ASSOCIATIONS BETWEEN STRESS, INTUITIVE EATING, AND ADIPOSITY IN A COHORT OF MIDLIFE WOMEN

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ASSOCIATIONS BETWEEN STRESS, INTUITIVE EATING, AND ADIPOSITY
IN A COHORT OF MIDLIFE WOMEN

BY
BRIDGET A. OWENS

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY
IN
HEALTH SCIENCES

UNIVERSITY OF RHODE ISLAND
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ABSTRACT

Stress and eating behaviors can influence the health of midlife women, a population at risk for weight gain and redistribution of fat to the abdominal area related to shifts in reproductive hormones and aging. Higher stress is associated with negative health outcomes such as increased abdominal adiposity, depression, and chronic diseases such as cardiovascular disease. Women report higher stress and more emotional and physical side effects from stress than men and are more likely than men to engage in emotional eating in response to stress. Further, the desire to lose weight and the prevalence of body dissatisfaction is high among midlife women and research suggests that this age group demonstrates lower adaptive behaviors such as intuitive eating than younger women. There is a need for research to better understand the impact of stress on eating behaviors to improve health outcomes such as adiposity among midlife women. Intuitive eating (IE) is an adaptive eating behavior that has been consistently associated with a lower body mass index, though its relationship with adiposity, specifically abdominal adiposity, has not been studied. IE is associated with several positive psychosocial outcomes and its guiding principles emphasize the reliance on internal cues of what and when to eat instead of using environmental or external cues, including emotions, to guide food intake. Thus, individuals who use IE may be less vulnerable to using eating to cope with emotions such as stress or depression. However, there is limited evidence of the association between IE and stress, and no studies have explored the relationship between IE and stress using a biomarker such as cortisol. Further, IE has been associated with lower depression in
young adults and older women, though the relationship has not been studied in midlife women, who may be at higher risk of depression related to menopausal status. Thus, the objective of this dissertation is to examine the associations between IE, depression, stress, and adiposity in a sample of midlife women.

The three studies in this dissertation were cross-sectional analyses of data from the Women’s Health Improvement Initiative (WHII) study at the University of Rhode Island which enrolled 121 women to explore the role of physical and psychosocial factors in the quality of life of middle-aged women between the ages of 40-64. Participants included in the studies were 114 women with a mean age of $52.4 \pm 6.2$ years, 54% of whom identified as postmenopausal. Participants primarily identified as White (96%), had a high level of education with 86% having graduated college, and 82% had an annual household income greater than $75,000.

The first study used multivariable linear regression analyses to examine the association between IE and total percent body fat and abdominal adiposity. Higher IE was associated with lower total percent body fat and lower abdominal adiposity. Additionally, higher scores on the reliance on hunger and satiety cues and eating for physical rather than emotional reasons subscales of the intuitive eating scale were associated with lower total percent body fat and abdominal adiposity.

The second study used multivariable linear regression analyses to examine associations between perceived stress and IE and between features of diurnal cortisol and IE. Mediation models were tested to examine the indirect effect of IE on the association between perceived stress and adiposity and the indirect effect of IE on the association between cortisol measures and adiposity. Higher perceived stress, higher
waking cortisol, and higher cortisol 30 minutes after waking were associated with lower scores on the eating for physical rather than emotional reasons subscale. In mediation analyses, there was a significant indirect effect of waking cortisol on total body fat and abdominal adiposity through eating for physical reasons, such that higher waking cortisol was associated with lower eating for physical rather than emotional reasons which in turn promoted higher total and abdominal adiposity.

The third study used multivariable linear regression to determine associations between IE and depressive symptoms and analyses were further stratified by menopause status due to a significant interaction between menopause status and depressive symptoms. Higher IE and higher scores on the unconditional permission to eat subscale were associated with lower depressive symptoms in all participants. When stratified by menopause status, higher IE and higher unconditional permission to eat were associated with lower depressive symptoms in premenopausal women but not in postmenopausal women.

These findings have implications for promoting IE in the clinical and public health setting, particularly for midlife women who may be vulnerable to stress, depression, and eating to cope with emotions. Results from this study suggest that higher IE is associated with lower total and abdominal adiposity and lower depressive symptoms. Further, having higher IE may mediate the association between higher waking cortisol and greater adiposity. Future studies are needed to understand the temporal relationship and causal pathways between higher IE and positive health outcomes, such as lower adiposity and lower depressive symptoms.
ACKNOWLEDGEMENTS

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PREFACE

This dissertation was written to comply with the University of Rhode Island Graduate School Manuscript Dissertation Format. This Dissertation contains three manuscripts:

Manuscript 1: Higher Intuitive Eating is Associated with Lower Adiposity in Midlife Women. This manuscript has been submitted to Eating Behaviors.

Manuscript 2: Intuitive Eating Mediates the Association Between Waking Cortisol and Adiposity in a Cohort of Midlife Women. This manuscript has been submitted to Psychoneuroendocrinology.

Manuscript 3: Intuitive Eating is Associated with Lower Depression in Premenopausal but Not Postmenopausal Women. This manuscript will be submitted to Menopause.

Declarations of interest: The views and information presented are those of the authors and do not represent the official position of the U.S. Army Medical Center of Excellence, the U.S. Army Training and Doctrine Command, or the Departments of Army, Department of Defense, or U.S. Government.
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Higher Intuitive Eating is Associated with Lower Adiposity in Midlife Women

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This manuscript has been submitted to Eating Behaviors for publication.
Abstract

**Objective:** Intuitive eating (IE) is consistently associated with a lower body mass index, though its relationship with adiposity, specifically abdominal adiposity, is unknown. Given that midlife women often experience increases in adiposity during midlife, our objective was to examine the association between IE and adiposity in midlife women. We also aimed to validate the factor structure of the Intuitive Eating Scale (IES) in a sample of midlife women.

**Method:** We analyzed data from a cross-sectional study of 116 women between 40-64 years of age. Participants completed in-person visits and self-reported questionnaires, including the 21-item IES. Adiposity was assessed using dual energy x-ray absorptiometry. Measurements included total body fat percentage and android/gynoid (AG) ratio as a measure of abdominal adiposity.

**Results:** Confirmatory factor analysis of the IES demonstrated a poor fit to the data. Thus, we conducted an exploratory factor analysis which resulted in a 15-item scale with five items on each subscale, and demonstrated improved fit. Higher intuitive eating was associated with lower total body fat percentage ($\beta=-6.77, p<0.0001$) and lower abdominal adiposity ($\beta=-0.09, p=0.0005$). Higher scores on eating for physical reasons and reliance on internal hunger and satiety cues were associated with lower total body fat and lower abdominal adiposity.

**Conclusions:** Our findings suggest that higher intuitive eating is associated with lower total body fat percentage and lower abdominal adiposity. These results may have
public health implications to promote intuitive eating in midlife women, a population at risk of weight gain and changes to body fat distribution.
1. Introduction

Midlife in women, defined as ages 40 to 65 years, is marked by notable physiological and lifestyle changes including menopause (Thomas et al., 2018), which results in increased total body fat and abdominal adiposity (Ambikairajah et al., 2019; Greendale et al., 2019). Higher adiposity in midlife is associated with chronic diseases including cardiovascular disease, type 2 diabetes, and several types of cancer, highlighting the importance of prevention and promotion of healthy eating behavior (Everson-Rose et al., 2021; Parra-Soto et al., 2021). Dieting and emotional eating can result in weight gain, which may further contribute to abdominal fat deposition and disease risk in midlife women (van Strien et al., 2020). In fact, midlife women engage in more dieting and emotional eating than men (Péneau et al., 2013; Smith et al., 2020). Thus, there is a need to identify behaviors that promote positive and healthy eating in midlife women.

Intuitive eating (IE) is an alternative approach to dieting that promotes physical and mental health through attention to body awareness, hunger and satiety cues, and removing food intake rules (Tribole & Resch, 2020). Though IE is not designed as a weight loss tool, IE is consistently associated with lower body mass index (BMI) (Camilleri et al., 2016). The Intuitive Eating Scale is used to measure IE and consists of three subscales: unconditional permission to eat (UPE), which captures food intake rules and restricted foods; eating for physical rather than emotional reasons (EPR), which measures eating according to hunger cues versus satisfying emotions; and reliance on internal hunger and satiety cues (RHSC), which measures trusting hunger and satiety cues of when and how much to eat (Tylka, 2006). Higher BMI is
associated with lower scores on the RHSC (Herbert et al., 2013; Robinson et al., 2021) and EPR subscales (Herbert et al., 2013), but associations between BMI and the UPE subscale are less consistent, suggesting BMI may be more specifically associated with eating according to physiological hunger and satiety cues. It is plausible the association between BMI and IE is due to regularly using IE to guide when and how much to eat leading to a lower energy intake and reducing adiposity. However, literature examining appetite regulation and adiposity show individuals with greater adiposity can experience biological disruptions of weight regulating hormones, such as leptin, and acute appetite regulating hormones, such as ghrelin (Farhadipour & Depoortere, 2021; Miller, 2019). Thus, it is possible the association between BMI and IE is a result of individuals with higher BMI being physiologically unable to practice IE as effectively, with higher adiposity leading to reduced IE.

Although BMI is often used as a proxy measure for adiposity, BMI is less useful in estimating adiposity in postmenopausal women given the decrease in bone and lean mass that occurs in this population (Banack et al., 2018; Greendale et al., 2019). However, previous research on IE in midlife women has exclusively used BMI and there is an absence of research that uses an accurate measure of adiposity in relation to IE among midlife women.

Therefore, this study examined the association between IE, total percent body fat, and abdominal adiposity in a sample of midlife women. Given that previous studies have found the factor structure of the Intuitive Eating Scale-2 to be equivocal in various samples (Swami et al., 2022) and that the original Intuitive Eating Scale was validated in a population of university aged women (Tylka, 2006), we also aimed to
validate the factor structure of the Intuitive Eating Scale in a sample of midlife women. We hypothesized that 1) women with higher IE would have lower total percent body fat and lower abdominal adiposity than women with lower IE, and 2) women with higher scores on the EPR and RHSC subscales would have lower total percent body fat and lower abdominal adiposity than women who score lower on these subscales.

2. Materials and Methods

2.1. Participants and procedure

Data for this study were from the Women’s Health Improvement Initiative (WHII) study, which enrolled 121 midlife women between April 2017 and July 2019. The study explored the role of physical and psychosocial factors in relation to quality of life. Study rationale and recruitment are described elsewhere (Ward-Ritacco et al., 2020). Women were included if they were 40–64 years of age, had no recent changes in body weight (within five pounds for the past three months), could speak and read English, had a BMI between 18.5 – 45.0 kg/m², and were a non-smoker. Participants were recruited from a university and the surrounding area via flyers, email, word of mouth, and social media. Participants completed body composition measurements in-person and provided self-reported data using web-based questionnaires on sociodemographic characteristics, physical activity, and intuitive eating. Women were included in this present analysis if they had body composition measurements and intuitive eating data. All participants provided written informed consent prior to enrollment and all procedures were approved by the University of Rhode Island Institutional Review Board.
2.2. Measures

2.2.1. Intuitive eating

The 21-item Intuitive Eating Scale (IES) was used to assess IE (Tylka, 2006). This scale assesses three domains, as previously discussed, including: UPE (9 items); EPR (6 items); and RHSC (6 items). The items are rated along a 5-point scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Higher scores indicate higher levels of IE. Items were averaged to obtain a mean score. Previous studies have demonstrated internal consistency and reliability of the IES. In a study of 194 women, the test-retest reliability over a three-week period was $r=0.90$ and Cronbach’s alpha of 0.85 for the total IES (Tylka, 2006). In this study, Cronbach’s alpha were 0.88 for the total IES score and ranged from 0.77 to 0.89 for subscales.

2.2.2. Anthropometric measurements

Trained technicians measured participants’ weight to the nearest 0.01 kg using a digital scale (Tanita WB-100, Arlington Heights, IL) and height to the nearest 0.1 cm using a stadiometer (Seca 213, Chino, CA). Both weight and height were measured twice and the average of the two measurements was used to calculate BMI (kg/m²).

2.2.3. Adiposity

Total percent body fat and abdominal adiposity were measured using dual-energy x-ray absorptiometry (DXA) (GE Lunar iDXA, Waukesha, WI) and all scans were conducted by a trained technician. Total percent body fat was calculated as the ratio between total fat mass (kg) and total body mass (kg). Abdominal adiposity was
based on the android/gynoid (AG) ratio, calculated as the ratio between the percent fat in the android (central) region and that in the gynoid (hip and thigh) region.

2.2.4. Covariates

Potential covariates were selected based on previous literature of covariates associated with the outcomes of total percent body fat and abdominal adiposity. Potential covariates identified included age, menopause status, physical activity, race and ethnicity, highest educational level completed, and income (Ambikairajah et al., 2019; Bray et al., 2018; Ogden et al., 2017). Menopause status was classified as premenopausal (before menopause or perimenopause) and postmenopausal (after menopause). Participants self-reported race and ethnicity as American Indian or Alaska Native, Asian or Pacific Islander, Black, Hispanic, White, or Other. Participants who selected Other for race and ethnicity were asked to provide a write-in response. Physical activity was assessed using the International Physical Activity Questionnaire and categorized as low, moderate, and high (Craig et al., 2003).

