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Intrinsic motivation for physical activity, healthy eating, and self-weighing in association with corresponding behaviors in early pregnancy

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ABSTRACT

Healthy lifestyle behaviors influence maternal cardiovascular health, but motivation for them in pregnancy is poorly understood. We examined whether intrinsic motivation (assessed on 5-point scales for each behavior) is associated with three lifestyle behaviors in early pregnancy: physical activity, by intensity level; healthy eating, quantified with the Alternate Healthy Eating Index for Pregnancy (AHEI-P); and weight self-monitoring, a standard weight management technique. Participants in the Northern California Pregnancy, Lifestyle and Environment Study (PETALS) population-based cohort completed validated surveys in early pregnancy (2017–18; $N = 472$; 22 % Asian, 6 % Black, 30 % Hispanic, 13 % multiracial, 30 % White). Cross-sectional data were analyzed in 2021–22. Overall, 40.7 % ($n = 192$) met United States national physical activity guidelines; the average AHEI-P score was 62.3 out of 130 (SD 11.4); and 36.9 % reported regular self-weighing (≥once/week; $n = 174$). In models adjusted for participant characteristics, 1-unit increases in intrinsic motivation were associated with increased likelihood of meeting physical activity guidelines (risk ratio [95 % CI]: 1.66 [1.48, 1.86], $p < 0.0001$); meeting sample-specific 75th percentiles for vigorous physical activity (1.70 [1.44, 1.99], $p < 0.0001$) and AHEI-P (1.75 [1.33, 2.31], $p < 0.0001$); and regular self-weighing (2.13 [1.92, 2.37], $p < 0.0001$). A 1-unit increase in intrinsic motivation lowered the risk of meeting the 75th percentile for sedentary behavior (0.79 [0.67, 0.92], $p < 0.003$). Intrinsic motivation was not associated with reaching 75th percentiles for total, light, or moderate activity. Intrinsic motivation is associated with physical activity, healthy eating, and self-weighing among diverse individuals in early pregnancy. Results can inform intervention design to promote maternal health via increased enjoyment of lifestyle behaviors.

1. Introduction

Physical activity, healthy eating, and weight management behaviors optimize cardiovascular health in pregnancy and across the life course (Parikh et al., 2021; Lloyd-Jones et al., 2022). Indeed, research and expert consensus have identified perinatal physical activity and nutrition as scientific, public health, and public policy priorities (Piercy et al., 2018; American College of Obstetricians and Gynecologists, 2020; Marshall et al., 2022; Koletzko et al., 2019). United States (US) clinical and national guidelines recommend physical activity during pregnancy to maintain and improve cardiovascular health, specifically a minimum of 150 min per week of moderate-to-vigorous physical activity (MVPA) (Piercy et al., 2018; American College of Obstetricians and Gynecologists, 2020). Healthy eating guidelines emphasize "eating better, not more," such as replacing poorer-quality processed foods and beverages with nutrient-dense whole foods (e.g., vegetables, fruits, whole grains,

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and sources of omega-3 fatty acids) (Marshall et al., 2022; U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2023). A behavioral pattern of healthy eating has been associated with lower blood pressure during pregnancy (Courtney et al., 2020), and with lower risks for hypertensive disorders of pregnancy, giving birth to a large-for-gestational-age infant, and pre-term birth (Abdollahi et al., 2021; Zhu et al., 2021; Grieger et al., 2014), the latter an increasingly common adverse pregnancy outcome (Hamilton et al., 2021). Meeting or exceeding physical activity and healthy eating guidelines may also reduce risk for gestational diabetes (Mijatovic-Vukas et al., 2018; Ehrlich et al., 2021). Perinatal physical activity and eating behaviors further predict postpartum weight retention, which is a risk factor for obesity and its complications (Siega-Riz et al., 2010; Rooney and Schauberger, 2002; Kew et al., 2014; Ostbye et al., 2012; von Ruesten et al., 2014).

Self-monitoring is a standard behavioral weight management technique (National Heart L, and Blood Institute, 2013), providing feedback to enhance self-regulation of physical activity and eating behaviors that results in better weight management outcomes (Vanwormer et al., 2008; Phelan et al., 2011; Pacanowski et al., 2014; Teixeira et al., 2015; Madigan et al., 2015). As noted in a US Preventive Services Task Force (USPSTF) report and related trials, self-weighing is also relevant in pregnancy (Cantor et al., 2021; Brown et al., 2019) —a time when appropriate weight gain, particularly in the first trimester, impacts risk for adverse maternal health outcomes, such as gestational diabetes (Hedderson et al., 2010), and infant health outcomes (Davidson et al., 2021). Both the USPSTF and American College of Obstetricians and Gynecologists (ACOG) recommend behavioral weight management to improve gestational weight gain (Davidson et al., 2021; ACOG Committee, 2013).

