs/day and hrs/day were calculated, and Spearman correlation coefficients were calculated to assess internal and external validity of the PPAQ-SF. Based on the internal validation, the PPAQ-SF produced statistically significant and similar estimates of MVPA MET-hours/day and hours/day overall and during each assessment (r=0.96-0.99) compared to the updated PPAQ. ActiGraph estimates of MVPA MET-hours/day were consistently higher than the PPAQ-SF and had moderate to no correlation with the PPAQ-SF (r=0.21-0.49). Based on the external validation, the PPAQ-SF estimates of MVPA MET-hours/day were consistently lower overall but had strong correlations (r=0.94) with the updated and original PPAQ. The

PPAQ-SF produced sufficient estimates of MVPA MET-hours/day and MVPA hours/day compared to the updated and original PPAQ long-forms. The PPAQ-SF can provide a quick measure of MVPA during pregnancy.

INTRODUCTION

Physical activity during pregnancy has been associated with a lower risk of adverse maternal health outcomes (e.g., gestational diabetes mellitus, excessive gestational weight gain, preeclampsia) and infant health outcomes (e.g., macrosomia) (75, 76). The American College of Gynecologists (ACOG) recommends that women obtain at least 30 minutes of moderate-intensity physical activity on most days of the week during pregnancy and postpartum (75). Despite the benefits of physical activity, physical activity levels are consistently lower in pregnant as compared to non-pregnant populations and have been shown to decrease across the course of pregnancy and postpartum (77-80). In 2020, the Surgeon General's Call to Action for Maternal Health highlighted the importance of improving the quality of data on risk factors for adverse maternal and child outcomes during pregnancy such as physical activity (81).

Self-reported assessments are the most common measure of physical activity in large-scale clinical trials, interventions, and surveillance studies. Although the use of wearable activity monitors has grown in popularity in recent years, they are more costly and can require additional personnel and expertise to extract usable information. Additionally, lower compliance and challenges with measuring long-term or habitual activity have been reported with wearable activity monitors compared to self-reported assessment tools (82). In studies without a primary focus on physical activity and which involve the administration of multiple questionnaires, short-form versions of questionnaires are critical to reduce participant burden. It is therefore essential that such short forms have acceptable validity.

Only two short-form questionnaires, the International Physical Activity Questionnaire-Short Form (IPAQ-SF) and the Short Pregnancy Leisure-Time Questionnaire (S-PLTQ), have been used to measure physical activity in pregnancy (41, 45). Although both questionnaires were subsequently validated in pregnant populations, neither were originally developed with this purpose in mind. In addition, the measures of moderate-to-vigorous physical activity (MVPA) were mainly limited to leisure-time activities, and therefore did not consider moderate-to-vigorous activities within the domains of occupational, household/caregiving, and transportation. This omission could result in misclassifying pregnant women as inactive when the opposite is true (83).

The Pregnancy Physical Activity Questionnaire (PPAQ) is one of the most widely used instruments for assessing physical activity during pregnancy and has been translated and validated for use in over 13 languages and used in approximately 70 countries (6). Despite widespread use of the PPAQ, it involves 32 questions and can take up to 20 minutes to complete depending upon the study population. The PPAQ has recently been updated to include contemporary sedentary behaviors and the most recent MET values (84).

Therefore, our overall goal was to develop a 10-item short form version of the updated PPAQ with a focus on providing a valid measure of MVPA. Our specific aims were to: 1) develop the PPAQ-SF using a data-driven approach in a pregnant population, 2) evaluate the validity of the PPAQ-SF in a free-living setting using an ActiGraph, and

3) evaluate the validity of the PPAQ-SF using the long-form PPAQ (original and updated versions) as the referents in both an internal and external dataset of pregnant participants.