2.3. Statistical analyses

Preliminary analyses were conducted to assess for normality, linearity, and homoscedasticity through univariate analyses examining for skewness and kurtosis and visual inspections of QQ plots of standardized residuals. We conducted an a priori statistical power analysis which indicated that with four predictors in each model and statistical power level of 0.80 and alpha of 0.05, a sample of 80 participants would be sufficient to detect an effect of 0.15 (Faul et al., 2007).
A confirmatory factor analysis (CFA) was conducted using PROC CALIS in SAS version 9.4 to assess whether the IES adequately fit the data (Bentler & Bonett, 1980; Hu & Bentler, 1999). The results from the CFA demonstrated a poor fit: $\chi^2(186)=419.55, p < 0.0001$, $\text{CFI}=0.78$, $\text{RMSEA}=0.107$ [90% CI: 0.093, 0.121], $\text{SRMR}=0.113$. Given that the current factor structure provided a poor fit to the data, an exploratory factor analysis (EFA) was conducted to determine the best factor structure using an oblique rotation due to the intercorrelation of the factors. Items were retained if they had factor loadings of at least 0.3 and did not significantly load on more than one factor (Brown, 2015). Fifteen items were retained with five items on each of the subscales (see Supplemental Table 1). The new model demonstrated improved fit: $\chi^2(87)=142.87, p=0.0002$, $\text{CFI}=0.918$, $\text{RMSEA}=0.076$ [90% CI: 0.053, 0.098], $\text{SRMR}=0.09$. Cronbach’s alpha for the modified RHSC (0.79) and EPR subscales (0.91) demonstrated good reliability; however, the modified UPE retained a low alpha (0.63) which was not associated with any specific item. Thus, the modified UPE subscale was omitted from analysis.

Linear regression models were used to determine associations between IE (overall scale and subscales), total percent body fat and AG ratio. Logistic regression models were used to examine the associations between IE, total percent body fat and AG ratio as categorical variables. Total percent body fat was categorized as either normal (<35% total body fat) or high body fat (≥35% total body fat) (Bray, 1993). As there are currently no established cutoffs for IE or AG ratio, overall IE and IE subscales (RHSC, EPR) were categorized as either low or high according to the median in this study population (low IE: < 3.2; low RHSC: <3.8; and low EPR: <3.0).
AG ratio measures were categorized as low or high according to the median AG ratio (high AG ratio: \( \geq 0.43 \)).

Results of the regression models are presented as standardized and unstandardized B-coefficients with corresponding 95% confidence intervals (CI) and \( p \) values. For the adjusted regression analysis, bivariate analysis was conducted for sociodemographic variables and physical activity with IE and adiposity measures. Only covariates associated with both IE and adiposity at \( p < 0.1 \) in bivariate models were included in adjusted regression models. Physical activity was the only covariate associated with adiposity and though it was not associated with IE, it was kept as a covariate in adjusted models given its strong relationship to adiposity (Marsh et al., 2023; Verheggen et al., 2016). Age was retained as a covariate due to increasing body fat with age in women until older adulthood (Imboden et al., 2017; Kelly et al., 2009). All regression models were adjusted for age and physical activity. Normality and goodness of fit were verified through Kolmogorov-Smirnov tests for linear regression and Hosmer and Lemeshow tests for logistic regression. All variables included in the final adjusted model were examined for multicollinearity by assessing for variance inflation factor of less than 10.

Six participants were missing at least one IES item, representing 1.9% of IES items, and three participants were missing physical activity. Multiple imputation was used to account for missing items on the IES and subscales and physical activity by using scale-level imputation. Linear regression and logistic regression analyses were conducted using pooled results from five imputation data sets using a fully conditional
specification regression model. All analyses were conducted using SAS 9.4 (SAS Institute, Inc., Cary, NC). Statistical significance for all analyses was set at $p < 0.05$.

3. Results

From the 121 participants enrolled in the WHII study, 116 were included in this analysis (Supplemental Figure 1). Women withdrew (n=2), were missing both intuitive eating and adiposity measures (n=1), or considered ineligible for having a BMI less than 18.5 (n=2). Participants were primarily white (96%) with a mean age of $52.7 \pm 6$ years, and 54% identified as postmenopausal (Supplemental Table 2). A high percentage (>90%) of the sample were participants who identified as White, therefore race and ethnicity were categorized as participants who identified as Hispanic, participants who identified as White, and participants who identified with more than one race. Participants’ mean BMI was $26.6 \pm 5$ kg/m$^2$ and 45% of participants had a normal BMI. Participants had a high level of education with 86% having graduated college.

3.1. Associations between intuitive eating, total percent body fat, and abdominal adiposity

In adjusted linear regression analyses, higher IE was associated with lower total percent body fat ($\beta=-6.77$, 95% CI: -9.18, -4.36, $p<0.0001$), where every one-point increase in mean intuitive eating scale score was associated with a 6% lower total percent body fat (see Table 1). When analyzed categorically, low IE (<3.14) was not associated with a high total percent body fat ($\geq 35\%$) in both unadjusted and adjusted models (see Table 2). In adjusted linear regression analyses, higher IE was associated with lower abdominal adiposity ($\beta=-0.09$, 95% CI: -0.15, -0.04, $p=0.0005$).
In adjusted logistic regression models, low IE was not associated with having high abdominal adiposity (AG ratio ≥0.43).

3.2. Associations between intuitive eating subscales, total percent body fat, and abdominal adiposity

In adjusted linear regression models, both the modified RHSC and EPR subscales were inversely related with total percent body fat. RHSC had a larger magnitude of association ($\beta=-4.86$, 95% CI: -7.12, -2.59, $p<0.0001$) compared to EPR ($\beta=-3.13$, 95% CI: -4.38, -1.88, $p<0.0001$). Higher scores on the EPR subscale and higher scores on the RHSC subscale were associated with lower abdominal adiposity in adjusted models (EPR: $\beta=-0.05$, 95% CI: -0.08, -0.02, $p<0.001$; RHSC: $\beta=-0.08$, 95% CI: -0.13, -0.04, $p<0.001$) (see Table 1). In adjusted logistic regression models, neither low EPR nor low RHSC were associated with greater odds of high total percent body fat or greater odds of high abdominal adiposity. (see Table 2).

4. Discussion

This study explored whether IE is associated with total percent body fat and abdominal adiposity among midlife women. Higher IE was associated with lower total percent body fat and lower abdominal adiposity. While higher scores on both RHSC and EPR subscales were associated with lower total percent body fat and abdominal adiposity, RHSC had the largest magnitude in association.

Our study population had a mean total percent body fat and AG ratio consistent with previous studies. A study of midlife Finnish women reported a mean total percent body fat of 35.8% and AG ratio of 0.45 compared to our findings of 37.3% and 0.43,
respectively (Juppi et al., 2022). Our findings are also consistent with results from previous literature exploring IE and BMI in midlife women (Augustus-Horvath & Tylka, 2011; Madden et al., 2012; Modica, 2021). Our study moves this body of literature forward by using measures of total percent body fat and fat distribution which are more accurate indicators of health risk and adiposity compared to BMI. During menopause, women experience a concomitant increase in body fat and loss of lean mass and bone density (Dehghan et al., 2021; Greendale et al., 2019). Thus, their BMI may remain stable, despite increased adiposity, obscuring their actual health risks. This is critically important for researchers examining adiposity-related outcomes in midlife women given that research has suggested a lower BMI cut-off to avoid misclassification of obesity in postmenopausal women (Banack et al., 2018).

Our results demonstrating inverse associations between the modified EPR and RHSC subscales and total percent body fat are also consistent with previous research that only RHSC and EPR were associated with a lower BMI (Modica, 2021). These results suggest that RHSC and EPR explained most of the association between IE and adiposity. This may be because the UPE subscale differs from the other two in that the questions relate more to feelings about food perceived as unhealthy. The RHSC and EPR questions specifically address eating behaviors and trusting one’s physiological cues of what, when, and how much to eat, which may more directly translate into overall calorie intake.

Given the cross-sectional design of this study, it is unclear whether the direction of the association between adiposity and IE is due to higher body fat influencing IE. Leptin is a satiety hormone secreted by adipose tissue which has a role
in long-term energy balance, and among obese individuals, leptin resistance often occurs leading to impaired satiety and resulting in increased calorie intake (Izquierdo et al., 2019). Impairments to hunger and satiety cues resulting from leptin resistance and higher total body fat may explain this association. Studies have found positive associations between leptin and uncontrolled eating and between uncontrolled eating and BMI in populations of midlife adults (Würfel et al., 2022). Thus, leptin resistance resulting from increased adiposity may play a role in uncontrolled eating, thus inhibiting IE mechanisms.

Interoceptive awareness may also explain the association between IE behaviors and lower adiposity. Interoceptive awareness centers around an individual’s awareness and responsiveness to sensations and body systems, including the gastrointestinal system (O.G. Cameron, 2001). IE is associated with interoceptive sensitivity, specifically through reliance on internal hunger and satiety cues and eating for physical rather than emotional reasons (Herbert et al., 2013; Richard et al., 2019). Those that eat in response to hunger and stop when full may have decreased incidence of overeating leading to a more physiologically appropriate calorie intake. Our findings support this concept, as higher RHSC scores were significantly associated with lower total percent body fat and abdominal adiposity. Further, the RHSC subscale explained 18% of the variance in total percent body fat and 11% of the variance in abdominal adiposity.

The present study should be considered in light of its limitations. The study was cross-sectional, and our results cannot establish directionality of these associations. Additionally, this study population was primarily White women with
high education and income levels. Therefore, further research is needed in other populations to determine whether these results are generalizable to the general population. Future studies should examine these associations in more diverse populations of race and ethnicity with varying socioeconomic statuses using prospective study designs to explore temporality. There were several strengths in this study, most notably the use of DXA to accurately measure total percent body fat and abdominal adiposity. Additionally, we analyzed associations between individual IE subscales and adiposity which allowed us to explore differences between the subscales.

5. Conclusion

Our findings demonstrate that higher IE is associated with lower total percent body fat and lower abdominal adiposity. These results may have public health implications, as our results are supportive of promotion of IE in midlife women, a population at risk of increased adiposity. Such interventions have the potential to lower disease risk and improve quality of life through reduced adiposity and promoting a healthy relationship with food.
References


Table 1. Associations between intuitive eating and adiposity in midlife women ($n = 116$)

<table>
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<tr>
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<td>0.0005</td>
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<td>Adjusted&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>$&lt;0.0001$</td>
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<td>0.0005</td>
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<tr>
<td>Unadjusted</td>
<td>-3.30 (-4.61, -1.99)</td>
<td>$&lt;0.0001$</td>
<td>-0.05 (-0.08, -0.02)</td>
<td>0.0005</td>
</tr>
<tr>
<td>Adjusted&lt;sup&gt;c&lt;/sup&gt;</td>
<td>-3.13 (-4.38, -1.88)</td>
<td>$&lt;0.0001$</td>
<td>-0.05 (-0.08, -0.02)</td>
<td>0.0007</td>
</tr>
<tr>
<td>Modified RHSC Subscale</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>-5.34 (-7.69, -2.99)</td>
<td>$&lt;0.0001$</td>
<td>-0.09 (-0.14, -0.04)</td>
<td>0.0003</td>
</tr>
<tr>
<td>Adjusted&lt;sup&gt;d&lt;/sup&gt;</td>
<td>-4.86 (-7.12, -2.59)</td>
<td>$&lt;0.0001$</td>
<td>-0.08 (-0.13, -0.04)</td>
<td>0.0007</td>
</tr>
</tbody>
</table>

<sup>a</sup>AG ratio, android gynoid ratio; IES, intuitive eating scale; EPR, eating for physical reasons; RHSC, reliance on hunger and satiety cues; UPE, unconditional permission to eat.

<sup>b</sup>Unstandardized $\beta$ coefficients.

<sup>c</sup>Adjusted model includes age and physical activity.

Table 2. Risk of high total percent body fat (>35%) and high AG ratio (> 0.43) according to low intuitive eating score in midlife women ($n = 116$)

<table>
<thead>
<tr>
<th>Intuitive eating score</th>
<th>Total Body Fat</th>
<th></th>
<th>AG Ratio&lt;sup&gt;b&lt;/sup&gt;</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Odds Ratio&lt;sup&gt;a&lt;/sup&gt; (95% CI)</td>
<td>$p$ - value</td>
<td>Odds Ratio (95% CI)</td>
<td>$p$ - value</td>
</tr>
<tr>
<td>Low intuitive eating&lt;sup&gt;e&lt;/sup&gt;</td>
<td>6.26 (0.51, 12.01)</td>
<td>0.07</td>
<td>2.08 (0.48, 3.68)</td>
<td>0.19</td>
</tr>
<tr>
<td>Low EPR score</td>
<td>5.84 (0.71, 10.97)</td>
<td>0.06</td>
<td>2.01 (0.47, 3.54)</td>
<td>0.20</td>
</tr>
<tr>
<td>Low RHSC score</td>
<td>3.16 (0.54, 5.78)</td>
<td>0.11</td>
<td>1.87 (0.41, 3.32)</td>
<td>0.24</td>
</tr>
</tbody>
</table>

<sup>a</sup>Adjusted model includes age and physical activity.