Despite clinical recommendations and the impact of physical activity, healthy eating, and self-weighing on maternal health, few studies have scrutinized individuals' motivation to engage in these lifestyle behaviors during pregnancy. According to self-determination theory, sources of motivation span a continuum from controlled (e.g., to gain an extrinsic reward or avoid punishment or guilt) to autonomous (e.g., valuing the benefits of a behavior or genuine enjoyment, i.e., intrinsic motivation) (Teixeira et al., 2015; Deci and Ryan, 2004; Rhodes and Yao, 2015; Rhodes and Pfaeffli, 2010; Williams and Rhodes, 2016). Intrinsic motivation is the most autonomous form of self-regulation; it reflects engaging in a behavior "for its own sake," because it is self-rewarding and stems from personal enjoyment or accomplishment (Teixeira et al., 2015; Deci and Ryan, 2004; Rhodes and Yao, 2015; Rhodes and Pfaeffli, 2010; Williams and Rhodes, 2016). This construct has predicted readiness to change (Mattavelli et al., 2017), intentions (McEachan et al., 2016), and actual engagement in physical activity and healthy eating behaviors outside of pregnancy (McEachan et al., 2016; Santos et al., 2016; Lewis et al., 2016). Emerging research also suggests intrinsic motivation is a distal determinant of physical activity behavior during pregnancy (Hamilton et al., 2019). Little research has examined intrinsic motivation for self-weighing, which may be perceived as unpleasant; this barrier could result in avoidance, forestalling the potential benefit of feedback that this behavior provides.

The present study assessed whether intrinsic motivation is associated with engagement in physical activity, healthy eating, and self-weighing during early pregnancy. We hypothesized there would be positive associations between behavior-specific measures of intrinsic motivation and corresponding lifestyle behaviors, and an inverse association between intrinsic motivation and sedentary behavior. We also assessed psychometric properties of intrinsic motivation scales in early pregnancy. Study results could inform the design of behavioral interventions that leverage intrinsic motivation to promote maternal engagement in healthy lifestyle behaviors.

2. Materials and methods

2.1. Study sample and design

The Pregnancy, Lifestyle and Environment Study (PETALS) is a population-based study of healthy pregnant individuals; PETALS methods have been described elsewhere (Zhu et al., 2017). Eligible participants were aged 18–45 years with a singleton pregnancy and no recognized pre-existing diagnosis of diabetes, cancer, hepatitis C, or liver cirrhosis. Individuals were identified via electronic health record (EHR) in Kaiser Permanente Northern California (KPNC), a US integrated health system of ~ 4.5 million members whose diversity approximates that of the Northern California region (Gordon, 2017). Participants were invited to complete a baseline visit in early pregnancy (10–13 weeks' gestation); the PETALS recruitment rate was 75% (Zhu et al., 2017). All participants provided written informed consent. The study met institutional guidelines for the protection of human subjects safety and privacy and was approved by the Kaiser Foundation Research Institute human subjects committee (IRB protocol no. 1274934). The present cross-sectional study is reported using the STROBE guidelines (von Elm et al., 2008).

Intrinsic motivation scales were administered in the baseline PETALS survey from September 2017-December 2018 ($N = 535$). Of those, we excluded participants who subsequently withdrew from PETALS ($n = 1$), experienced pregnancy or infant loss ($n = 9$), or declined contact for future studies ($n = 53$), yielding an analytic sample of 472. Relevant analyses for each lifestyle behavior excluded participants with missing data for dietary intake ($n = 36$), self-weighing ($n = 1$), or access to a scale ($n = 1$); or implausible caloric intake (<400 or > 6000 kcal/day; $n = 2$), as done previously (Zhu et al., 2021).

2.2. Assessment of participant characteristics

Sociodemographic characteristics including age, race/ethnicity, education, annual household income, marital status, and parity were obtained from the PETALS survey. Pre-pregnancy body mass index (BMI) was calculated as pre-pregnancy weight (kg) divided by squared height (m^2). Pre-pregnancy weight was abstracted from the EHR as the weight measured by clinical staff closest to, and within 6 months prior to the last menstrual period. For participants with unavailable measured weights in the EHR ($n = 7$; 1.5 %), we used self-reported pre-pregnancy weight. Height was measured by study staff at the PETALS baseline visit using a stadiometer and standard anthropometric protocols (Lohman et al., 1988).