METHODS

<u>Development of the Pregnancy Physical Activity Questionnaire – Short Form</u>

Study Population

Participants (N = 50) were part of an observational cohort study (March 2019-January 2021) designed to develop and validate an updated version of the PPAQ long-form and to develop a new PPAQ-SF (NIH/NICHD 1R21HD094565). Details of the validity and the reliability of the updated PPAQ long-form have been previously published (84). Participants were recruited in early pregnancy using flyers, local advertisements, and paid Facebook™ advertisements. A single item rating scale for level of physical activity was used to ensure participants represented a range of physical activity levels (e.g., low active to high active participants) (8). Exclusionary criteria for the study included having: 1) >20 weeks gestation, 2) under 16 or over 40 years of age, 3) pregnant with twins or triplets as this is often accompanied by clinically prescribed PA restrictions, 4) musculoskeletal issues that limited ambulation, 5) chronic disease (e.g., diabetes requiring insulin, hypertension or heart disease requiring medication, chronic renal disease, emphysema) or life-threatening illnesses, or 6) lack of a telephone. Each participant read and signed a written informed consent approved by the Institutional Review Board of the University of Massachusetts, Amherst.

<u>Study Design</u>

Three assessments (seven consecutive days) were conducted in early (baseline), mid, and late pregnancy. At the baseline assessment, information on age, first day of last menstrual period, expected delivery date, parity, and race/ethnicity were collected via self-report, and height and weight were measured using a stadiometer and a calibrated scale. Due to the COVID-19 pandemic, the in-person protocol was modified to be fully remote. For remote, height and weight information were collected via self-report. Early pregnancy body mass index (BMI) was calculated as kg/m^2, and gestational age (weeks) was calculated using first day of last menstrual period and/or expected delivery date.

At the beginning of each of the three assessment periods, the updated PPAQ long-form was interviewer-administered (in-person, n=40 or virtually, n=10) (Figure 1.1). Participants were instructed on how to wear the ActiGraph for the following seven days and were provided with a wear log to record periods when the accelerometer was not worn (e.g., during sleep or water-based activities). Video demonstrations of how to correctly wear the monitor and links to paper-based materials were available for participants on the study website and provided via hardcopy. At the end of each assessment period, the PPAQ long-form was repeated.

Selection of activities for the questionnaire

To select questions from the Updated PPAQ for inclusion in the PPAQ-SF (Appendix 3.1), activities were ranked based on the relative contribution of each activity to the between-person variance in total MET-hrs/wk. Specifically, we used stepwise multiple regression with the total MET-hrs/wk as the dependent variable and the MET-score associated with each activity as the independent variables for overall pregnancy and for each pregnancy time period assessment. This approach has been used to reduce the length of questionnaires by selecting only the most informative activities and potentially identifying activities that may be overlooked as contributors to total energy expenditure (85). We then selected the top ten activities that explained the most between-person variance in total MET-hrs/wk. The change in cumulative R^2, statistical significance of the contribution to the cumulative R^2, and the total number of activities included in the model were used to determine the inclusion of each question. Coding instructions for the PPAQ-SF are presented in Appendix 3.2.

<u>Validation of the Pregnancy Physical Activity Questionnaire – Short Form</u>

PPAQ-SF Internal Validation – Objective Measure

Participants were instructed to wear the ActiGraph, ActiGraph GT3X-BT (Pensacola, FL), on the non-dominant wrist during the three assessment periods except during sleep or water-based activities. Monitors were initialized to collect data at 80 Hz using ActiLife 6 software (version 6.13.1). After each assessment period, data were exported as raw and 1-second epoch files.

Wear time was based on self-report or, if missing, using the Choi wear time algorithm.(22) Assessment periods with at least 10 hours of wear time for at least 4 days were included.(23) Time and frequency-domain features were computed from raw acceleration data in 15-second non-overlapping epochs and used in previously trained random forest models to classify accelerometer data according to intensity (24).

We calculated the mean and standard deviation for variables derived from the PPAQ-SF and ActiGraph. To evaluate the validity of the PPAQ, we calculated Spearman correlation coefficients between the PPAQ-SF (the mean of the pre- and post-assessments) compared to weekly summaries of the ActiGraph measures, within each measurement period. Based on the Qualitative Attributes and Measurement Properties of Physical Activity Questionnaires (QAPAQ) and the systematic review of pregnancy physical activity questionnaires by Sattler et al., validity scores for correlations with accelerometers of >0.4 were deemed acceptable(4, 86). We inspected scatterplots as graphical displays of these relationships.