<sup>b</sup>AG ratio, android gynoid ratio; EPR, eating for physical reasons; RHSC, reliance on hunger and satiety cues; UPE, unconditional permission to eat.

<sup>c</sup>Low intuitive eating is defined as $< median$ score of 3.2 and high intuitive eating is defined as $\geq median$ score of 3.2

<sup>d</sup>Low EPR is defined as $< median$ score of 3.0 and high EPR is defined as $\geq median$ score of 3.0.

<sup>e</sup>Low RHSC is defined as $< median$ score of 3.8 and high RHSC is defined as $\geq median$ score of 3.8.
<table>
<thead>
<tr>
<th>Item</th>
<th>Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Eating for Physical Rather Than Emotional Reasons</strong></td>
<td></td>
</tr>
<tr>
<td>I find myself eating when I’m feeling emotional (e.g., anxious,</td>
<td>0.87</td>
</tr>
<tr>
<td>depressed, sad), even when I’m not physically hungry</td>
<td></td>
</tr>
<tr>
<td>I find myself eating when I am bored, even when I’m not physically</td>
<td>0.72</td>
</tr>
<tr>
<td>hungry</td>
<td></td>
</tr>
<tr>
<td>I find myself eating when I am lonely, even when I’m not physically</td>
<td>0.74</td>
</tr>
<tr>
<td>hungry</td>
<td></td>
</tr>
<tr>
<td>I use food to help me soothe my negative emotions</td>
<td>0.85</td>
</tr>
<tr>
<td>I find myself eating when I am stressed out, even when I’m not</td>
<td>0.90</td>
</tr>
<tr>
<td>physically hungry</td>
<td></td>
</tr>
<tr>
<td><strong>Reliance on Hunger and Satiety Cues</strong></td>
<td></td>
</tr>
<tr>
<td>I can tell when I’m slightly full</td>
<td>0.81</td>
</tr>
<tr>
<td>I can tell when I’m slightly hungry</td>
<td>0.50</td>
</tr>
<tr>
<td>When I’m eating, I can tell when I am getting full</td>
<td>0.77</td>
</tr>
<tr>
<td>I trust my body to tell me when to eat</td>
<td>0.63</td>
</tr>
<tr>
<td>I trust my body to tell me what to eat</td>
<td>0.43</td>
</tr>
<tr>
<td><strong>Unconditional Permission to Eat</strong></td>
<td></td>
</tr>
<tr>
<td>I try to avoid certain foods high in fat, carbohydrates, or calories</td>
<td>0.69</td>
</tr>
<tr>
<td>If I am craving a certain food, I allow myself to have it</td>
<td>0.47</td>
</tr>
<tr>
<td>I follow eating rules or dieting plans that dictate what, when, and/or</td>
<td>0.59</td>
</tr>
<tr>
<td>how much to eat</td>
<td></td>
</tr>
<tr>
<td>I have forbidden foods that I don’t allow myself to eat</td>
<td>0.52</td>
</tr>
<tr>
<td>I think of a certain food as “good” or “bad” depending on its</td>
<td>0.35</td>
</tr>
<tr>
<td>nutritional content</td>
<td></td>
</tr>
</tbody>
</table>
**Supplemental Table 2.** Characteristics of study participants (n=116a)

<table>
<thead>
<tr>
<th>Participant characteristic</th>
<th>Frequency (%) or mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>52.7 ± 6</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>71.4 ± 15</td>
</tr>
<tr>
<td>BMIb (kg/m²)</td>
<td>26.6 ± 5</td>
</tr>
<tr>
<td>Normal weight (BMI &lt; 24.9 kg/m²)</td>
<td>52 (45%)</td>
</tr>
<tr>
<td>Overweight (BMI 25 – 29.9 kg/m²)</td>
<td>39 (34%)</td>
</tr>
<tr>
<td>Obese (BMI &gt;30 kg/m²)</td>
<td>24 (21%)</td>
</tr>
<tr>
<td>Total body fat, %</td>
<td>37.3 ± 8</td>
</tr>
<tr>
<td>Android-gynoid fat ratio</td>
<td>0.43 ± 0.2</td>
</tr>
<tr>
<td>Menopause status, %</td>
<td></td>
</tr>
<tr>
<td>Pre-menopause</td>
<td>51 (46%)</td>
</tr>
<tr>
<td>Post-menopause</td>
<td>61 (54%)</td>
</tr>
<tr>
<td>Race and ethnicity, %</td>
<td></td>
</tr>
<tr>
<td>Identify as Hispanic</td>
<td>1 (1%)</td>
</tr>
<tr>
<td>Identify with more than one race</td>
<td>3 (3%)</td>
</tr>
<tr>
<td>Identify as White</td>
<td>112 (96%)</td>
</tr>
<tr>
<td>Income, %</td>
<td></td>
</tr>
<tr>
<td>Less than $75,000</td>
<td>19 (18%)</td>
</tr>
<tr>
<td>Over $75,000</td>
<td>89 (82%)</td>
</tr>
<tr>
<td>Education level, %</td>
<td></td>
</tr>
<tr>
<td>High school to associate degree</td>
<td>16 (14%)</td>
</tr>
<tr>
<td>Bachelor’s degree</td>
<td>54 (46%)</td>
</tr>
<tr>
<td>Graduate degree</td>
<td>46 (40%)</td>
</tr>
<tr>
<td>Mean IES score</td>
<td>3.2 ± 0.5</td>
</tr>
<tr>
<td>High IES, %</td>
<td>66 (57%)</td>
</tr>
<tr>
<td>Low IES, %</td>
<td>50 (43%)</td>
</tr>
<tr>
<td>Physical activity, %</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>25 (22%)</td>
</tr>
<tr>
<td>Moderate</td>
<td>33 (28%)</td>
</tr>
<tr>
<td>High</td>
<td>58 (50%)</td>
</tr>
</tbody>
</table>

aMissing data: menopause status (n = 4), income (n = 8)
bBMI, body mass index; IES, intuitive eating scale.
Supplemental Figure 1. Study participant flowchart
MANUSCRIPT 2

Intuitive Eating Mediates the Association Between Waking Cortisol and Adiposity in a Cohort of Midlife Women

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Abstract

Background: Stress is associated with negative health outcomes in adults, including increased adiposity. Eating behaviors to cope with stress can have a negative effect on adiposity. There is limited research on positive eating behaviors, such as intuitive eating (IE), and their relationship to stress and adiposity. Thus, this study aimed to examine the association between stress and adiposity and to assess whether IE is a mediator of that pathway.

Methods: Data were analyzed from a cross-sectional study of 114 women between 40-64 years of age. Participants completed in-person visits and self-reported questionnaires, including the Intuitive Eating Scale and Perceived Stress Scale. Adiposity was assessed using dual energy x-ray absorptiometry. Measurements included total body fat percentage and android/gynoid (AG) ratio as a measure of abdominal adiposity. Participants provided ten salivary cortisol samples over two days, collected upon waking, 30-, 45-, and 60-minutes after waking, and prior to bed. Several methods were used to characterize cortisol secretion and exposure, including the diurnal cortisol slope, the cortisol awakening response, the cortisol area under the curve with respect to ground, and cortisol at five different timepoints throughout the day. Linear regression was used to assess the associations between perceived stress and IE and between features of diurnal cortisol and IE. Mediation models were tested to examine the indirect effects of IE on the relationship between perceived stress and adiposity and to test the indirect effects of IE on the relationship between cortisol measures and adiposity.
**Results:** In adjusted linear regression analyses, higher perceived stress was associated with lower scores on the IE subscale eating for physical reasons ($\beta$: -0.05, $p = 0.02$). Both higher waking cortisol ($\beta$: -0.47, $p < 0.05$) and cortisol at 30-minutes after waking ($\beta$: -0.65, $p < 0.01$) were associated with lower eating for physical reasons. In mediation analyses, there was a significant indirect effect of waking cortisol on total body fat ($ab$: 0.08; 95% bootstrap CI: 0.02, 0.18) and abdominal adiposity ($ab$: 0.06; 95% bootstrap CI: 0.008, 0.12) through eating for physical reasons.

**Conclusion:** Higher perceived stress and higher morning cortisol were associated with lower IE, specifically the eating for physical reasons subscale, in this sample of midlife women. This subscale mediated the association between higher waking cortisol and adiposity, such that higher waking cortisol was related to lower eating for physical reasons, which in turn was related to higher adiposity. These findings are consistent with previous literature suggesting a relationship between perceived stress and IE.
1. Introduction

Stress is associated with poor health outcomes in adults, including obesity, cardiovascular disease, and depression (Adam et al., 2017; Cohen et al., 2007). Women report higher stress and more emotional and physical side effects from stress than men (American Psychological Association, 2017), and are more likely to experience stress-related chronic diseases than men (Heraclides et al., 2009; Stewart et al., 2018). These differences in stress and health outcomes may be attributed to social and structural gender-related inequalities, including gender oppression and discrimination (Heise et al., 2019). Changes to health behaviors to cope with stress have been proposed as potential pathways between stress and health outcomes (Cohen et al., 2007) and these behaviors may affect women more adversely than men as women are more likely than men to engage in emotional eating (Smith et al., 2020). Thus, there is a need to better understand the pathways leading from stress to poor health outcomes in women.

Chronic stress may result in a dysregulated hypothalamic pituitary adrenal (HPA) axis, which in turn affects cortisol secretion and is associated with certain maladaptive eating behaviors (Yau and Potenza, 2014). Natural cortisol release follows a circadian diurnal rhythm, rising to its peak about 30 to 45 minutes after waking and gradually decreasing throughout the day resulting in a negative diurnal slope (Adam and Kumari, 2009). Cortisol rises acutely in response to psychological stress and exposure to stress over time can accumulate, disrupting normal cortisol release (Adam et al., 2017). This may manifest as cortisol levels that remain elevated throughout the day or as a blunted cortisol response, both of which result in flatter diurnal cortisol slopes and
are associated with several poor health outcomes including depression, obesity,
cancer, and mortality (Adam et al., 2017).

Cortisol dysregulation due to chronic stress has been associated with adiposity;
though the relationship is complex, and findings are inconsistent across studies. For
example, conflicting findings exist between perceived stress and adiposity (Isasi et al.,
2015; Tenk et al., 2018) and between cortisol and adiposity (Incollingo Rodriguez et
al., 2015). A limitation within this body of research is that many studies estimate
adiposity using body mass index (BMI) or waist circumference rather than using more
objective measurements, such as dual-energy x-ray absorptiometry. Given this
limitation and the inconsistencies in associations between cortisol indices and
adiposity, there is a gap in understanding how the diurnal cortisol slope and cortisol
measured at various timepoints throughout the day relate to total adiposity and
abdominal adiposity.

Though there is conflicting evidence supporting the association between total body
adiposity and cortisol, the association between increased cortisol release in response to
stress and abdominal adiposity is more consistent (Incollingo Rodriguez et al., 2015).
It is hypothesized that manifestations of the stress response, including elevated
cortisol, drive for intake of palatable food, and alterations in appetite-regulating
hormones result in abdominal fat deposition (Dallman et al., 2005; Yau and Potenza,
2014). Thus, dysregulations in the HPA-axis resulting from chronic stress are
associated with increased abdominal adiposity through mechanisms that include eating
behaviors. Several eating behaviors, including emotional eating, are frequently studied
in the context of stress and adiposity (Chang et al., 2022; Herhaus et al., 2020; Järvelä-
Findings suggest that emotional eating is associated with a higher cortisol response to acute stress (Chang et al., 2022; Herhaus et al., 2020; Sinha et al., 2019) and that these findings are often associated with higher food intake in participants with greater adiposity (Herhaus et al., 2020; Sinha et al., 2019). Thus, individuals who engage in eating behaviors such as emotional eating may be more vulnerable to the effects of stress on adiposity.

Presently most work has examined relationships between maladaptive eating behaviors, such as emotional eating and stress. There is a dearth of literature exploring the association between stress and more adaptive eating behaviors, such as intuitive eating (IE), and adiposity outcomes. IE promotes a positive relationship with food through respect for the body and attending to internal hunger and satiety cues to guide food intake versus following external or environmental stimuli, which may include emotions (Tribole & Resch, 2020). The Intuitive Eating Scale is typically used to measure IE and consists of three subscales: unconditional permission to eat, eating for physical rather than emotional reasons, and reliance on internal hunger and satiety cues (Tylka, 2006). Given that IE involves following internal signals of when and what to eat rather than eating to cope with emotions and is associated with many positive psychosocial outcomes (Bruce and Ricciardelli, 2016), IE may have a protective effect on the relationship between stress and adiposity. Thus, those who practice IE may have more adaptive coping mechanisms and resilience to stress, resulting in less overeating during times of stress and relatedly, lower adiposity. Promoting more adaptive eating behaviors to women vulnerable to emotional eating
and chronic stress may be useful towards reducing the risk of increased adiposity related to stress.