2.3. Assessment of intrinsic motivation

Intrinsic motivation was assessed separately for each lifestyle behavior. Participants indicated endorsement of items on 5-point Likert scales. To improve interpretation, response options of *not at all* (1), *a little bit* (2), *moderately* (3), *quite a bit* (4), and *extremely* (5) were made consistent across scales. Scores were generated by averaging item responses. Thus, higher scores indicate greater intrinsic motivation and mean scores directly correspond to response options.

Motivation for physical activity was assessed with the 4-item Intrinsic Regulation subscale of the Behavioral Regulation in Exercise Questionnaire-Version 2 (BREQ-2) (Markland and Tobin, 2004). Reliability and validity have been demonstrated in varied adult samples (Markland and Tobin, 2004; Ingledew and Markland, 2008; Chmielewski et al., 2016). Scores correlate with in-the-moment positive emotions in response to physical activity (Schneider and Kwan, 2013) and have predicted MVPA (Chmielewski et al., 2016). In adult and student samples the subscale outperformed alternative measures in internal consistency reliability, test–retest reliability, convergent validity, and criterion validity, with the latter evidenced by the strongest prediction of MVPA (Chmielewski et al., 2016). The subscale was slightly

modified to simplify sentence construction and replace "exercise" with "physical activity," similar to Verloigne et al. (Verloigne et al., 2011) (e.g., changing "I find exercise a pleasurable activity" to "I find physical activity pleasurable"). Labels were applied to all response options on the 1–5 scale to promote reliability.

Motivation for healthy eating was assessed with the 6-item Attitudes Toward Healthy Foods scale, initially developed in a behavioral weight management randomized controlled trial testing "stability skills first" (items available upon request from Michaela Kiernan, PhD) (Kiernan et al., 2013). The scale examines affective attitudes toward healthy eating including taste (enjoying the taste of healthy foods), deprivation (feeling a sense of loss when eating healthy foods), and moderation (feeling able to include favorite unhealthy foods into an overall healthy eating pattern). Sample items include "I feel that most healthy foods I eat taste really good," and "I feel as if I'm missing out on something when I eat healthy" (reverse scored).

Motivation for self-weighing was assessed with the 6-item Attitudes Toward Weighing scale, developed in a prior behavioral weight management trial testing "stability skills first" (items available upon request from Michaela Kiernan, PhD) (Kiernan et al., 2013). Given that self-weighing can be perceived as unpleasant, this scale assesses the extent to which respondents endorse a *neutral sense of ease* towards self-weighing (rather than "enjoyment" per se). Sample items include "I feel at peace with the scale" and "Weighing myself feels neutral.".

2.4. Assessment of behavioral outcomes

Physical activity, healthy eating, and self-weighing behaviors were assessed using validated self-report measures. Physical activity was assessed with the Pregnancy Physical Activity Questionnaire (Chasan-Taber et al., 2004). Participants reported time spent in 36 population-appropriate activities in the prior two months, with response options expressed in ranges (e.g., none, $<$ ½ hour per day, ½ to almost 1 h per day, 1 to almost 2 h per day, 2 to almost 3 h per day, or $\geq$ 3 h per day). The questionnaire was slightly modified from the original to reference current technologies (e.g., time spent watching video clips) (Ehrlich et al., 2021). To generate a conservative estimate of activity, the minimum value of the selected range of duration and frequency was multiplied by the intensity (i.e., metabolic equivalent of task, or MET), yielding the volume of physical activity in MET-hours per week. Activities other than walking and household tasks used compendium-based MET values, derived from field-based measurements among pregnant individuals (Chasan-Taber et al., 2004).

We first considered moderate-to-vigorous intensity physical activity in the sports and exercise domain, or MVPA hereafter. MVPA comprises activities intentionally performed to improve health, wellness, or fitness, that expends energy beyond the demands of everyday living, and thereby fulfills the US national guidelines (Ehrlich et al., 2021). Therefore, moderate-to-vigorous intensity physical activity within the sports and exercise domain was categorized by meeting or exceeding the lower threshold of national physical activity guidelines for at least 150 min per week (Piercy et al., 2018; American College of Obstetricians and Gynecologists, 2020). In addition, we examined physical activity overall (i.e., across all domains), by intensity level. This was categorized as meeting or exceeding the sample-specific 75th percentiles for vigorous physical activity (VPA, for which all PPAQ items are within the sports and exercise domain); moderate, light, and total activity (the latter encompassing all light activity and above); and sedentary behavior. This approach was selected given that self-reported physical activity is subject to bias, and is thus best suited to ranking respondents on their volume of physical activity.