PPAQ-SF Internal Validation - Self Report

We evaluated the validity of the PPAQ-SF using the updated PPAQ (long-form) as a referent in our internal dataset of 50 pregnant participants. The updated PPAQ is a semi-quantitative instrument that measures duration and intensity of time spent in household/caregiving, occupational, transportation, sports/exercise activities, and sedentary behavior (6, 84). Metabolic equivalent (MET) values are based upon pregnancy studies, and, when not available, the 2011 Compendium of Physical Activity (12-14). MET-hours/week are calculated by multiplying the number of hours spent in each reported activity by its MET level using standard cut points to define activity by intensity: sedentary (1- <1.5 METs), light (≥1.5–<3 METs), moderate-to-vigorous (≥3 METs) and by type: sports/exercise, household/caregiving, occupational, and transportation.

We calculated the mean and standard deviation of variables derived from the PPAQ-SF and the updated PPAQ long-form. To evaluate the validity of the PPAQ, we calculated Spearman correlation coefficients between the PPAQ-SF (the mean of the two assessments) compared to weekly summaries of the PA measurements from the PPAQ long-form within each measurement period.

PPAQ-SF External Validation - Self Report

We then evaluated the validity of the PPAQ-SF using the updated and original long-form versions of the PPAQ as referents in an external dataset of 222 pregnant participants, Proyecto Mamá. Details of Proyecto Mamá have been previously published (87). Briefly, Proyecto Mamá was a randomized controlled trial (2014-2020) conducted to test the efficacy of a culturally and linguistically modified, individually-tailored lifestyle intervention to reduce excess gestational weight gain, increase postpartum weight loss, and improve maternal metabolic status (NIH/ 1R01DK097011). The trial was conducted at the ambulatory obstetrical practices of Baystate Medical Center in Western Massachusetts. Hispanic women with overweight or obesity (BMI$\geq$25 kg/m^2) between the ages of 18-45 years in early pregnancy (<16 weeks gestation) were eligible for the study. All protocols were approved by the Institutional Review Boards at the University of Massachusetts Amherst and Baystate Health. Bicultural and blinded assessors administered the original long-form PPAQ in early, mid, and late pregnancy (6).

Like the updated long-form PPAQ, the original long-form PPAQ includes 33 questions and asked women to self-report time spent in four physical activity domains (i.e., household/caregiving, occupational, sports/exercise, transportation) in the past trimester. We calculated two sets of MVPA MET-hours/week and hours/week using: 1) the original PPAQ long-form instructions which were primarily based on the 2000 Compendium of Physical Activity,(88) and 2) using the updated instructions which were primarily based on the 2011 Compendium of Physical Activity (14).

Because pregnancy assessment time points differed between the two studies, this analysis focused on total pregnancy activity. We calculated the mean and standard deviation for variables derived from the PPAQ-SF and the original and updated PPAQ long-forms. To evaluate the validity of the PPAQ, we calculated Spearman correlation coefficients between the PPAQ-SF (the mean of the two assessments) compared to total PA from the original and updated PPAQ long-forms.

RESULTS

Participants in the PPAQ Study (internal dataset) were on average 32.9 (SD 4.2) years, predominantly non-Hispanic white (80%), and parous (56%) with an early pregnancy BMI of 25.1 (SD 3.6) kg/m^2 (Table 3.1). Across pregnancy assessments, most participants in the PPAQ Study did not meet the PA guidelines (Figure 3.1). Participants in Proyecto Mamá were 100% Hispanic and on average younger than participants in the internal dataset 24.8 (SD 5.2) years, with lower proportion of nulliparous (36%) and higher average BMI (33.0 kg/m^2 (SD 6.9)).