There is limited evidence to suggest an association between higher perceived stress and lower IE (Järvelä-Reijonen et al., 2016; Jayne et al., 2020), but evidence supports the association between higher IE and lower BMI (Camilleri et al., 2016). However, there are no studies that have examined IE’s association with stress using biomarkers, such as cortisol. This study aims to determine if an adaptive eating behavior such as IE can serve to mediate the relationship between stress and adiposity. We hypothesized 1) that a flatter diurnal cortisol slope and higher perceived stress would be associated with higher adiposity, 2) that lower IE would be associated with a flatter diurnal cortisol slope and higher perceived stress, and 3) that IE mediates the relationship between stress and adiposity through the reliance on hunger and satiety cues and eating for physical reasons subscales (see Supplemental Figure 1).

2. Material and Methods

2.1. Participants and procedure

Participants were enrolled in the Women’s Health Improvement Initiative (WHII) study, which aimed to explore the role of physical and psychosocial factors in the quality of life of middle-aged women between the ages of 40-64 years. The rationale, design, and methodology of the study are described elsewhere (Ward-Ritacco et al., 2020). Briefly, participants were recruited from the University of Rhode Island (URI) and surrounding area via flyers, email advertisements, word of mouth, and social media postings from April 2017 to July 2019. Recruitment materials included a direct
link to an online screening questionnaire to determine eligibility. To participate, women had to be 40 – 64 years old, have had no recent changes in body weight (within ~5 pounds for the past 3 months), speak and read English, have a BMI between 18.5 – 45.0 kg/m², and be a non-smoker. Participants completed anthropometric and body composition measurements in-person, collected saliva samples at home, and provided self-reported data using web-based questionnaires on sociodemographic characteristics, physical activity, perceived stress, depression, sleep, and intuitive eating.

This is a cross-sectional study examining the pathway from stress to adiposity through IE. Participants were excluded if they had missing data on primary variables (intuitive eating scale, adiposity, perceived stress, and cortisol). All participants provided written informed consent prior to enrollment and all procedures were approved by URI’s Institutional Review Board.

2.2 Methods

2.2.1 Adiposity

Total percent body fat and abdominal adiposity were measured using dual-energy x-ray absorptiometry (DXA) using fan-beam technology (GE Lunar iDXA, Waukesha, WI). All scans were conducted by a trained technician. Total percent body fat was calculated as the ratio between total fat mass (kg) and total body mass (kg) multiplied by 100. Android/gynoid (AG) ratio was calculated as the ratio between the percent fat in the android (central) region and that in the gynoid (hip and thigh) region.

2.2.2 Anthropometric measurements
Trained technicians measured participants’ weight to the nearest 0.01 kg using a digital scale (Tanita WB-100, Arlington Heights, IL) and height to the nearest 0.1 cm using a stadiometer (Seca 213, Chino, CA). Both weight and height measurements were taken twice and the average of the two measurements was used in statistical analysis. BMI was calculated from height and weight (kg/m²).

2.2.3. Salivary cortisol

Participants provided ten saliva samples over two consecutive weekdays. Participants were provided with labeled Salivettes (SalivaBio Oral Swab, Salimetrics, State College, PA) and instructed to collect saliva immediately upon waking before getting out of bed, 30, 45, and 60 minutes after waking, and right before going to bed. Participants received a log with instructions to record the date, time of waking and saliva collection for each measurement. Participants were instructed to: not brush their teeth or eat from one hour prior to and during sampling, store samples in their freezer immediately after collection and return them to the lab at URI at their next visit, where they were stored at -80°C. Saliva samples were centrifuged at 1500 x g for 15 minutes before analysis and analyzed in duplicate using high sensitivity salivary cortisol enzyme immunoassay (Expanded Range High Sensitivity Salivary Cortisol Kit, Salimetrics, State College, PA). All samples with intra-assay coefficients of variation greater than 10% were repeated. The intra-assay coefficients of variation were below 4% and inter-assay coefficients of variation were below 13%. The mean cortisol of both days for each timepoint were used in analysis and if participants were missing a sample for one day, the sample of the day that was present was used to preserve data. 

2.2.4 Perceived stress
Perceived stress was measured using the 10-item Perceived Stress Scale (PSS). The PSS assesses the degree to which an individual perceives situations in their life as stressful (Cohen et al., 1983). The items are rated along a 5-point Likert scale, ranging from 0 (never) to 4 (very often). Scores were obtained by reversing the scores on the four positive items and then summing across all 10 items. Scores range from 0 to 40 and higher scores are associated with greater perceived stress.

2.2.5 Intuitive eating

IE was measured using the 21-item Intuitive Eating Scale (IES). The scale includes three subscales: 1) unconditional permission to eat (UPE), which captures the rules one associates with eating and avoidance of certain foods; 2) eating for physical rather than emotional reasons (EPR), which measures an individual’s ability to eat in accordance with internal hunger cues versus eating to satisfy emotions; and 3) reliance on internal hunger and satiety cues (RHSC), which measures trusting hunger and satiety cues of when and how much to eat (Tylka, 2006). The items are rated along a 5-point scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Scores range from 21 to 105 and higher scores indicate higher levels of IE. Item responses were averaged to obtain total and subscale mean scores. The IES has demonstrated good internal consistency with Cronbach’s alpha scores of 0.85 for the total IES scores and between 0.85 and 0.87 for the subscales (Tylka, 2006).

2.2.6. Covariates

Participants provided self-reported data using web-based questionnaires on sociodemographic characteristics including age, menopause status, physical activity level, race and ethnicity, educational level, and annual household income. Menopause
status was classified as premenopausal (before menopause) or perimenopause and postmenopausal (after menopause). Physical activity was assessed using the International Physical Activity Questionnaire and categorized as low, moderate, and high (Craig et al., 2003). Participants self-reported race and ethnicity as Asian or Pacific Islander, Black, Hispanic, American Indian or Alaska Native, White, or Other. Participants who selected Other for race and ethnicity were asked to provide a write-in response. A high percentage (>90%) of the sample were participants who identified as White, therefore race and ethnicity was categorized as either participants who identified as Hispanic, participants who identified as White, and participants who identified with more than one race.

We considered additional covariates that have been related to cortisol secretion, including alcohol use, physical health and comorbidities, depression, sleep quality and duration, and medications affecting cortisol (Adam and Kumari, 2009; Stalder et al., 2016). Alcohol use was categorized as less than three drinks per week, four to six drinks per week, and one to two drinks per day. Physical health was measured as a continuous variable based upon the number of self-reported chronic diseases (hypertension, dyslipidemia, cardiovascular disease, stroke, pulmonary disease, arthritis, gastrointestinal disease, liver disease, cancer, or diabetes). Depression was measured using the Center for Epidemiologic Studies Depression Scale (CES-D), a 20-item self-report scale used to measure depressive symptomology (Radloff, 1977). Sleep was assessed using the Pittsburgh Sleep Quality Index (PSQI), a 19-item self-reported questionnaire measuring components of sleep duration, disturbance, latency, dysfunction, efficiency, and overall sleep quality over the past
month (Buysse et al., 1989). Medication use was classified as using any medication known to affect cortisol including steroid inhalers, steroid medications or creams, oral contraceptives, anti-depressants, and anti-anxiety medications (Dmitrieva et al., 2013).

2.3 Statistical analysis

Statistical analyses were conducted to assess all primary variables (IE, cortisol, PSS, total percent body fat, and abdominal adiposity) for normality, linearity, and homoscedasticity through univariate analyses. We conducted an *a priori* statistical power analysis which indicated that with four predictors in each model and statistical power level of 0.80 and alpha of 0.05, a sample of 80 participants would be sufficient to detect an effect of 0.15 (Faul et al., 2007).

All cortisol variables were positively skewed; therefore, we used a natural log transformation to normalize the distribution (Adam and Kumari, 2009). Various methods exist to capture cortisol secretion and variability throughout the day, including the diurnal cortisol slope, cortisol awakening response (CAR), and total cortisol secretion or area under the curve (AUC). Given that the diurnal cortisol slope is consistently associated with poor health and psychosocial outcomes (Adam et al., 2017), we selected this variable to predict IE and adiposity in regression and mediation analyses. The diurnal cortisol slope for each participant was estimated on both days by fitting a linear regression line of cortisol on time of sample collected, excluding the samples taken at 30- and 45-minutes post-awakening to minimize modeling the CAR (Cowell et al., 2021). The mean slope was calculated using data from both days if participants had at least a waking and bedtime cortisol measurement and recorded the time of collection (Stawski et al., 2013). To assess the magnitude of
the CAR, the difference in cortisol from waking to 30 minutes after waking was calculated, adjusting for waking cortisol (Adam and Kumari, 2009; Stalder et al., 2016). To assess the overall cortisol secretion from waking to 60 minutes after waking, the cortisol AUC with respect to ground (AUC$_g$) was determined (Pruessner et al., 2003).

To compare cortisol at each sampling timepoint between participants with high IE and low IE, $t$-tests were conducted. As there are currently no established cutoffs for categorizing IE, low or high IE were categorized according to the median in this study population (low IE: $< 3.14$ and high IE: $\geq 3.14$).

Linear regression models were used to determine associations between PSS and IE (overall scale and subscales) and between features of diurnal cortisol (including the diurnal cortisol slope, CAR, AUC$_g$, cortisol at awakening, 30-, 45-, and 60-minutes after waking, and at bedtime) and IE (overall scale and subscales). Linear regression models were used to determine associations between PSS and features of diurnal cortisol and adiposity measures (total percent body fat and abdominal adiposity). Results of the regression models are presented as unstandardized B-coefficients with corresponding 95% confidence intervals and $p$ values. In regression models examining associations between IE and stress, only covariates associated with both IE and PSS or cortisol at $p < 0.1$ in bivariate linear regression models were included in adjusted regression models. In regression models examining associations between stress and adiposity and in mediation models, only covariates that were associated with PSS and adiposity at $p < 0.1$ were included in adjusted models. Given previous research findings that body fat increases with age in women up until older
adulthood (Imboden et al., 2017; Kelly et al., 2009), age was selected as a covariate *a priori* and included in adjusted models where adiposity was an outcome. All variables included in the final adjusted models were examined for multicollinearity by assessing for variance inflation factor of less than 10.

In mediation analyses related to PSS, a simple mediation model (see **Supplemental Figure 1**) using PROCESS for SAS was utilized to measure the indirect effects of IE on the relationship between PSS and total percent body fat and abdominal adiposity (Hayes, 2022). A parallel multiple mediation model was tested to examine whether the IE subscales mediated the association between PSS and total percent body fat and abdominal adiposity. We generated bootstrap confidence intervals based on 5,000 bootstrap samples to examine the indirect effects of PSS on total body fat and abdominal adiposity through IE and IE subscales. IE and subscales were considered mediators if the confidence interval for indirect effects did not include zero (Hayes, 2022). Given that sleep and depression were associated only with total percent body fat and not abdominal adiposity, these were not selected as covariates in adjusted analyses. The number of comorbidities and physical activity were both significantly associated with both total percent body fat and abdominal adiposity, thus were included in adjusted models. Unadjusted models and models adjusted for age, number of comorbidities, and physical activity are presented.

In mediation analyses related to the diurnal cortisol slope, the same procedures as above were followed. Additionally, since there were multiple cortisol variables, each variable was analyzed separately to determine any bivariate associations with adiposity measures. The cortisol variable with the most significant association was
selected as the independent variable for mediation analysis. Any of the IE subscales that were found to be significantly associated with that cortisol variable were included as mediators to determine the indirect effect of IE on the relationship between cortisol and adiposity (Hayes, 2022). Unadjusted models and models adjusted for age are presented. Mediation results are presented as standardized $B$-coefficients and bootstrap confidence intervals. All analyses were conducted using SAS 9.4 (SAS Institute, Inc., Cary, NC). Statistical significance for all analyses was set at $p < 0.05$.

3. Results

From the 121 participants enrolled in the WHII study, 114 were included in this analysis (Supplemental Figure 2). Two participants withdrew from the study and five participants were excluded for missing data, including those missing IE scores ($n = 2$), adiposity measures ($n = 1$), or those having a BMI less than 18.5 ($n = 2$). Table 1 presents participant characteristics. Participants had a mean $\pm$ SD age of 52.6 $\pm$ 6.2 years with a mean total percent body fat of 37.3 $\pm$ 7.8. Most participants (83%) had an annual income of greater than $75,000 and 86% had a bachelor’s degree or higher for completed education level.

In this sample, variables demonstrated good reliability with Cronbach’s alpha of 0.88 for the total IES and ranging between 0.77 to 0.89 for subscales. Cronbach’s alpha for PSS was 0.88, alpha for CES-D was 0.89, and alpha for the seven components of PSQI was 0.71.