Dietary intake was assessed with the Block Food Frequency Questionnaire (FFQ) (Block et al., 1986). The FFQ has demonstrated reliability and validity compared to multiple dietary records (Block et al., 1990) and has been used in diverse perinatal samples (Harley et al., 2005; Brown et al., 2016). Participants report their typical diet in the prior three months, which corresponds here to the period between conception and the PETALS assessment. To quantify healthy eating, FFQ data were used to calculate the Alternate Healthy Eating Index for Pregnancy (AHEI-P). The AHEI-P is a validated measure based on the AHEI-2010 (Chiuve et al., 2012) and a pregnancy AHEI developed by Rifas-Shiman and colleagues (Rifas-Shiman et al., 2009), and has been applied previously (Zhu et al., 2021; Poon et al., 2013). Using a 130-point scale, the AHEI-P assesses overall dietary quality in relation to the 2010 USDA Dietary Guidelines for Americans, modified for pregnancy; its 13 components and the distribution of each component in original units are displayed in Appendix Table 1. As with self-reported physical activity, we examined self-reported dietary quality as meeting or exceeding the sample-specific 75th percentile for AHEI-P score.

Self-monitoring of weight was assessed with an item adapted from the EARLY Self-Weighing Questionnaire (Lytle et al., 2014) and a prior behavioral weight management trial testing "stability skills first" (Kiernan and Brown, 2013). Participants reported their frequency of self-weighing in the last month, not including instances of being weighed by a healthcare provider, on a 6-point scale from *never* to *more than once a day*. Weighing at least once per week was classified as regular self-weighing. Access to a body weight scale at home was assessed with a single survey item.

2.5. Statistical analysis

We used Cronbach's α to assess internal consistency of each intrinsic motivation scale; Spearman's rank order correlations to examine associations among them; and the Wilcoxon Rank-Sum test to assess bivariate associations between each intrinsic motivation scale and meeting pre-specified thresholds for behavioral outcomes. We used modified Poisson regression models to estimate adjusted risk ratios (RR) and corresponding 95% confidence intervals (CI) for associations between intrinsic motivation and meeting pre-specified thresholds for corresponding behaviors, adjusting for maternal age at delivery, pre-pregnancy BMI, race/ethnicity, education, and parity. Analyses were conducted in 2021–22 using SAS version 9.4 (SAS Institute).

3. Results

Sample characteristics are shown in Table 1. Average gestational age at the time of participation was 13.5 weeks (SD 3.0). Intrinsic motivation scales demonstrated adequate internal consistency (α = 0.70-0.93) and non-significantly or modestly correlated with one another (Table 2). Absolute levels of mean intrinsic motivation were higher for physical activity and healthy eating than self-weighing (Table 2). For example, 48.9 % and 61.2 % of participants, respectively, endorsed the items "I find physical activity pleasurable" and "Most healthy foods I eat taste really good" as *quite a bit* or *extremely*. In contrast, only 29.5 % and 25 %, respectively, endorsed feeling "at peace with the scale" and "weighing feels neutral" at the same levels.

Overall, 40.7 % of participants (n = 192) met US national physical activity guidelines for $\geq$ 150 min/week of MVPA. Average total daily energy intake was 1534.8 kcal (SD 638.7), with an average AHEI-P score of 62.3 out of 130 (SD 11.4). A total of 36.9 % reported regular self-weighing ($\geq$once/week; n = 174); 69.6 % (n = 328) reported access to a scale at home. Additional descriptive data are shown in Appendix Tables 1 and 2.