<u>PPAQ-SF Internal Validation – Objective Measure</u>

Internal validity was assessed by comparing the PPAQ-SF to ActiGraph and updated PPAQ long form in the 50 pregnant participants. Compared to the updated PPAQ long-form, ActiGraph estimates of MVPA MET-hours/day overall and during each pregnancy time period were consistently higher (e.g., 3.5 [7.4] vs. 5.5 [SD 18.8] for overall pregnancy). Spearman correlations between the ActiGraph and the PPAQ-SF ranged from 0.21 for early pregnancy to 0.49 to mid-pregnancy with an overall pregnancy correlation of 0.34. Findings for MVPA hours/day were slightly lower, ranging from 0.15 for late pregnancy to 0.38 for mid pregnancy.

Compared to the updated PPAQ long-form, the PPAQ-SF produced similar estimates of MVPA MET-hours/day and MVPA hours/day in overall pregnancy (mean difference of ≤0.3 MET-hours/day, ≤0.1 hours/day) (Table 3.2) as well as during each pregnancy period. Spearman correlations between the updated PPAQ long-form and the PPAQ-SF ranged from 0.96 to 0.99 and were statistically significant.

PPAQ-SF External Validation – Self Report

We then evaluated the validity of the PPAQ-SF in an external dataset of 222 pregnant participants (Proyecto Mamá). Compared to the updated and original long-form versions of the PPAQ, the PPAQ-SF estimates of MVPA MET-hours/day were consistently lower (e.g., 10.8 vs. 12.2 for the updated PPAQ) for overall pregnancy. (Table 3.3). Spearman correlations between the updated and original PPAQ long-forms for MVPA MET-hours/day were 0.94. Findings for MVPA hours/day were nearly identical.

DISCUSSION

In this study involving the development of a short form version of the updated PPAQ long-form, we found that the new 10-item PPAQ-SF had high validity in detecting MVPA MET-hours/day and MVPA hours/day as compared to the updated PPAQ long-form. The PPAQ-SF had only one validity compared to the ActiGraph.

To date, only two other short-form, self-report assessment tools have been validated to measure physical activity during pregnancy (41, 45). Aittasalo et al. assessed the validity of the 7-item leisure-time physical activity questionnaire (LTPAQ, modified from the IPAQ-SF) among 79 pregnant women in Finland (41). The authors found moderate correlations with a self-reported logbook for structured, moderate-to-vigorous-intensity leisure-time activity (r=0.68, 95% CI: 0.48-0.81) but low to no correlation with weekly step frequency (r=0.16, 95% CI: 0.14, 0.43) and duration (r= -0.18, 95% CI: -0.45, 0.12) (41). Sandra et al. assessed validity of the 7-item IPAQ-SF with the SenseWear Armband among 154 pregnant women in Norway (45). The authors found a significant, moderate correlation with vigorous physical activity in minutes/week (r=0.38, p=0.002) among the whole sample, moderate physical activity (r=0.38, p=0.037) among the inactive group, and vigorous physical activity (r=0.42, p=0.013) among the active group. Similarly, in the current study we found validity scores of r=0.34 for MVPA MET-hours/week for overall pregnancy between the PPAQ-SF and the ActiGraph.

Alternatively, we observed higher correlations between the PPAQ-SF and the original and updated PPAQ (ranging from r=0.93-0.94) in our external validation. These findings indicate that the PPAQ-SF can be used to adequately measure MVPA with fewer questions. However, it is important to note that the PPAQ-SF should not be used to measure absolute energy expenditure, as use of fewer questions would yield to lower estimates of MVPA compared to the original and updated PPAQ.

Findings of lower validity between short form questionnaires and objective measures as compared to self-reported measures, are consistent with the fact that these tools measure different aspects of physical activity. Specifically, wearable monitors measure all movement irrespective of the domain of physical activity while the PPAQ-SF was designed to measure physical activity of moderate to vigorous intensity only, due to the strong association between MVPA and several maternal and fetal outcomes (76). Neither tool is the gold-standard for physical activity measurement. Instead, recent review articles have called for the use of a combination of tools to provide the most accurate and comprehensive understanding of physical behavior during pregnancy as it relates to health of the mother and infant (1, 89).

