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Physical activity and sedentary behavior during pregnancy and postpartum, measured using hip and wrist-worn accelerometers

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ABSTRACT

Background: Physical activity in pregnancy and postpartum is beneficial to mothers and infants. To advance knowledge of objective physical activity measurement during these periods, this study compares hip to wrist accelerometer compliance; assesses convergent validity (correlation) between hip- and wrist-worn accelerometry; and assesses change in physical activity from pregnancy to postpartum.

Methods: We recruited women during pregnancy (n = 100; 2014–2015), asking them to wear hip and wrist accelerometers for 7 days during Trimester 2 (T2), Trimester 3 (T3), and 3-, 6-, 9- and 12-months postpartum. We assessed average wear-time and correlations (axis-specific counts/minute, vector magnitude counts/day and step counts/day) at T2, T3, and postpartum.

Results: Compliance was higher for wrist-worn accelerometers. Hip and wrist accelerometers showed moderate to high correlations (Pearson's r 0.59 to 0.84). Hip-measured sedentary and active time differed little between T2 and T3. Moderate-to-vigorous physical activity decreased at T3 and remained low postpartum. Light physical activity increased and sedentary time decreased throughout the postpartum period.

Conclusions: Wrist accelerometers may be preferable during pregnancy and appear comparable to hip accelerometers. As physical activity declines during later pregnancy and may not rebound post birth, support for re-engaging in physical activity earlier in the postpartum period may benefit women.

1. Introduction

Physical activity confers benefits to physical and mental health (Department of Health, 2011; Department of Health and Human Services, 2008), including during pregnancy and the postpartum period (American College of Obstetricians and Gynecologists, 2015). In women with uncomplicated pregnancies, regular physical activity is known to facilitate weight management and physical fitness, reduce the risk of gestational diabetes, and improve mental wellbeing (American College of Obstetricians and Gynecologists, 2015). The American College of Obstetrics and Gynecology (American College of Obstetricians and Gynecologists, 2015) therefore advocates that women engage in at least 20–30 min of exercise on most or all days of the week, with activity ideally spread throughout the week. Though women should be aware of medical contraindications (American College of Obstetricians and Gynecologists, 2015), those who were physically active prior to pregnancy can continue to be so, and those who lead more sedentary lives also benefit from gradual increases in physical activity (American College of Obstetricians and Gynecologists, 2015; U.S. Department of Health and Human Services, 2008).

To date, much of the research assessing women's physical activity during pregnancy and postpartum, including derivation of the guidelines, has relied on self-report measures (da Silva et al., 2016). Studies conducted in nationally representative samples of women in the United States (US) indicate that many women self-report engaging in low levels of physical activity during pregnancy and do not meet physical activity guidelines (Evenson and Wen, 2010; Hesketh and Evenson, 2016). Further, a review of studies in pregnant women showed that the

Abbreviations: US, United States; SED, Sedentary time; LPA, Light physical activity; MPA, Moderate physical activity; VPA, Vigorous physical activity; MVPA, Moderate-to-vigorous physical activity; VM, Vector magnitude; T2, Trimester 2; T3, Trimester 3; PP3, 3 months postpartum; PP6, 6 months postpartum; PP9, 9 months postpartum; PP12, 12 months postpartum

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agreement between questionnaire derived physical activity levels and objective measures (i.e. pedometers and accelerometers) was only slight to fair (Evenson et al., 2012a). A limited number of epidemiological studies that have used objective measures (e.g., accelerometer) to assess physical activity during pregnancy, suggest that physical activity is indeed even lower compared to that self-reported by women (da Silva et al., 2016).

Objective measures of physical activity provide insight in addition to self-report measures as they minimize responder and recall bias, providing a more tangible estimate of frequency, duration, and intensity of women's physical activity. Objective accelerometer placement has, to date, tended to be at the hip, with most epidemiological studies to date using hip-worn accelerometers to measure physical activity (da Silva et al., 2016). However, there has been a recent move toward using wrist-worn activity accelerometers in larger epidemiological studies (Mannini et al., 2013). Wrist-worn accelerometers may be more convenient to wear and encourage greater compliance with wear protocols (Mannini et al., 2013). They may also be particularly well-suited to measuring physical activity during pregnancy given the potential practical difficulties of wearing a hip-worn accelerometer. Comparison of the two placement locations, using the same monitor type, has been conducted, for example in younger (Tudor-Locke et al., 2015) and older adults (Kamada et al., 2016), but, to our knowledge, not in pregnant women.

A recent study evaluated validity and reliability of accelerometry in pregnancy and postpartum with accelerometers placed on the hip, ankle, and triceps, but this was a lab-based study (Conway et al., 2018). Indeed, assessing the correlation between locations in free-living situations is scarce, and a large proportion of evidence about physical activity during pregnancy and postpartum therefore comes from subjective self-report measures. Moreover, with the known benefits of being active for both mother and child, it is important to establish valid and realistic high-compliance protocols for assessing physical activity and sedentary behavior using objective measures during this important period.