In bivariate analyses, intrinsic motivation for physical activity, healthy eating, and self-weighing were associated with engaging in corresponding behaviors (Table 3). Intrinsic motivation was higher among participants who met or exceeded national physical activity guidelines; the 75th percentile of 3.3 MET-hours/week of VPA; and the AHEI-P 75th percentile score of 70.3 out of 130, as compared to those who did not meet these thresholds (p values $\leq$ 0.0001). As expected, intrinsic motivation was lower among those who met or exceeded the 75th percentile of 72.7 MET-hours/week of sedentary behavior (p =

Table 1
Characteristics of PETALS intrinsic motivation study participants, KPNC, 2017–18 ($N = 472$).

	n (%)
Age at delivery, years	
18–24	51 (10.8)
25–29	110 (23.3)
30–34	181 (38.3)
35–39	110 (23.3)
40–44	20 (4.2)
Race/ethnicity	
Asian/Pacific Islander	102 (21.6)
Black/African American	30 (6.4)
Hispanic	139 (29.5)
Non-Hispanic White	139 (29.5)
More than one race/ethnicity	62 (13.1)
Education	
High school or less	55 (11.7)
Some college	137 (29.0)
College graduate	140 (29.7)
Postgraduate	140 (29.7)
Marital status	
Married/civil union	337 (71.4)
Living with a partner	67 (14.2)
Divorced/separated	5 (1.1)
Single	63 (13.3)
Household income, $[a]	
< 50,000	104 (22.2)
50,000–99,000	139 (29.6)
100,000–149,999	90 (19.2)
≥ 150,000	136 (29.0)
Parity[a]	
0	244 (52.9)
1	147 (31.9)
≥ 2	70 (15.2)
Pre-pregnancy BMI[a], kg/m^2	
Underweight (<18.5)	6 (1.3)
Normal (18.5–24.9)	205 (44.5)
Overweight (25.0–29.9)	138 (29.9)
Obese (≥30.0)	112 (24.3)

BMI, body mass index; KPNC, Kaiser Permanente Northern California; PETALS, Pregnancy, Lifestyle and Environment Study.
[a] Missing data for household income ($n = 3$), parity ($n = 11$), and pre-pregnancy BMI ($n = 11$).

0.0005). Intrinsic motivation was also significantly higher among participants who self-weighed regularly ($p < 0.0001$).

Results of bivariate analyses were robust after adjusting for participant characteristics. In modified Poisson regression models adjusted for sociodemographic and clinical factors (Fig. 1), one-unit increases in intrinsic motivation were associated with increased likelihood of meeting or exceeding national physical activity guidelines (risk ratio [95 % CI]: 1.66 [1.48, 1.86], $p < 0.0001$) and the 75th percentile for VPA (1.70 [1.44, 1.99], $p < 0.0001$). As expected, a 1-unit increase in intrinsic motivation score decreased the likelihood of meeting or exceeding the 75th percentile for sedentary behavior (0.79 [0.67, 0.92], $p < 0.003$). Intrinsic motivation was not significantly associated with reaching the 75th percentiles for moderate (1.08 [0.94, 1.26], $p = 0.28$), light (1.10 [0.95, 1.26], $p = 0.19$), or total physical activity (1.06 [0.92, 1.23], $p = 0.40$). One-unit increases in intrinsic motivation were associated with increased likelihood of meeting or exceeding the AHEI-P 75th percentile (1.75 [1.33, 2.31] $p < 0.0001$) and self-weighing regularly (2.13 [1.92, 2.37], $p < 0.0001$).

4. Discussion

Despite the importance of lifestyle behaviors for maternal cardiovascular health, motivation for these behaviors during pregnancy has been rarely assessed. In this cross-sectional analysis among diverse pregnant individuals, as hypothesized, higher levels of behavior-specific intrinsic motivation were associated with meeting thresholds for healthy lifestyle behaviors in pregnancy, including MVPA, VPA, healthy eating, and regular self-weighing, with a corresponding inverse relationship between intrinsic motivation and sedentary behavior. These results suggest that intrinsic motivation may be an important target for interventions aimed at increasing maternal engagement in lifestyle behaviors, which is consistent with self-determination theory (described above) and with empirical analyses in pregnant and non-pregnant samples (Hamilton et al., 2019; Ryan and Deci, 2000; Hagger and Chatzisarantis, 2009). The present study also provides novel data supporting the reliability and validity of the BREQ-2 intrinsic motivation subscale, Attitudes Toward Healthy Foods scale, and Attitudes Toward Weighing scale in pregnant populations.