This study has several strengths. We validated the PPAQ-SF in both an internal and an external sample. Demonstrating the validity of the PPAQ-SF to the Updated PPAQ and Original PPAQ in an external dataset that differs in characteristics (e.g., race/ethnicity, BMI, parity) to the PPAQ Study shows that the PPAQ-SF could be generalizable tool. An added benefit of the use of the external sample was that we were able to compare the validity of the PPAQ-SF to the original PPAQ long-form which has been widely used to measure physical activity during pregnancy. Similarly, researchers will be able to compare the PPAQ long-form used in prior studies with the PPAQ-SF (6). Unlike other short-form pregnancy questionnaires, we used a data-driven approach to develop the PPAQ-SF (41, 45). Additionally, the questionnaire that the PPAQ-SF was developed from was designed for use during pregnancy and may provide a more accurate representation of MVPA during pregnancy.

This study also faced several limitations. Because of the limited number of questions in the PPAQ-SF, the tool is not designed to measure light intensity activity nor sedentary behavior. Thus, researchers interested in the association between sedentary behavior and pregnancy outcomes could use the long form version of the PPAQ.

In summary, our findings indicate that the PPAQ-SF can provide valid estimates of MVPA-MET hours/day and MVPA hours/day during pregnancy. For research whose primary focus is not physical activity, the PPAQ-SF can serve as a time-efficient tool.

Table 3.1 Participant Characteristics in the PPAQ Study (2019-21) and the Proyecto Mama (2014-20) Study

Characteristics	PPAQ Study Population (Internal Dataset)	Proyecto Mamá Study Population (External Dataset)
N	50	222
Age (years [SD])	32.9 (4.2)	24.8 (5.2)
Body mass index (kg/m^2 [SD])	25.1 (3.6)	33.0 (6.9)
Parity (N, %))		
Nulliparous	22 (44%)	80 (36%)
1-2	20 (40%)	10 (48%)
≥ 3	8 (16%)	36 (16%)
Mean gestational age (weeks [SD])		
Early pregnancy assessment*	14.9 (3.8)	11.8 (3.5)
Mid pregnancy assessment	26.0 (3.0)	
Late pregnancy assessment	35.9 (1.6)	
Race/ethnicity (N, %)		
Asian	3 (6%)	
Black	1 (2%)	
Hispanic	3 (6%)	222 (100%)
Multi-race	3 (6%)	
Non-Hispanic White	40 (80%)	

*Gestational age at baseline in Proyecto Mamá.