3.1. Association between IE and PSS

In unadjusted linear regression analyses, higher PSS was associated with lower mean IE scores ($\beta$: -0.02, 95% CI: -0.04, -0.01, $p = 0.009$) (see Table 2). In
unadjusted analyses examining associations between IE subscales and PSS, higher PSS was associated with lower scores on the EPR subscale ($\beta$: -0.04, 95% CI: -0.07, -0.02, $p = 0.002$); whereas RHSC and UPE were not associated with PSS. After adjusting for covariates, PSS was no longer associated with mean IE scores ($\beta$: -0.02, 95% CI: -0.04, 0.007, $p = 0.187$). In adjusted linear regression models examining the IE subscales, the association between higher PSS and lower scores on the EPR subscale persisted ($\beta$: -0.04, 95% CI: -0.08, -0.002, $p = 0.038$) and PSS was not associated with the RHSC and UPE subscales.

### 3.2. Association between IE and cortisol

The mean diurnal cortisol slope for both days was characterized by a normal pattern with mean waking cortisol at 9.6 nmol/L, increasing by about 50% to 14.0 nmol/L at 30 minutes after waking, declining to 12.8 nmol/L then 10.9 nmol/L at 45 minutes and 60 minutes after waking, respectively, then decreasing to 1.8 nmol/L at bedtime.

Participants with a lower mean IE score (< the median, 3.14) trended towards higher cortisol at waking ($t(104) = 1.83$, $p = 0.07$) and 30 minutes after waking ($t(103) = 1.88$, $p = 0.06$) than participants with a higher mean IE score (≥ the median, 3.14) (see Figure 1), though these results were not statistically significant.

In age-adjusted linear regression models examining the association between the diurnal cortisol slope and IE and subscales, a flatter diurnal slope was associated with both higher mean IE scores ($\beta$: 33.54, 95% CI: 0.18, 66.90, $p = 0.049$) and higher EPR scores ($\beta$: 62.17, 95% CI: 9.20, 115.16, $p = 0.022$) (see Table 2). In exploratory
analyses examining unadjusted associations between salivary cortisol at specific
timepoints and IE, higher log-cortisol at 30 minutes after waking was associated with
lower mean IE scores ($\beta$: -0.31, 95% CI: -0.58, -0.04, $p = 0.025$) and higher $AUC_g$
was associated with lower mean IE scores ($\beta$: -0.01, 95% CI: -0.01, -0.0004, $p =
0.034$) (see Table 3). The CAR and log-cortisol at other timepoints (waking, 45-
minutes after waking, 60-minutes after waking, and bedtime) were not associated with
mean IE scores.

In unadjusted analyses examining associations between cortisol at specific
timepoints and the IE subscales, higher log-cortisol at waking ($\beta$: -0.48, 95% CI: -
0.91, -0.05, $p = 0.029$) and 30-minutes after waking ($\beta$: -0.64, 95% CI: -1.07, -0.21, $p$
= 0.004) were associated with lower scores on the EPR subscale. Higher $AUC_g$ was
associated with lower scores on the EPR subscale ($\beta$: -0.01, 95% CI: -0.02, -0.003, $p$
= 0.006), but was not associated with the RHSC and UPE subscales. Further, there
were no significant associations between the CAR or log-cortisol at any timepoints
and the RHSC and UPE subscales (see Table 2).

In adjusted analyses, the relationship between log-cortisol at 30-minutes after
waking remained associated with both mean IE scores ($\beta$: -0.31, 95% CI: -0.58, -0.04,
$p = 0.027$) and EPR scores ($\beta$: -0.65, 95% CI:-1.09, -0.22, $p = 0.004$) (see Table 3).
The association between waking cortisol and EPR was slightly attenuated ($\beta$: -0.47,
95% CI: -0.91, -0.03, $p = 0.037$) and $AUC_g$ remained significantly associated with
both mean IE scores ($\beta$: -0.01, 95% CI: -0.01, -0.0001, $p = 0.036$) and EPR ($\beta$: -0.01,
95% CI: -0.02, -0.003, $p = 0.006$).

3.3. Mediation analysis
3.3.1 Associations between PSS, cortisol, and adiposity

There were no associations in unadjusted models between PSS and total percent body fat ($\beta$: 0.19, 95% CI: -0.05, 0.43, $p = 0.119$) or between PSS and abdominal adiposity ($\beta$: 0.001, 95% CI: -0.003, 0.006, $p = 0.538$) (see Table 4). In exploratory analyses examining unadjusted associations between cortisol at specific timepoints (waking, 30 minutes after waking, 45 minutes after waking, 60 minutes after waking, and bedtime), the diurnal cortisol slope, CAR, and AUCg with adiposity measures, we did not find any significant associations. However, after adjusting for age, physical activity and comorbidities, higher bedtime cortisol was associated with lower abdominal adiposity ($\beta$: -0.04, 95%CI: -0.08, -0.001, $p = 0.046$).

3.3.2 Association between PSS and adiposity through IE

In unadjusted simple mediation models, there was a significant indirect effect of PSS on total percent body fat through IE ($ab = 0.11, SE = 0.05, 95\% CI = 0.01, 0.22$) and abdominal adiposity through IE ($ab = 0.08, SE = 0.04, 95\% CI = 0.01, 0.17$). However, after adjusting for covariates, these results became nonsignificant (see Figure 2a and 2b). In a parallel multiple mediation model using the IE subscales as mediators, there was a significant indirect effect of PSS on total percent body fat through EPR ($ab = 0.07, SE = 0.04, 95\% CI = 0.004, 0.18$). However, there were no significant indirect effects of PSS on abdominal adiposity through any of the IE subscales and after adjusting for covariates, the indirect effect of PSS on total percent body fat through EPR became nonsignificant (see Figure 2c and 2d).

3.3.3 Association between cortisol and adiposity through IE
In unadjusted simple mediation models, there was a significant indirect effect of diurnal cortisol on total percent body fat through IE ($ab = -0.08$, $SE = 0.04$, 95% CI = -0.16, -0.006), but there was no indirect effect between diurnal cortisol and abdominal adiposity through IE ($ab = -0.04$, $SE = 0.03$, 95% CI = -0.11, 0.001). After adjusting for age, the results did not change (Figure 3a).

In a parallel multiple mediation model using the IE subscales as mediators, there was a significant indirect effect of diurnal slope on total percent body fat through EPR ($ab = -0.07$, $SE = 0.04$ 95% CI = -0.14, -0.002) and there were no significant indirect effects of diurnal slope on abdominal adiposity through any of the IE subscales. After adjusting for covariates, the indirect effect of diurnal slope on total percent body fat through EPR remained significant (Figure 3b).

Given that exploratory analyses found that waking cortisol was associated with both EPR and trending towards an association with abdominal adiposity, an exploratory mediation model was tested to examine whether waking cortisol was associated with total percent body fat and abdominal adiposity through the EPR subscale. In unadjusted simple mediation models, a significant indirect effect of waking cortisol on total percent body fat ($ab = 0.09$, $SE = 0.03$, 95% CI = 0.02, 0.17) and abdominal adiposity ($ab = 0.05$, $SE = 0.03$, 95% CI = 0.01, 0.12) through EPR was found. After adjusting for age, the results did not change and remained significant (see Figure 3c and 3d).

4. Discussion
The current study examined the associations between stress, IE, and adiposity in a cohort of midlife women and tested whether IE is a mediator between stress and adiposity. It was found that overall morning cortisol secretion, as measured by AUC_{g}, and higher cortisol 30 minutes after waking were associated with both lower mean IE scores and lower scores on the eating for physical reasons subscale. Additionally, higher perceived stress was associated with lower eating for physical reasons scores, providing further support of a relationship between the eating for physical reasons construct of IE and perceived stress. In mediation analyses, a significant indirect effect of waking cortisol on both total percent body fat and abdominal adiposity through the eating for physical reasons subscale was found. This suggests that higher waking cortisol may result in greater eating for emotional reasons (i.e., stress, loneliness, and boredom), which in turn may promote higher total and abdominal adiposity in midlife women.

We found that both higher morning cortisol secretion and higher perceived stress were associated with lower IE, specifically lower eating for physical rather than emotional reasons. This adds to the body of literature as previous work has not explored the relationship between biomarkers of stress and adaptive eating behaviors, such as IE. These findings are consistent with previous literature supporting a relationship between higher perceived stress and lower IE (Järvelä-Reijonen et al., 2016; Jayne et al., 2020). In contrast to findings by Jayne et al. (2020) who found that emotional eating mediated the association between perceived stress and BMI in a sample of U.S. military servicemembers (Jayne et al., 2020), we did not find an indirect effect of perceived stress on adiposity through eating for physical reasons in
our adjusted analyses. However, the findings by Jayne et al. (2020) do align with our findings that eating for physical reasons mediated the relationship between higher waking cortisol and adiposity. Overall, these findings suggest that higher morning cortisol may drive eating behaviors that are less reliant on internal cues to eat and more reliant on eating to soothe or cope with negative emotions which in turn promote higher total percent body fat and higher abdominal adiposity.

Our results suggest that the eating for physical reasons rather than emotional reasons subscale is independently associated with both perceived stress and cortisol, but the other IE subscales are not and that lower eating for physical reasons mediates the relationship between higher waking cortisol and higher adiposity. This may be because the eating for physical reasons subscale reflects aspects of emotional eating, which have been previously associated with stress (Chao et al., 2016; Jayne et al., 2020) and weight gain (Frayn and Knäuper, 2018). Previous work suggests that individuals with higher self-reported emotional eating are more likely to increase intake following a stressful event (Mantau et al., 2018). Further, research suggests that cortisol reactivity may predict emotional eating during periods of acute stress (Epel et al., 2001; Herhaus et al., 2020). Overall, these findings suggest that higher cortisol secretion in response to stress drives greater emotional eating, promoting increased food intake and calorie excess, which may lead to increased adiposity. Prior to our mediation analyses, we found that neither PSS nor morning cortisol were related to adiposity alone; however, when eating for physical reasons was introduced into the model as a mediator, it was found to have an indirect effect on the relationship between the two. Indeed, Chao et al. (2017) found that higher morning cortisol and
self-reported stress predicted weight gain over a period of 6-months in a cohort of adults, though the authors did not examine emotional eating (Chao et al., 2017). Our research provides further insight into mechanisms which could be involved in the relationship between waking cortisol and weight gain over time, suggesting that stress may induce emotional eating in some individuals as a coping mechanism, which then promotes weight gain and adiposity (Tomiyama, 2014).

Given that midlife women have high rates of disordered eating and body dissatisfaction (Gagne et al., 2012), another plausible explanation for our findings that may be especially relevant to midlife women is the relationship between stress and dieting. Though our work did not study dieting specifically, we did find that higher morning cortisol is associated with greater adiposity through lower eating for physical reasons and instead eating more to cope with emotions. This aligns with pathways found in previous work suggesting that dieting is associated with increased BMI through emotional eating in women (van Strien et al., 2020). Thus, stress related to weight concerns and body dissatisfaction may first lead to dietary restraint followed by subsequently overeating at a later point, resulting in weight gain. This is supported by research by Lorig et al. (2016) who found that women with obesity had higher cortisol secretion after an acute laboratory stressor and higher dietary restraint than women with normal weight (Lorig et al., 2016). Further, a study in women found that perceived stress and chronic stress were related to more rigid dietary restraint and suggested that feeling a loss of control due to stress may lead to first restricting food intake followed by later overcompensating due to prior deprivation (Groesz et al., 2012). While our study did not measure dietary restraint or dieting, IE encourages
rejecting the diet mentality and greater respect for one’s body (Tribole and Resch, 2020). Thus, those who practice IE may be less likely to be affected by diet-related stressors and responses that lead to overeating.

Finally, though we hypothesized that a flatter diurnal cortisol slope and higher perceived stress would be associated with higher adiposity, neither the diurnal cortisol slope nor perceived stress were associated with adiposity measures. A meta-analysis found that literature on the association between adiposity and cortisol measures is inconsistent, suggesting more longitudinal studies to further explore this relationship (Incollingo Rodriguez et al., 2015). The only cortisol indices approaching significance in this study suggested an association between higher waking cortisol and higher abdominal adiposity and higher bedtime cortisol and lower abdominal adiposity. However, these results only became significant after adjusting for covariates. Thus, it may have been that confounders including number of comorbidities or physical activity were masking the association between these timepoints and abdominal adiposity. The current findings are inconsistent with some previous literature that suggests elevated evening cortisol is typically associated with a flatter diurnal slope and worse health outcomes (Incollingo Rodriguez et al., 2015; Kumari et al., 2010). However, our findings are consistent with Joseph et al. (2017) who found that prior increase in BMI was associated with lower bedtime cortisol in cross-sectional analyses (Joseph et al., 2017). Further, in longitudinal analyses, the authors found that a flattened diurnal slope was associated with increasing BMI in participants with obesity, suggesting that obesity may drive dysregulations in the HPA-axis. Indeed,
more research is needed to further explore the mechanisms driving the associations between cortisol and adiposity (Tomiyama, 2014).