Only 41 % of study participants met US national physical activity guidelines in early pregnancy, consistent with the 41 % and 43 % of Black and Hispanic women, respectively, who meet the guidelines nationally (versus 55 % of White women) (Tsao et al., 2023). Yet here, despite the low percentage of participants meeting national guidelines, those with higher intrinsic motivation were more likely to do so, and were more likely to engage in more VPA and be less sedentary in early pregnancy. This is consistent with research on the broader construct of autonomous motivation (i.e., driven by internal forces such as personal values or enjoyment, rather than external forces such as guilt or others' directives): Greater autonomous motivation was positively associated with physical activity in a smaller study of 75 individuals spanning all trimesters of pregnancy, using a longer 15-item original version of the BREQ (Gaston et al., 2013). Autonomous motivation may also be important for health behavior maintenance. Compared to other motivational profiles, those with stronger autonomous motivation (as assessed with the BREQ-2) maintained increased levels of MVPA, without long-term support, following behavioral intervention in a predominantly female sample of adults with overweight or obesity (Ostendorf et al., 2021). Of note, our finding that BREQ-2 scores were positively related only with meeting the US guideline for MVPA and with VPA, but not total physical activity, appears to signal that intrinsic motivation is a stronger correlate of higher intensities of physical activity.

As with physical activity, levels of healthy eating here (AHEI-P mean ± SD: 62.3 ± 11.4) were comparable to estimates from several large US cohort studies of pregnant individuals (61 ± 10 in Project Viva; 61.7 ±

Table 2
Reliability, discriminant validity, and descriptive statistics for measures of intrinsic motivation for lifestyle behaviors among PETALS participants, KPNC, 2017–18 ($N = 472$).

Intrinsic motivation (5-point scales)	Internal consistency (α)	Correlation[a]		Mean (SD)	Median (IQR)
		Healthy eating	Self-weighing		
Physical activity (BREQ-2)	0.93	**0.33****	**0.20****	3.3 (1.1)	3.5 (2.5–4.0)
Healthy eating (Attitudes Toward Healthy Foods scale)[b]	0.70	–	−0.01	3.9 (0.7)	3.9 (3.3–4.3)
Self-weighing (Attitudes Toward Weighing scale)[b]	0.78	–	–	2.5 (0.9)	2.5 (1.8–3.2)

BREQ-2, Behavioral Regulation in Exercise Questionnaire-2 intrinsic motivation subscale; KPNC, Kaiser Permanente Northern California; PETALS, Pregnancy, Lifestyle and Environment Study.
[a] Obtained by Spearman's rank order correlation. Boldface indicates statistical significance (*$p < 0.001$, **$p < 0.0001$).
[b] Missing data for Attitudes Toward Healthy Foods ($n = 1$) and Attitudes Toward Weighing scales ($n = 1$).

Table 3
Intrinsic motivation scores by corresponding lifestyle behavior thresholds among PETALS participants, KPNC, 2017–18 ($N = 472$).

Behavior (threshold)	*n* (%)	Intrinsic motivation, mean (SD)[a]	*P*[b]
Physical activity			
US national guideline			**< 0.0001****
Met (≥150 min/week of MVPA)	192 (40.7)	3.8 (0.9)	
Did not meet	280 (59.3)	2.9 (1.0)	
Vigorous activity[c]			**< 0.0001****
≥ 75th %ile (≥3.3 MET-hours/week)	131 (27.8)	3.9 (0.9)	
< 75th %ile	341 (72.2)	3.1 (1.0)	
Moderate activity[c]			0.39
≥ 75th %ile (≥93.7 MET-hours/week)	118 (25.0)	3.2 (1.1)	
< 75th %ile	354 (75.0)	3.3 (1.1)	
Light activity[c]			0.35
≥ 75th %ile (≥88.9 MET-hours/week)	118 (25.0)	3.2 (1.0)	
< 75th %ile	354 (75.0)	3.3 (1.1)	
Total activity[c]			0.24
≥ 75th %ile (≥191.8 MET-hours/week)	118 (25.0)	3.2 (1.1)	
< 75th %ile	354 (75.0)	3.3 (1.1)	
Sedentary behavior[c]			**0.0005***
≥ 75th %ile (≥72.7 MET-hours/week)	119 (25.2)	3.0 (1.1)	
< 75th %ile	353 (74.8)	3.4 (1.0)	
Healthy eating [c,d]			**< 0.0001****
≥ 75th %ile (AHEI-P ≥ 70.3 out of 130)	108 (22.9)	4.2 (0.6)	
< 75th %ile	326 (69.1)	3.8 (0.7)	
Self-weighing[e]			**< 0.0001****
Regular self-weighing (≥once/week)	174 (36.9)	3.2 (0.8)	
Non-regular self-weighing (<once/week)	296 (62.7)	2.1 (0.8)	

AHEI-P, Alternate Healthy Eating Index for Pregnancy; BREQ-2, Behavioral Regulation in Exercise Questionnaire-2; KPNC, Kaiser Permanente Northern California; MET, metabolic equivalent of task; MVPA moderate-to-vigorous physical activity; PETALS, Pregnancy, Lifestyle and Environment Study.