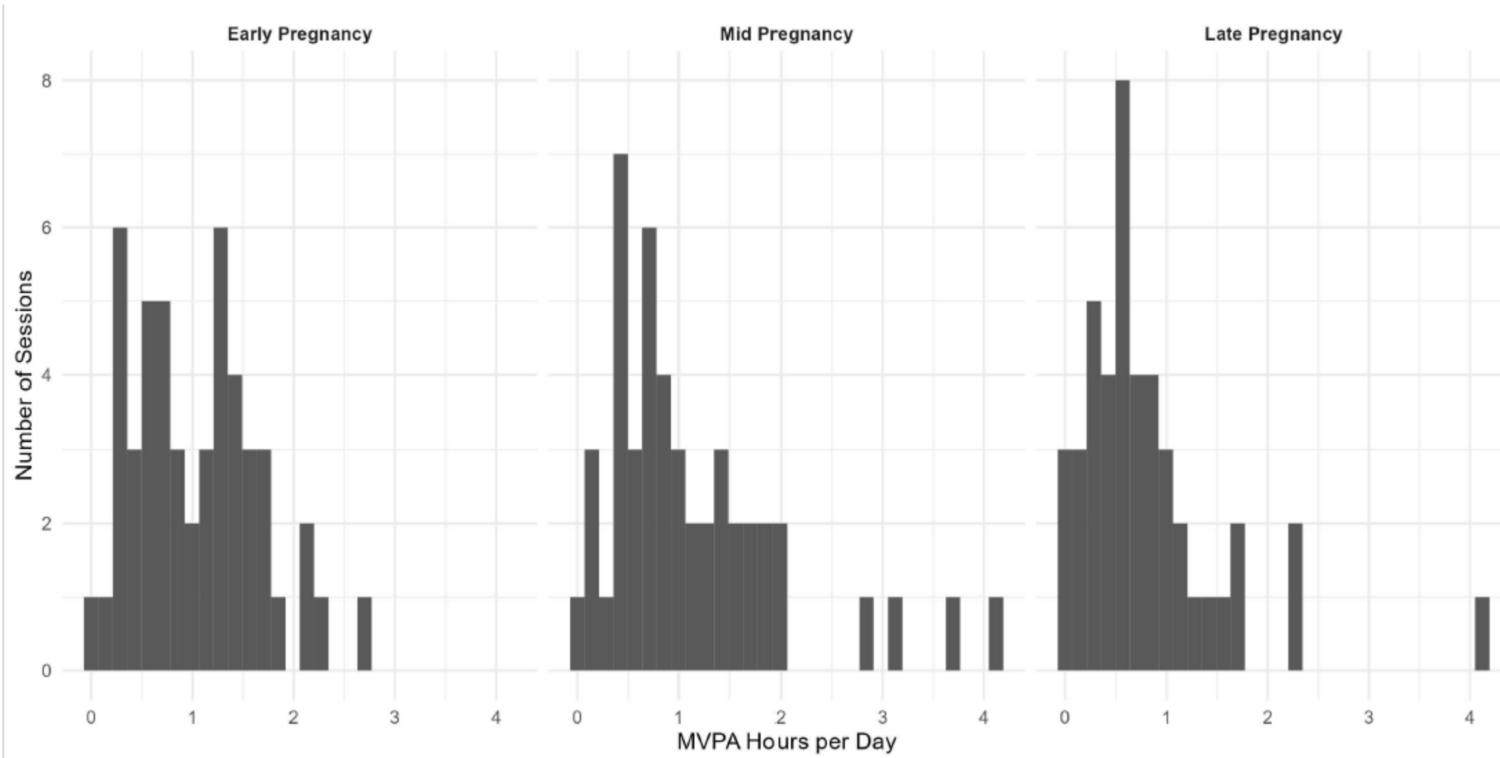
Table 3.2 Spearman Validity Coefficients between PPAQ-Short Form vs. the Updated PPAQ Long-Form and ActiGraph according to Pregnancy Time Period.

Measures		Correlation	
	Mean (SD)	Correlation Coefficient	95%CI
Overall Pregnancy			
MVPA MET-hours/day			
PPAQ-SF	3.5 (7.4)	-	-
Updated PPAQ Long-Form	3.8 (7.5)	0.98	0.97, 0.98
ActiGraph	5.5 (18.8)	0.34	0.18, 0.48
MVPA Hours/day			
PPAQ-SF	0.9 (1.9)		
Updated PPAQ Long-Form	1.0 (1.9)	0.98	0.98, 0.99
ActiGraph	1.0 (4.1)	0.26	0.10, 0.41
Early Pregnancy			
MVPA MET-hours/day			
PPAQ-SF	3.8 (6.4)	-	-
Updated PPAQ Long-Form	4.1 (6.2)	0.98	0.97, 0.99
ActiGraph	5.9 (20.2)	0.21	-0.07, 0.47
MVPA Hours/day			
PPAQ-SF	1.0 (1.7)		
Updated PPAQ Long-Form	1.0 (1.6)	0.99	0.98, 0.99
ActiGraph	1.1 (3.8)	0.17	-0.12, 0.44
Mid Pregnancy			
MVPA MET-hours/day			
PPAQ-SF	4.1 (9.3)	-	-
Updated PPAQ Long-Form	4.5 (9.6)	0.98	0.96, 0.99
ActiGraph	5.6 (18.2)	0.49	0.23, 0.69
MVPA Hours/day			
PPAQ-SF	1.1 (2.3)		
Updated PPAQ Long-Form	1.1 (2.4)	0.99	0.98, 0.99
ActiGraph	1.0 (3.4)	0.38	0.10, 0.61
Late Pregnancy			
MVPA MET-hours/day			
PPAQ-SF	2.6 (5.3)	-	-
Updated PPAQ Long-Form	2.9 (5.8)	0.96	0.92, 0.98
ActiGraph	4.9 (17.3)	0.26	-0.05, 0.52
MVPA Hours/day			
PPAQ-SF	0.7 (1.4)	-	-
Updated PPAQ Long-Form	0.7 (1.5)	0.96	0.93, 0.98
ActiGraph	0.9 (3.5)	0.15	-0.16, 0.43

Table 3.3 Spearman Validity Coefficients between PPAQ Short-Form vs. the Updated PPAQ and Original PPAQ Long-Forms in Proyecto Mamá 2014-2020.