There were several strengths in this study, most notably the collection of salivary cortisol at five different timepoints over two days, allowing for capture of various features of the diurnal cortisol rhythm. Another strength is the conduction of mediation analyses using both self-reported stress and cortisol to explore associations between adiposity, eating behaviors, and different stress measures. Finally, the use of DXA allowed for the accurate measurement of total percent body fat and abdominal adiposity. However, some limitations should be considered in interpretation of our findings. Given the cross-section nature of the study, we are not able to establish temporality. Additionally, we may have lacked the power to find significance, specifically regarding the adjusted mediation analyses. While a significant indirect effect of PSS on adiposity through IE in unadjusted analysis was found, the sample size decreased significantly after adjusting for covariates which may have increased the risk of a type one error. Finally, the sample population was primarily White women with high education and income levels with low overall perceived stress scores. Thus, further research should examine these findings in other populations to determine whether they are generalizable.

Our findings provide novel insights of the association between higher cortisol and lower eating for physical rather than emotional reasons, which may result in higher adiposity in midlife women. Future studies should consider investigating interventions using techniques to reduce cortisol reactions to stress, especially in those who use emotional eating to cope with stress. Our findings that eating for physical rather than
emotional reasons mediates the relationship between waking cortisol and adiposity are consistent with extant literature demonstrating an association between emotional eating and increased cortisol. Thus, those working with clients vulnerable to emotional eating to cope with stress should consider including the principles of IE to reduce the risk of excess adiposity related to stress.

5. Conclusion

Our findings demonstrate consistent relationships between higher perceived stress and higher morning cortisol with lower scores on the eating for physical reasons subscale of the IES. Further, we found that eating for physical reasons mediates the relationship between waking cortisol and total percent body fat and abdominal adiposity such that higher waking cortisol is associated with lower eating for physical reasons which in turn is associated with both higher total body fat and abdominal adiposity. Given the inverse association between stress and eating for physical reasons, but not reliance on hunger and satiety cues, the current research suggests that emphasizing components of IE related to eating for physical reasons versus reliance on hunger and satiety cues may be most advantageous when working with those vulnerable to using food to cope with emotions. Future research should seek to understand how intuitive eating may be used as a technique for individuals who engage in emotional eating to cope with stress, and to prevent excess adiposity resulting from stress in midlife women.
References


Kumari, M., Chandola, T., Brunner, E., Kivimaki, M., 2010. A nonlinear relationship of generalized and central obesity with diurnal cortisol secretion in the Whitehall II

52


<table>
<thead>
<tr>
<th>Participant characteristic</th>
<th>Frequency (%) or mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>52.6 ± 6.2</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>71.7 ± 14.7</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>26.6 ± 5.1</td>
</tr>
<tr>
<td>Normal weight (BMI 18.5-24.9 kg/m²)</td>
<td>51 (45%)</td>
</tr>
<tr>
<td>Overweight (BMI 25 – 29.9 kg/m²)</td>
<td>38 (34%)</td>
</tr>
<tr>
<td>Obese (BMI &gt;30 kg/m²)</td>
<td>24 (21%)</td>
</tr>
<tr>
<td>Total percent body fat, %</td>
<td>37.3 ± 7.8</td>
</tr>
<tr>
<td>Android-gynoid fat ratio</td>
<td>0.43 ± 0.2</td>
</tr>
<tr>
<td>Menopause status, %</td>
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</tr>
<tr>
<td>Pre-menopause</td>
<td>51 (46%)</td>
</tr>
<tr>
<td>Post-menopause</td>
<td>59 (54%)</td>
</tr>
<tr>
<td>Annual household income, %</td>
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</tr>
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<td>Less than $75,000</td>
<td>18 (17%)</td>
</tr>
<tr>
<td>Over $75,000</td>
<td>88 (83%)</td>
</tr>
<tr>
<td>Highest education attained, %</td>
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</tr>
<tr>
<td>Completed high school and/or associate degree</td>
<td>16 (14%)</td>
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<tr>
<td>Bachelor’s degree or graduate degree</td>
<td>98 (86%)</td>
</tr>
<tr>
<td>Race and ethnicity, %</td>
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<tr>
<td>Identify as White</td>
<td>110 (96%)</td>
</tr>
<tr>
<td>Identify as Hispanic</td>
<td>1 (1%)</td>
</tr>
<tr>
<td>Identify with more than one race</td>
<td>1 (1%)</td>
</tr>
<tr>
<td>Race and ethnicity not specified</td>
<td>2 (2%)</td>
</tr>
<tr>
<td>Mean IES score</td>
<td>3.2 ± 0.6</td>
</tr>
<tr>
<td>PSS score</td>
<td>11.3 ± 6.1</td>
</tr>
<tr>
<td>Raw diurnal cortisol slope</td>
<td>-0.01 ± 0.01</td>
</tr>
<tr>
<td>Depression score (CES-D)</td>
<td>6.6 ± 6.6</td>
</tr>
<tr>
<td>Sleep score (PSQI)</td>
<td>5.5 ± 3.4</td>
</tr>
<tr>
<td>Number of comorbidities</td>
<td>0.8 ± 0.9</td>
</tr>
<tr>
<td>Medication, %</td>
<td></td>
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<tr>
<td>Yes</td>
<td>25 (22%)</td>
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<tr>
<td>No</td>
<td>89 (78%)</td>
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<td>Alcohol use, %</td>
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Less than or equal to 3 drinks per week  81 (71%)
4-6 drinks per week  20 (18%)
1-2 drinks per day  13 (11%)

Physical activity, %
Low  23 (21%)
Moderate  32 (29%)
High  56 (50%)

*M Missing data: BMI (n = 1), menopause status (n = 4), income (n = 8), education (n = 1), PSS (n = 3), diurnal cortisol slope (n = 15), depression (n = 3), sleep (n = 3), comorbidities (n = 10), physical activity (n = 3)

*BMI, body mass index; IES, intuitive eating scale; PSS, perceived stress score; CES-D, Center for Epidemiological Studies – Depression; PSQI, Pittsburgh Sleep Quality Index
Table 2. Association between measures of self-reported stress and features of diurnal cortisol and intuitive eating in midlife women (n = 111a)

<table>
<thead>
<tr>
<th></th>
<th>Mean IES</th>
<th>EPR Subscale</th>
<th>RHSC Subscale</th>
<th>UPE Subscale</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β (95% CI)</td>
<td>p-value</td>
<td>β (95% CI)</td>
<td>p-value</td>
</tr>
<tr>
<td>Perceived stress</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>-0.02 (-0.04, -0.01)</td>
<td>0.009</td>
<td>-0.04 (-0.07, -0.02)</td>
<td>0.002</td>
</tr>
<tr>
<td>Adjusted</td>
<td>-0.02 (-0.04, 0.01)</td>
<td>0.156</td>
<td>-0.05 (-0.09, -0.01)</td>
<td>0.020</td>
</tr>
<tr>
<td>Diurnal cortisol slope</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>33.59 (0.37, 66.81)</td>
<td>0.047</td>
<td>62.14 (9.43, 114.84)</td>
<td>0.021</td>
</tr>
<tr>
<td>Adjusted</td>
<td>33.54 (0.18, 66.90)</td>
<td>0.049</td>
<td>62.17 (9.20, 115.16)</td>
<td>0.022</td>
</tr>
<tr>
<td>CAR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>-0.02 (-0.04, 0.005)</td>
<td>0.153</td>
<td>-0.03 (-0.06, 0.003)</td>
<td>0.073</td>
</tr>
<tr>
<td>Adjusted</td>
<td>-0.01 (-0.04, 0.01)</td>
<td>0.191</td>
<td>-0.03 (-0.07, 0.002)</td>
<td>0.067</td>
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<td>AUC0</td>
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<td>Unadjusted</td>
<td>-0.01 (-0.01, -0.0004)</td>
<td>0.034</td>
<td>-0.01 (-0.02, -0.003)</td>
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<td>Adjusted</td>
<td>-0.01 (-0.01, -0.0001)</td>
<td>0.036</td>
<td>-0.01 (-0.02, -0.003)</td>
<td>0.006</td>
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</table>

aAssociations between PSS and IES (n = 111) and between diurnal cortisol slope using log transformed variables and IES (n = 97).

bIntuitive eating scale, EPR, eating for physical reasons, RHSC, reliance on hunger and satiety cues; UPE, unconditional permission to eat; CAR, cortisol awakening response; AUC0, area under the curve with respect to ground.

cUnstandardized β coefficients

Model adjusted for age and depression (n = 111)

cCortisol variables are log-transformed (n = 106). Missing data for cortisol at 30- and 45-minutes post-awakening (n = 1) and bedtime (n = 3). Models using cortisol variables are adjusted for age.

dAdjusted for waking cortisol.
Table 3. Association between measures of salivary cortisol taken at specific timepoints and intuitive eating in midlife women (n = 106)

<table>
<thead>
<tr>
<th>Timepoint</th>
<th>Mean IES&lt;sup&gt;a&lt;/sup&gt;</th>
<th>EPR Subscale</th>
<th>RHSC Subscale</th>
<th>UPE Subscale</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β (95% CI)</td>
<td>p-value</td>
<td>β (95% CI)</td>
<td>p-value</td>
</tr>
<tr>
<td>Waking cortisol&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Unadjusted</td>
<td>-0.25 (-0.52, 0.03)</td>
<td>0.076</td>
<td>-0.48 (-0.91, -0.05)</td>
<td>0.029</td>
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<tr>
<td>Adjusted</td>
<td>-0.26 (-0.53, 0.02)</td>
<td>0.070</td>
<td>-0.47 (-0.91, -0.03)</td>
<td>0.037</td>
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<td>Cortisol 30 minutes after waking</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>-0.31 (-0.58, -0.04)</td>
<td>0.025</td>
<td>-0.64 (-1.07, -0.21)</td>
<td>0.004</td>
</tr>
<tr>
<td>Adjusted</td>
<td>-0.31 (-0.58, 0.04)</td>
<td>0.027</td>
<td>-0.65 (-1.09, -0.22)</td>
<td>0.004</td>
</tr>
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<td>Cortisol 45 minutes after waking</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>-0.13 (-0.34, 0.08)</td>
<td>0.226</td>
<td>-0.31 (-0.64, 0.03)</td>
<td>0.073</td>
</tr>
<tr>
<td>Adjusted</td>
<td>-0.13 (-0.34, 0.08)</td>
<td>0.227</td>
<td>-0.32 (-0.65, 0.02)</td>
<td>0.068</td>
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<tr>
<td>Cortisol 60 minutes after waking</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>-0.15 (-0.40, 0.11)</td>
<td>0.260</td>
<td>-0.27 (-0.68, 0.14)</td>
<td>0.189</td>
</tr>
<tr>
<td>Adjusted</td>
<td>-0.15 (-0.40, 0.11)</td>
<td>0.267</td>
<td>-0.29 (-0.70, 0.12)</td>
<td>0.167</td>
</tr>
<tr>
<td>Bedtime cortisol</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>-0.001 (-0.16, 0.16)</td>
<td>0.985</td>
<td>0.02 (-0.22, 0.28)</td>
<td>0.845</td>
</tr>
<tr>
<td>Adjusted</td>
<td>-0.002 (-0.16, 0.16)</td>
<td>0.980</td>
<td>0.03 (-0.22, 0.28)</td>
<td>0.842</td>
</tr>
</tbody>
</table>

<sup>a</sup>IES, intuitive eating scale; EPR, eating for physical reasons; RHSC, reliance on hunger and satiety cues; UPE, unconditional permission to eat; CAR, cortisol awakening response; AUC<sub>g</sub>, area under the curve with respect to ground.