Although relatively few studies have assessed how physical activity and sedentary behavior changes from pregnancy to postpartum, several cohort studies have used self-report measures to suggest that there is an overall decrease in physical activity during pregnancy (Borodulin et al., 2008; McParlin et al., 2010; Rousham et al., 2006) and subsequent rebound and maintenance postpartum (Borodulin et al., 2008; Borodulin et al., 2009; Melzer et al., 2009; Pereira et al., 2007). This is borne out in several studies using objective measures: both a UK and Norwegian study suggest that women's moderate-to-vigorous physical activity (MVPA) decreases during pregnancy (Currie et al., 2015; Richardsen et al., 2016), but may then increase after delivery (Richardsen et al., 2016). In a sample of 80 women from North Carolina, at both 3 and 12 months postpartum women engaged in approximately 20 min/day of MVPA (Evenson et al., 2012b). Women's average counts per minute (cpm) did, however, increase from 3- to 12-months postpartum, indicating an increase in total physical activity. Decreases in sedentary time were also observed over the same period (9.3 h to 8.8 h per day) (Evenson et al., 2012b).

This study therefore sought to assess physical activity and sedentary behavior in a sample of low-resource women during pregnancy and postpartum, using wrist- and hip-worn accelerometers. Specifically, the aims of this paper were to: a) determine the relative wear-time and compliance with each accelerometer type, b) assess the convergent validity (or correlation) between hip and wrist accelerometers at several time points during pregnancy and postpartum; and c) using hip-worn accelerometers, determine how physical activity and sedentary behavior changes during pregnancy and postpartum. It was hypothesized that women would have greater compliance with wrist-worn accelerometers, and that physical activity would decrease and sedentary behavior would increase during pregnancy but rebound during the year following birth.

2. Methods

2.1. Study participants

We used data from Nurture, a US cohort study of low-income, predominately black mother-child pairs followed from pregnancy to 12 months postpartum. The study is described in detail elsewhere (Neelon et al., 2017); briefly, we enrolled 860 women during pregnancy, of whom 799 delivered a singleton live infant, and 666 were eligible to participate at 3 months postpartum. The purpose of Nurture was to determine the influence of multiple caregivers on infant anthropometric outcomes and health behaviors in the first year of life (Neelon et al., 2017). Women were eligible to participate in Nurture if they were 20–36 weeks pregnant; carrying a singleton with no known congenital abnormalities; were ≥18 years of age; could speak and read English; intended to keep the baby; and planned to stay within the area until at least 12 months postpartum (Neelon et al., 2017).

For these analyses, we used data from a convenience sample of women who consented to participate in the sub-study to assess how objectively-measured physical activity during pregnancy and postpartum was related to weight gain and subsequent weight retention. From September 2014, we asked all participants already enrolled in the Nurture study, who were still pregnant (between 20.0 and 35.0 weeks), if they wanted to participate in the sub-study during a prenatal visit. We also invited new participants in Nurture to participate in the sub-study after they had provided informed consent for the primary study. Study staff gave all women a full explanation of study procedures and showed them the accelerometers; we then obtained informed consent, separately from the Nurture study, if women wanted to participate. We ceased recruitment when 100 women had consented to participate. We collected data from September 2014 through April 2015. The Duke University Medical Center Institutional Review Board (Pro 00036242) provided ethical approval for the main Nurture study and physical activity sub-study.

2.2. Data collection

We approached 167 women to participate in the sub-study. At recruitment [during trimester 2 (T2) (n = 42) or 3 (T3) (n = 58)], we asked women to wear two ActiGraph GT3X+ accelerometers (Pensacola, Florida, USA; valid and reliable in adult women (McClain et al., 2007; Ozemek et al., 2014; Sasaki et al., 2011) and specifically, in pregnant and postpartum women (Conway et al., 2018)) for 7 days to measure free-living physical activity and sedentary behavior. Women wore one accelerometer on the wrist for 24 h/day and, concurrently, one at the hip during waking hours only (removing accelerometers during water-based activity or bathing). We asked those recruited in T2 to also wear the accelerometers again during T3 (n = 31). At baseline (either T2 or T3), we asked women to complete a questionnaire to gather socio-demographic and pre-pregnancy anthropometric data. We subsequently contacted women at 3-, 6,- 9-, and 12-months post birth (PP3, PP6, PP9 and PP12 respectively) and asked those who had participated in the sub-study to follow the same physical activity measurement protocol.

2.3. Physical activity data

For both accelerometer locations, we collected physical activity data in 60-second epochs. We downloaded and processed these data using ActiLife software (ActiGraph, Pensacola, FL, USA). We defined accelerometer non-wear time as an interval of ≥90 consecutive minutes of zero counts/min, allowing up to 2 min of nonzero counts if no counts were detected during the 30 min up- or downstream of that interval (Choi et al., 2011). Any nonzero counts (except the allowed short intervals) were considered wear time. As done previously in older women (Kamada et al., 2016), for both the hip and wrist accelerometers we