[a] Values correspond to corresponding intrinsic motivation scores for physical activity (BREQ-2 intrinsic motivation subscale), healthy eating (Attitudes Toward Healthy Foods scale), or self-weighing (Attitudes Toward Weighing scale), on 5-point scales (1–5).

[b] Obtained by Wilcoxon Rank-Sum test. Boldface indicates statistical significance (*$p < 0.001$, **$p < 0.0001$).

[c] Sample-specific 75th percentiles.

[d] Excluded $n = 2$ due to implausible total daily energy intake (<400 kcal or > 6000 kcal). Missing data for Attitudes Toward Healthy Foods scale ($n = 1$) and dietary intake to calculate AHEI-P score ($n = 36$).

[e] Missing data for self-weighing ($n = 1$).

10.8 in the Infant Feeding Practices Study II) (Monthé-Drèze et al., 2021; Parker et al., 2020), although higher than observed in the 1999–2006 National Health and Nutrition Examination Survey (mean [CI]: 44.5 [43.3–45.7]) (Gamba et al., 2019). Similar as well were the positive associations between intrinsic motivation and healthy eating, consistent with research demonstrating associations between autonomous motivation and diet quality as assessed with the HEI-2015 (Krebs-Smith et al., 2018) in early pregnancy (Mooney et al., 2021), and in parent-adolescent dyads (Dwyer et al., 2017). The current study lends further evidence that internally-driven motives may promote healthful eating during a critical period of the life course. Psychometric results also demonstrate that intrinsic motivation for healthy eating can be

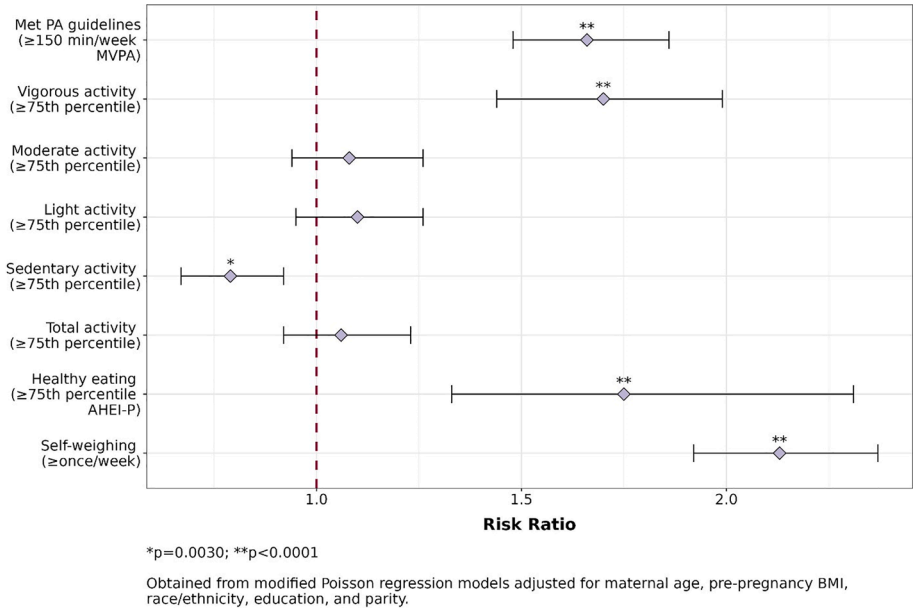

Fig. 1. Adjusted risk ratios for the associations of intrinsic motivation with corresponding lifestyle behavior thresholds. Risk ratios correspond to 1-unit increases in behavior-specific intrinsic motivation scores.

measured quickly and reliably.