<sup>b</sup>Unstandardized β coefficients

<sup>c</sup>Cortisol variables are log-transformed. Missing data for cortisol at 30- and 45-minutes post-awakening (n = 1) and bedtime (n = 3). Models using cortisol variables are adjusted for age.
Table 4. Associations between perceived stress, cortisol, and adiposity in midlife women (*n* = 111)\(^a\)

<table>
<thead>
<tr>
<th></th>
<th>Total body fat</th>
<th>Abdominal adiposity</th>
<th>(\beta) (95% CI)</th>
<th><em>p</em>-value</th>
<th>(\beta) (95% CI)</th>
<th><em>p</em>-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Perceived stress</strong>(^c)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>0.19 (-0.05, 0.43)</td>
<td>0.119</td>
<td>0.001 (-0.003, 0.006)</td>
<td>0.538</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted</td>
<td>0.05 (-0.19, 0.28)</td>
<td>0.701</td>
<td>-0.001 (-0.006, 0.004)</td>
<td>0.654</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Waking cortisol</strong>(^d)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>2.19 (-1.39, 5.78)</td>
<td>0.227</td>
<td>0.06 (-0.01, 0.14)</td>
<td>0.100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted</td>
<td>1.67 (-2.04, 5.37)</td>
<td>0.375</td>
<td>0.06 (-0.01, 0.14)</td>
<td>0.091</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cortisol 30 minutes after waking</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>2.63 (-1.04, 6.31)</td>
<td>0.159</td>
<td>0.05 (-0.03, 0.13)</td>
<td>0.226</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted</td>
<td>1.55 (-2.08, 5.18)</td>
<td>0.398</td>
<td>0.03 (-0.05, 0.10)</td>
<td>0.485</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cortisol 45 minutes after waking</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>0.93 (-1.89, 3.74)</td>
<td>0.515</td>
<td>0.01 (-0.05, 0.07)</td>
<td>0.789</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted</td>
<td>0.17 (-2.53, 2.88)</td>
<td>0.899</td>
<td>-0.006 (-0.06, 0.05)</td>
<td>0.806</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cortisol 60 minutes after waking</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>0.38 (-3.04, 3.79)</td>
<td>0.828</td>
<td>-0.003 (-0.08, 0.07)</td>
<td>0.942</td>
<td></td>
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</tr>
<tr>
<td>Adjusted</td>
<td>-0.02 (-3.36, 3.32)</td>
<td>0.991</td>
<td>-0.0002 (-0.07, 0.07)</td>
<td>0.995</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Bedtime cortisol</strong>(^e)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>-0.004 (-2.10, 2.09)</td>
<td>0.996</td>
<td>-0.04 (-0.08, 0.01)</td>
<td>0.114</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted</td>
<td>0.15 (-1.85, 2.13)</td>
<td>0.885</td>
<td>-0.04 (-0.08, -0.001)</td>
<td>0.046</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Diurnal cortisol slope</strong>(^f)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>-300.77 (-735.75, 134.19)</td>
<td>0.173</td>
<td>-4.77 (-14.19, 4.63)</td>
<td>0.316</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted</td>
<td>-270.90 (-720.46, 178.65)</td>
<td>0.234</td>
<td>-5.19 (-14.83, 4.45)</td>
<td>0.288</td>
<td></td>
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<tr>
<td><strong>Cortisol awakening response</strong>(^g)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>0.14 (-0.14, 0.43)</td>
<td>0.321</td>
<td>0.001 (-0.004, 0.01)</td>
<td>0.695</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted</td>
<td>0.10 (-0.17, 0.39)</td>
<td>0.450</td>
<td>-0.0002 (-0.01, 0.01)</td>
<td>0.944</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>AUC(_g)(^h)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>0.04 (-0.03, 0.11)</td>
<td>0.242</td>
<td>0.0007 (-0.001, 0.002)</td>
<td>0.334</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted</td>
<td>0.02 (-0.05, 0.08)</td>
<td>0.566</td>
<td>0.0003 (-0.001, 0.002)</td>
<td>0.627</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^a\)Not included in cortisol variable analysis due to missing or excluded (*n* = 6)

\(^b\)Unstandardized \(\beta\) coefficients

\(^c\)Model adjusted for age, physical health, and physical activity (*n* = 101)

\(^d\)Cortisol variables are log-transformed and adjusted for age, physical activity, and physical health (*n* = 94)

\(^e\)Adjusted for alcohol and age (*n* = 97)

\(^f\)Adjusted for waking cortisol, age, physical activity, and physical health (*n* = 93)

\(^g\)AUC\(_g\), area under the curve with respect to ground; adjusted for age, physical activity, and physical health (*n* = 90)
**Figure 1.** Mean diurnal salivary cortisol categorized by high and low intuitive eating (IE) based on median score of 3.14. Participants with a lower mean intuitive eating score (< the median, 3.14) trended towards higher cortisol at waking ($t(104) = 1.83, \ p = 0.07$) and 30 minutes after waking ($t(103) = 1.88, \ p = 0.06$) than participants with a higher mean intuitive eating score ($\geq$ the median, 3.14).
Figure 2. Single and multiple parallel mediation models examining intuitive eating and subscales as mediators between perceived stress and (a) total percent body fat and (b) abdominal adiposity ($n = 101$)
(a) Intuitive eating

Diurnal cortisol slope

-0.06

Total body fat

*p<0.05, ***p<0.001
After adjusting for age, there was a significant indirect effect of diurnal cortisol on total body fat through intuitive eating (ab: -0.08; 95% bootstrap CI: -0.16, -0.01)

(b) Reliance on hunger and satiety cues

Diurnal slope

-0.03

Unconditional permission to eat

Total body fat

* p<0.05
After adjusting for age, there was a significant indirect effect of diurnal slope on total body fat through eating for physical reasons (ab: -0.06; 95% bootstrap CI: -0.14, -0.002)

(c) Eating for physical reasons

Waking cortisol

0.04

Total body fat

*p<0.05, ***p<0.001
After adjusting for age, there was a significant indirect effect of waking cortisol on total body fat through the eating for physical reasons subscale of the intuitive eating scale (ab: 0.08; 95% bootstrap CI: 0.02, 0.18)
Figure 3. Single and multiple mediation models examining intuitive eating (a) and intuitive eating subscales (b) as mediators between diurnal cortisol and total body fat ($n = 97$). Single mediation models examining eating for physical reasons as a mediator between waking cortisol and (c) total percent body fat and (d) abdominal adiposity ($n = 106$).

Supplemental Figure 1. Hypothesized mediation models. We will measure stress as both perceived stress scores and diurnal cortisol slope and adiposity as total percent body fat and android-gynoid ratio. We tested a simple mediation model of stress to adiposity through intuitive eating and parallel multiple mediation models of stress to adiposity through intuitive eating subscales.
Supplemental Figure 2. Study participant flowchart
Intuitive Eating is Associated with Lower Depression in Premenopausal but Not Postmenopausal Women

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Abstract

Objective: Women are more vulnerable to depressive symptoms than men during, especially during specific periods of life, including perimenopause and postmenopause. Intuitive eating (IE) is associated with positive psychosocial outcomes, including lower depression. This study examined the association between IE and depressive symptoms in midlife women and explored whether the strength of the association differs between stages of menopause.

Methods: Data were analyzed from a cross-sectional study of 111 women between 40-64 years of age. Participants completed in-person visits and self-reported questionnaires, including the 21-item Intuitive Eating Scale and Center for Epidemiologic Studies Depression Scale (CES-D). Adjusted linear regression models were used to determine associations between IE and total CES-D scores and between the IE subscales and total CES-D scores.

Results: Higher overall IE (β = -0.41, p = 0.023) and higher unconditional permission to eat (β = -0.30, p = 0.029) were associated with lower depressive symptoms in all participants. There was a significant interaction between depressive symptoms and menopause status (p-for-interaction = 0.08) where higher IE was associated with lower depressive symptoms in premenopausal (β = -0.97, p = 0.015) but not postmenopausal women. There were no significant differences in depressive symptoms between groups by menopause status.

Conclusion: Though we found no differences in depressive symptoms by groups of menopause status, our findings suggest that higher IE in premenopausal women is associated with lower depressive symptoms. We did not find that higher IE was
associated with lower depressive symptoms in postmenopausal women. There may be
differences in factors related to depression that are unique to the various stages of
menopause.
1. Introduction

Depression is one of the leading causes of disability in the U.S. and is associated with increased risk of both cardiovascular disease and mortality.\textsuperscript{1–3} Prevalence of depression among adults in the U.S. has increased from 7.3% to 9.2% between 2015 and 2020.\textsuperscript{4} Women consistently demonstrate higher rates of depression than men\textsuperscript{3–5} and it is further estimated that depression rates are higher in postmenopausal women compared to premenopausal women.\textsuperscript{6–10} It is suggested that the prevalence of depressive symptoms in postmenopausal women is 22 to 25%.\textsuperscript{11} Hormonal fluctuations including estradiol variability have been proposed as one potential mechanism of depression during this period.\textsuperscript{12,13} Additionally, other factors that may influence eating behaviors, including body image and weight concerns have been found to predict depressive symptoms in perimenopause.\textsuperscript{14} Thus, it is critical to determine whether there are modifiable health behaviors, such as eating behaviors, associated with decreased depressive symptoms in midlife women, specifically during menopause.

Numerous studies suggest an association between depression and higher emotional eating and uncontrolled eating\textsuperscript{15,16}, however, limited data exist on the relationship between depression and intuitive eating (IE), an adaptive eating behavior that is associated with a wide array of positive psychosocial outcomes.\textsuperscript{17} IE promotes a trusting and positive relationship with food and the body and is associated with higher self-esteem, optimism, positive affect, greater life satisfaction, and positive body image.\textsuperscript{18,19} Given that IE is related to greater psychological wellbeing, a bidirectional relationship has been proposed between IE and emotions such that greater IE may
promote more positive emotions or that when emotions are more positive, it is easier to eat intuitively. Previous studies in samples of older women and adolescents have demonstrated associations between higher IE and lower depression. However, there is a research gap around menopause status as a potential moderator of this relationship. Given that hormonal mechanisms may further increase depression risk in postmenopausal women, examining whether menopause status moderates this relationship will fill a critical gap towards determining whether higher intuitive eating can help mitigate depressive symptoms after the menopause transition.

Thus, this study aimed to 1) examine the association between intuitive eating and depression symptoms in midlife women and 2) explore whether the strength of the association differs between stages of menopause. Based on results from prior studies, we hypothesized that higher intuitive eating would be associated with lower depression symptoms in midlife women and the associations would be stronger in women who are postmenopausal than in women who are premenopausal.

2. Methods

2.1 Participants and procedure

Participants were enrolled in the Women’s Health Improvement Initiative (WHII) study that aimed to explore the role of physical and psychosocial factors in the quality of life of middle-aged women. The rationale, design, and methodology of the cross-sectional study are described elsewhere. Briefly, participants were recruited from the University of Rhode Island and surrounding area via flyers, email advertisements, word of mouth, and social media postings from April 2017 to July 2019. Recruitment
materials included a direct link to an online screening questionnaire to determine eligibility. In order to participate women had to be between the ages of 40 – 64 years, have had no recent changes in body weight (within ~5 pounds for the past 3 months), speak and read English, have a BMI between 18.5 – 45.0 kg/m², and be a non-smoker. Participants completed anthropometric measurements in-person and provided self-reported data using web-based questionnaires on sociodemographic characteristics, physical activity, depression, and intuitive eating.

This present study was a secondary analysis of data from the WHII study to examine the association between IE and depressive symptoms in midlife women. Participants were excluded if they had missing data on the Intuitive Eating Scale and Center for Epidemiologic Studies Depression Scale. All participants provided written informed consent prior to enrollment and all procedures were approved by the University of Rhode Island Institutional Review Board.

2.2 Measures

2.2.1 Intuitive eating

Intuitive eating was measured using the 21-item Intuitive Eating Scale (IES). The scale includes three subscales: 1) unconditional permission to eat (UPE), which captures the rules one associates with eating and avoidance of certain foods; 2) eating for physical rather than emotional reasons (EPR), which measures an individual’s ability to eat in accordance with internal hunger cues versus eating to satisfy emotions; and 3) reliance on internal hunger and satiety cues (RHSC), which measures trusting hunger and satiety cues of when and how much to eat. The items are rated along a 5-point scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Scores range
from 21 to 105 and higher scores indicate higher levels of intuitive eating. Item responses were averaged to obtain total and subscale mean scores. The IES has demonstrated good internal consistency with Cronbach’s alpha scores of 0.85 for the total IES scores and between 0.85 and 0.87 for the subscales.23

2.2.2 Depression

Depressive symptoms were measured using the Center for Epidemiologic Studies Depression Scale (CES-D), a 20-item self-report scale used to measure depressive symptomology.24 The items examine depressive symptomology over the past week using a 4-point scale, ranging from 0 (rarely or none of the time, less than one day) to 3 (most or all of the time, 5-7 days). Possible scores range from 0 to 60 where higher scores indicate higher levels of depressive symptoms. The CES-D has shown good reliability with Cronbach’s alpha of 0.90 in a representative sample of midlife adults in the United States.25

2.2.3 Menopause status

Menopause status was classified by the Stages of Reproductive Aging Workshop (STRAW) criteria, considered the gold standard for classifying women’s reproductive aging through menopause.26 Broadly, the STRAW phases include reproductive or premenopause, menopause transition or perimenopause, and postmenopause.26 Participants provided self-reported data on menopause status. Menopause status was classified as premenopausal (before menopause or regular menstrual periods), perimenopausal (changes in menstrual periods, but have not gone
12 months in a row without a menstrual period), and postmenopausal (after menopause or if the participant reported having a hysterectomy).

### 2.2.4 Covariates

Participants provided self-reported data using web-based questionnaires on sociodemographic characteristics including age, physical activity level, race and ethnicity, educational level, and annual household income. Physical activity was assessed using the International Physical Activity Questionnaire and categorized as low, moderate, and high. Participants self-reported race and ethnicity as American Indian or Alaska Native, Asian or Pacific Islander, Black, Hispanic, White, or Other. Participants who selected Other for race and ethnicity were asked to provide a write-in response.