Measures	Mean (SD)	Correlation	
		Correlation Coefficient	95%CI
MVPA MET-hours/day			
PPAQ-SF	10.8 (29.7)	-	-
Updated PPAQ	12.2 (30.8)	0.94	0.90, 0.96
Original PPAQ	12.4 (30.8)	0.94	0.91, 0.96
MVPA Hours/day			
PPAQ-SF	0.4 (1.1)	-	-
Updated PPAQ	0.5 (1.3)	0.93	0.90, 0.96
Original PPAQ	0.5 (1.3)	0.93	0.90, 0.96

Figure 3.1 Distribution of physical activity according to the PPAQ.



Appendix 3.1 Pregnancy Physical Activity Questionnaire Short Form

Pregnancy Physical Activity Questionnaire Short-Form

Your answers are confidential and will be used only for research purposes.

Example: During this trimester, when you are NOT at work, how much time do you usually spend:

1. Dressing, bathing, feeding, children while you are STANDING

- O None
- O Less than 1/2 hour per day
- O 1/2 to almost 1 hour per day
- O 1 to almost 2 hours per day
- ● 2 to almost 3 hours per day
- O 3 or more hours per day

If you spend 2 hours each day, doing these activities, then your answer should look like this…

It is very important that you tell us about yourself honestly. There are no right or wrong answers. We just want to know about the things you are doing during this trimester.

1. Today's Date: ☐☐ / ☐☐ / ☐☐☐☐
Month Day Year

2. What was the first day of your last period? ☐☐ / ☐☐ / ☐☐☐☐
Month Day Year

3. When is your due date? ☐☐ / ☐☐ / ☐☐☐☐
Month Day Year

During this trimester, when you are NOT at work, how much time do you usually spend:

4. Dressing, bathing, feeding children while you are <u>STANDING</u>

- O None
- O Less than 1/2 hour per day
- O 1/2 to almost 1 hour per day
- O 1 to almost 2 hours per day
- O 2 to almost 3 hours per day
- O 3 or more hours per day

5. Playing with children while you are <u>WALKING OR RUNNING</u>

- O None
- O Less than 1/2 hour per day
- O 1/2 to almost 1 hour per day
- O 1 to almost 2 hours per day
- O 2 to almost 3 hours per day
- O 3 or more hours per day

6. Taking care of an older adult

- O None
- O Less than 1/2 hour per day
- O 1/2 to almost 1 hour per day
- O 1 to almost 2 hours per day
- O 2 to almost 3 hours per day
- O 3 or more hours per day

During this trimester, how much time do you usually spend:

7. Walking <u>QUICKLY</u> to go places (such as to the bus, work, visiting) <u>NOT</u> for fun or exercise

- O None
- O Less than 1/2 hour per day
- O 1/2 to almost 1 hour per day
- O 1 to almost 2 hours per day
- O 2 to almost 3 hours per day
- O 3 or more hours per day

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Appendix 3.1 continued.

During this trimester, when you are NOT at work, how much time do you usually spend:

8. Walking QUICKLY for fun or exercise

- O None
- O Less than 1/2 hour per week
- O 1/2 to almost 1 hour per week
- O 1 to almost 2 hours per week
- O 2 to almost 3 hours per week
- O 3 or more hours per week

9. Jogging

- O None
- O Less than 1/2 hour per week
- O 1/2 to almost 1 hour per week
- O 1 to almost 2 hours per week
- O 2 to almost 3 hours per week
- O 3 or more hours per week

10. Doing other things for fun or exercise. Please tell us what they are:

____

Name of Activity

- O None
- O Less than 1/2 hour per week
- O 1/2 to almost 1 hour per week
- O 1 to almost 2 hours per week
- O 2 to almost 3 hours per week
- O 3 or more hours per week

Do you attend work or school, either for wages or as a volunteer?