To our knowledge, this is among the first studies to quantitatively examine motivation for self-weighing during pregnancy. Here we found that Attitudes Toward Weighing, a novel scale initially developed in a behavioral weight management trial testing "stability skills first" (Kiernan et al., 2013), displayed strong psychometrics in this sample of pregnant individuals. Psychometric results included robust internal consistency; criterion validity, with scores significantly higher among those who self-weighed regularly; and discriminant validity, given non-significant or modest correlations with the other two intrinsic motivation scales, suggesting that each scale captures related but distinct aspects. Intrinsic motivation for self-weighing was associated with corresponding behavior, noteworthy given that self-weighing is recommended within interventions to promote healthy weight gain during pregnancy (Cantor et al., 2021). Overall, attitudes toward self-weighing were relatively negative compared to those toward physical activity and healthy eating. Indeed, despite most participants having access to a scale at home, only 37 % reported regular self-weighing. This parallels reports of ambivalent and complex feelings about self-weighing in pregnancy, including aversions to being aware of one's weight (Brown et al., 2019; Ferrey et al., 2021). Yet in practical terms, a one-unit improvement in intrinsic motivation for self-weighing—e.g., moving from "a little bit" (2) to "moderately" (3) at peace with the scale—could yield a clinically significant doubling of individuals' likelihood of self-weighing regularly. The present study should be interpreted cautiously given scant observational data, outside of intervention trials, are available on regular self-weighing behavior during pregnancy. In one observational study (ancillary to a clinical trial), approximately 80 % of participants in engaged in regular weighing during pregnancy, but participants were prompted to do so weekly (Sanders et al., 2023).

Intrinsic motivation is potentially modifiable, and thus a promising target for behavioral interventions to increase engagement in lifestyle behaviors. Research in non-pregnant samples suggests affective attitudes are modifiable via persuasive communication, experiential, and evaluative conditioning techniques (Mattavelli et al., 2017; Kiernan et al., 2013; Antoniewicz and Brand, 2016). Interventions that increased enjoyment have yielded better physical activity and weight loss maintenance up to 3 years later (Kiernan et al., 2013; Silva et al., 2011; Silva et al., 2010). Improving motivation for self-weighing might enhance the efficacy of existing interventions that incorporate weight self-monitoring to promote healthy gestational weight gain (Brown et al., 2019; Clifton et al., 2016; Peaceman et al., 2018; Ferrara et al., 2020). Interventions could capitalize on comparatively high motivation for physical activity and healthy eating, while mitigating low motivation for self-weighing. Importantly, strategies to strengthen intrinsic motivation could be embedded within comprehensive interventions that address a range both psychological and social determinants of behavior change. However, to inform intervention design, prospective research is needed to establish whether intrinsic motivation impacts these maternal lifestyle behaviors throughout pregnancy and the postpartum period.

4.1. Limitations

While strengths include its racial/ethnic diversity, relatively large size, and psychometrically strong measures, the study has several limitations. Self-reported physical activity, diet, and self-weighing are subject to social desirability bias; we sought to mitigate this using primarily ranked thresholds, rather than absolute values. Participants with missing or implausible data were excluded from analyses, which could create bias; however, only 0.2 % to 7.6 % were excluded in any analysis. Generalizability is limited by the sample's relatively high education level. Future research in this area should include socioeconomically diverse samples and extend beyond early pregnancy. Finally, this is the first study to our knowledge to apply the BREQ-2 in a pregnant sample; however, results support the measure's psychometric properties in this unique population.

5. Conclusions

The current study provides novel evidence that intrinsic motivation is linked to healthy lifestyle behaviors among diverse pregnant individuals, and that intrinsic motivation for physical activity, healthy eating, and self-weighing can be assessed with brief, reliable, and valid scales. Intrinsic motivation may be a promising target for new interventions to improve maternal and infant cardiovascular health via increased enjoyment of lifestyle behaviors in early pregnancy.

CRediT authorship contribution statement

Susan D. Brown: Conceptualization, Investigation, Methodology, Supervision, Funding acquisition, Project administration, Writing – original draft, Writing – review & editing. **Michaela Kiernan:** Conceptualization, Methodology, Validation, Writing – review & editing. **Samantha F. Ehrlich:** Investigation, Methodology, Writing – review & editing. **Yeyi Zhu:** Investigation, Methodology, Writing – review & editing. **Monique M. Hedderson:** Investigation, Resources, Writing – review & editing. **Saher Daredia:** Data curation, Software, Formal analysis, Visualization, Writing – review & editing. **Juanran Feng:** Investigation, Data curation, Formal analysis, Writing – review & editing. **Andrea Millman:** Project administration, Writing – review & editing. **Charles P. Quesenberry:** Methodology, Formal analysis, Writing – review & editing. **Assiamira Ferrara:** Funding acquisition, Investigation, Methodology, Resources, Supervision, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Ethics Approval

This research was approved by the Kaiser Foundation Research Institute Human Subjects Committee (IRB protocol no. 1274934).

Prior presentation

Portions of this study were presented at scientific sessions of the American Heart Association (EPI|Lifestyle, Boston, MA, February 28-March 3, 2023) and Society of Behavioral Medicine (Phoenix, AZ,

April 26-29, 2023).

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2023.102456.

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