- O No (skip the remainder of the survey)
- O Yes (please fill out the remaining questions)

During this trimester, how much time do you usually spend:

11. Standing or SLOWLY walking at work or school while carrying things (heavier than a 1 gallon milk jug)

- O None
- O Less than 1/2 hour per day
- O 1/2 to almost 2 hours per day
- O 2 to almost 4 hours per day
- O 4 to almost 6 hours per day
- O 6 or more hours per day

12. Walking QUICKLY at work or school while carrying things (heavier than a 1 gallon milk jug)

- O None
- O Less than 1/2 hour per day
- O 1/2 to almost 2 hours per day
- O 2 to almost 4 hours per day
- O 4 to almost 6 hours per day
- O 6 or more hours per day

13. Walking QUICKLY at work or school NOT carrying anything

- O None
- O Less than 1/2 hour per day
- O 1/2 to almost 2 hours per day
- O 2 to almost 4 hours per day
- O 4 to almost 6 hours per day

Thank You!

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Appendix 3.2 Instructions for Pregnancy Physical Activity Questionnaire Short-Form

PREGNANCY PHYSICAL ACTIVITY QUESTIONNAIRE SHORT FORM

OVERVIEW:

This document provides instructions for the Pregnancy Physical Activity Questionnaire Short Form (PPAQ-SF). The PPAQ-SF is an abbreviated version of the Updated PPAQ and provides a measure of moderate-to-vigorous-intensity physical activity during pregnancy.

PURPOSE

The PPAQ-SF is designed to rank individuals according to their physical activity rather than to estimate their absolute energy expenditure.

INSTRUCTIONS:

The PPAQ is a self-and/or researcher-administered questionnaire. The time frame of recall is the current trimester of pregnancy. Specific instructions are listed on the questionnaire.

Individuals are asked to select the category that best approximates the time spent in 10 activities during the current trimester. An open-ended section allows the respondent to add activities not already listed in the PPAQ-SF.

Additional References

PRIMARY SOURCE OF INFORMATION:

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Appendix 3.2 continued.

CALCULATIONS

To calculate an estimate of weekly energy expenditure (MET-h·week^{-1}) for each activity, multiply the hours/week assigned to the duration category by the intensity (MET).

Duration

The lowest bound of each response option is used to estimate hours/week, due to the tendency for over-reporting of physical activity.

Intensity

Field-based measurements in pregnant women (Campbell 2012) estimate the intensity of questions #4 and #5, while the remaining questions use compendium-based MET values (Ainsworth 2011).

Question # (MET)	Duration Category	Hours/Week
#4 (3.0) #5 (3.5) #6 (4.0) #7 (4.1)	None	0
	Less than ½ hour per day	0.84
	½ to almost 1 hour per day	3.5
	1 to almost 2 hours per day	7
	2 to almost 3 hours per day	14
	3 or more hours per day	21
#8 (4.1) #9 (7.0) #10 (Compendium*)	None	0
	Less than ½ hour per week	0.12
	½ to almost 1 hour per week	0.5
	1 to almost 2 hours per week	1
	2 to almost 3 hours per week	2
	3 or more hours per week	3
#11 (3.8) #12 (4.8) #13 (4.3)	None	0
	Less than ½ hour per day	0.84
	½ to almost 1 hour per day	3.5
	1 to almost 2 hours per day	14
	2 to almost 3 hours per day	28
	3 or more hours per day	42

*For Question #10, use the Compendium for MET value.

INTENSITY CLASSIFICATION OF PHYSICAL ACTIVITY	
Moderate-intensity activity	sum of MET-hours/week for questions #4,5,6,7,8,11,12,13 and question #10 (if 3.0 - 5.9 METs)
Vigorous-intensity activity	sum of MET-hours/week for questions #9 and #10 (if ≥6.0 METs)

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