Additional covariates that have been related to depression were considered, including total percent body fat, sleep duration and quality, having multiple comorbidities, and alcohol use. Trained technicians measured participants’ weight to the nearest 0.01 kg using a digital scale (Tanita WB-100, Arlington Heights, IL) and height to the nearest 0.1 cm using a stadiometer (Seca 213, Chino, CA). Both weight and height measurements were taken twice and the average of the two measurements was used in statistical analysis. BMI was calculated as weight in kilograms divided by height in meters squared (kg/m²). Total percent body fat was measured using dual-energy x-ray absorptiometry (DXA) (GE Lunar iDXA, Waukesha, WI) and all scans were conducted by a trained technician. Total percent body fat was calculated as the ratio between total fat mass (kg) and total body mass (kg). Sleep was assessed using the Pittsburgh Sleep Quality Index (PSQI), a 19-item self-reported questionnaire
measuring components of sleep duration, disturbance, latency, dysfunction, efficiency, and overall sleep quality over the past month. The number of comorbidities was measured as a continuous variable based upon the number of self-reported chronic diseases (hypertension, dyslipidemia, cardiovascular disease, stroke, pulmonary disease, arthritis, gastrointestinal disease, liver disease, cancer, or diabetes). Alcohol use was categorized as less than three drinks per week, four to six drinks per week, and one to two drinks per day.

2.3 **Statistical analysis**

Statistical analyses were conducted to assess all primary variables (IE and depression) for normality, linearity, and homoscedasticity through univariate analyses examining for skewness and kurtosis and visual inspections of QQ plots of standardized residuals. Given that the CES-D was positively skewed and QQ plots demonstrated non-normality, we used a natural log transformation to normalize the distribution. If a participant had missing items and had completed at least 80% of the items, total IES scores and subscale scores and CES-D scores were imputed using the mean item score. We conducted an *a priori* statistical power analysis, which indicated that with four predictors in each model and statistical power level of 0.80 and alpha of 0.05, a sample of 80 participants would be sufficient to detect a medium effect size ($f^2$) of 0.15.

A one-way ANOVA was used to compare the differences in mean IE and mean CESD-scores between menopause status categories. Linear regression models were used to determine associations between IE (overall scale and subscales) and depressive symptoms. Participants were identified as at risk for depression based upon CES-D
cutoff scores of 16 or higher; however, due to the low case number of participants at risk for depression ($n = 9$) compared to those not at risk ($n = 102$), logistic regression was not possible.

Results of the regression models are presented as unstandardized B-coefficients with corresponding 95% confidence intervals and $p$ values. To determine potential covariates for adjusted regression models, bivariate analysis was conducted to examine associations between covariates with IE and depression symptoms. Only covariates associated with both IE and depression at $p < 0.1$ were included in adjusted regression models. All variables included in the final adjusted models were examined for multicollinearity by assessing for variance inflation factor of less than 10.

Due to our a priori hypothesis that menopause status would moderate the association between IE and depressive symptoms, we included a cross-product interaction term between depression and menopause status to test whether the association between IE and depressive symptoms differed depending on whether the participants were premenopausal or postmenopausal. We chose to exclude perimenopausal women from the interaction analysis given that we wanted to specifically explore the differences between pre- and postmenopausal women. Given the bidirectionality of the relationship between depressive symptoms and IE, we also tested for an interaction between IE and menopause status. We performed stratified analyses for significant interactions ($p$-for-interaction $< 0.1$). All analyses were conducted using SAS 9.4 (SAS Institute, Inc., Cary, NC). Statistical significance for all analyses was set at $p < 0.05$.  

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3. Results

From the 121 participants enrolled in the WHII study, 111 were included in this analysis. Two participants withdrew from the study, five were excluded for missing depression scores, and 3 were excluded for missing IE scores. Participants had a mean ± SD age of 52.4 ± 6.2 years and a mean total percent body fat of 37.2 ± 7.8%. Generally, participants were highly educated with 86% having a bachelor’s degree or higher and most had high income with 83% having an annual household income of greater than $75,000. A high percentage (>90%) of the sample were participants who identified as White, therefore race and ethnicity was categorized as participants who identified as Hispanic, participants who identified as White, and participants who identified with more than one race. Other demographic characteristics of participants are presented in Table 1.

Mean IES score was 3.2 ± 0.6 and mean CES-D score was 6.6 ± 6.6, with 92% of participants classified as “not at risk of depression.” There were no significant differences between IE score (premenopause: 3.2 ± 0.5, perimenopause: 3.2 ± 0.5, postmenopause: 3.2 ± 0.6, \( p = 0.869 \)) and CES-D score (premenopause: 6.9 ± 6.3, perimenopause: 7.8 ± 8.9, postmenopause: 6.1 ± 5.6, \( p = 0.537 \)) by menopause status. In this sample, the IES and CES-D demonstrated good reliability with Cronbach’s alpha of 0.88 for the total IES and ranging between 0.77 to 0.89 for subscales and Cronbach’s alpha of 0.90 for CES-D.

3.1 Association between IE and depression
In unadjusted linear regression analyses, higher mean IE was associated with lower depressive symptoms ($\beta$: -0.39, 95% CI: -0.71, -0.08, $p = 0.013$) (see Table 2). In unadjusted analyses examining associations between IE subscales and depressive symptoms, we found that higher scores on RHSC ($\beta$: -0.32, 95% CI: -0.61, -0.02, $p = 0.036$) and UPE ($\beta$: -0.28, 95% CI: -0.55, -0.01, $p = 0.039$) were associated with lower depressive symptoms but that EPR was not significantly associated with depressive symptoms ($\beta$: -0.76, 95% CI: -0.36, 0.02, $p = 0.078$). After adjusting for covariates, higher IE remained associated with lower depressive symptoms ($\beta$: -0.44, 95% CI: -0.78, -0.09, $p = 0.015$). In adjusted linear regression models examining the IE subscales, higher UPE remained associated with lower depressive symptoms ($\beta$: -0.31, 95% CI: -0.59, -0.04, $p = 0.026$) while the association between RHSC and depressive symptoms was attenuated ($\beta$: -0.30, 95% CI: -0.64, 0.04, $p = 0.089$) and EPR remained unassociated with depressive symptoms.

### 3.2 Association between IE and depression by menopause status

When participants were categorized as premenopausal and postmenopausal with perimenopausal participants removed from analysis, menopause status was a significant effect modifier for the association between IE and depressive symptoms ($p$-for-interaction = 0.08) (see Figure 1). In unadjusted analyses, higher IE was associated with lower depressive symptoms in premenopausal women ($\beta$: -0.91, 95% CI: -1.58, -0.25, $p = 0.009$) but not in postmenopausal women ($\beta$: -0.20, 95% CI: -0.60, 0.19, $p = 0.305$) (Table 2). Neither the EPR or RHSC subscales were associated with depressive symptoms in premenopausal or postmenopausal women in unadjusted analyses. Higher scores on the UPE subscale were associated with lower depressive
symptoms in premenopausal women ($\beta$: -0.58, 95% CI: -1.04, -0.13, $p = 0.014$) but not in postmenopausal women in unadjusted analyses ($\beta$: -0.07, 95% CI: -0.44, 0.28, $p = 0.663$).

In adjusted analyses, higher IE remained associated with lower depressive symptoms in premenopausal women ($\beta$: -0.99, 95% CI: -1.78, -0.20, $p = 0.017$) but not in postmenopausal women ($\beta$: -0.10, 95% CI: -0.57, 0.36, $p = 0.656$). After adjusting for covariates, the association between higher scores on the UPE subscale and lower depressive symptoms in premenopausal women remained significant ($\beta$: -0.60, 95% CI: -1.11, -0.08, $p = 0.025$) and remained non-significant in postmenopausal women ($\beta$: -0.03, 95% CI: -0.43, 0.36, $p = 0.860$). In adjusted analyses, associations between the EPR and RHSC subscales and depressive symptoms remained non-significant in all groups.

3.3 Sensitivity Analyses

Sensitivity analyses were conducted to determine if there were differences in findings when the postmenopausal group was categorized further into participants who underwent natural menopause versus those with surgical menopause (reported hysterectomy). Results of unadjusted and adjusted linear regression analyses did not differ from the initial results; thus, to preserve power we chose to keep the participants with surgical and natural menopause in the postmenopausal group.

4. Discussion

The present study examined the association between IE and depressive symptoms in a cohort of midlife women. Higher IE was associated with lower depressive
symptoms, and menopause status moderated this association, such that the association between IE and depressive symptoms was significant only in premenopausal women but not women who were postmenopausal. Specifically, we found that these associations were driven primarily by the unconditional permission to eat subscale as the eating for physical reasons and reliance on hunger and satiety cues subscales were not associated with depressive symptoms in any analyses after adjusting for covariates.

Our findings that higher IE is related to lower depressive symptoms in midlife women are consistent with findings exploring this association among both older women\textsuperscript{20,34} and adolescents and young adults\textsuperscript{21}. Interestingly, we found that the unconditional permission to eat subscale was associated with lower depressive symptoms only in premenopausal women but not in older women. This finding is consistent with findings by Carrard et al. who did not find a correlation between unconditional permission to eat and depression in a sample of older women\textsuperscript{20}. There was a significant age difference between the women in the premenopausal group versus the postmenopausal group (45.3 ± 3.4 vs. 56.4 ± 4.8, respectively) in our sample; thus, these findings may be explained by differences in age versus menopausal status.

When stratified by menopause status, we found that higher IE, specifically higher unconditional permission to eat, was related to lower depressive symptoms only in the premenopausal group but not the postmenopausal group. The unconditional permission to eat subscale is largely based on the intuitive eating principles to reject diet mentality and make peace with food, encouraging a positive and healthy
relationship towards food. Tylka frames this subscale as the absence of preoccupation with food and instead following the body’s cues to guide intake rather than subscribing to rigid rules around food intake and further suggests that those with low scores on this scale may be more likely to restrict their intake, which may lead to feelings of deprivation and subsequent overeating. Thus, it may be that in premenopausal women, eating behaviors are more strongly related to depression than in postmenopausal women. Given that we found that higher scores on unconditional permission to eat were associated with lower depressive symptoms, employing more adaptive eating behaviors such as respecting one’s body, being at peace with food, and releasing guilt associated with eating certain foods may all be important predictors of lower depressive symptoms specifically in this subgroup of women.

It is plausible that certain symptoms of menopause and aging, which may be perceived as unfavorable, such as changes to body composition, may predict lower intuitive eating during premenopause and perimenopause, driving the association between lower intuitive eating and depressive symptoms. Changes to body fat distribution begin in premenopause, are accelerated during perimenopause and taper off after menopause. Further, studies have suggested that women between 40-50 years of age gain on average 1.5 pounds per year, independent of menopause status. Dieting and poor body image may be related to menopause status. For example, studies have found that perimenopausal women have more body image dissatisfaction than premenopausal women and a higher prevalence of disordered eating compared to premenopausal women. Another study found that midlife women had lower intuitive eating and body appreciation than younger women. This study further
found that midlife women had lower unconditional permission to eat and reliance on hunger and satiety cues than younger women and suggested that this may be related to attempts to mitigate weight gain during midlife.\textsuperscript{39} In fact, Carrard et al. found that in a sample of older women, higher unconditional permission to eat was correlated with lower weight and shape concerns.\textsuperscript{20} They also found an indirect path from higher BMI to lower intuitive eating through higher weight and shape concerns, suggesting that a higher BMI was related to lower body image and in turn promoted lower intuitive eating.\textsuperscript{20} This may explain our findings that lower unconditional permission to eat was associated with higher depressive symptoms in only premenopausal women and this may be due to body image dissatisfaction and changes in body composition accompanying the menopause transition. Conversely, we did not find an association between IE and depression in postmenopausal women. It may be that as women age and transition to postmenopause that an adjustment to eating behaviors occurs which is related to greater acceptance and appreciation of their bodies. Body appreciation is often used as a method to measure aspects of positive body image.\textsuperscript{40} Indeed, findings consistently demonstrate that older women have greater body appreciation than younger and middle-adult women.\textsuperscript{41,42}

Given that our study was cross-sectional, it is also plausible that higher intuitive eating may predict lower depressive symptoms. Thus, our findings may be explained by intuitive eating as a predictor of greater body appreciation, self esteem, and body image which in turn are related to better psychosocial outcomes.\textsuperscript{18,43} Indeed, a prospective study found that higher baseline intuitive eating predicted lower body image concerns in a sample of women.\textsuperscript{44} These findings were consistent with a
longitudinal study by Hazzard et al. who found that higher intuitive eating at baseline was associated with lower odds of depression and body dissatisfaction in a cohort of young adults. Thus, individuals who have higher intuitive eating may have a healthier relationship with food and respect for their bodies and improved mental health versus those who use dieting in an attempt to remedy their body dissatisfaction.

There were several strengths to this study. We analyzed associations between depressive symptoms and mean intuitive eating score and the intuitive eating subscales, which allowed us to see in greater detail which facets of intuitive eating were related to depressive symptoms in this sample. Additionally, we were able to stratify analyses by menopause status. However, there are limitations that should be considered, which include the cross-sectional nature of the study design, which limits the ability to make causal conclusions. Another limitation was that due to the low number of participants at risk for depression in this sample, we were unable to replicate our findings from linear regression analyses in logistic regression analyses. Additionally, our study sample was primarily women identifying their race and ethnicity as White with high education and income levels which limits the generalizability of our findings.

5. Conclusion

Midlife women carry an increased risk of depression and our findings suggest that higher intuitive eating in premenopausal women is associated with lower depressive symptoms. We did not find that higher intuitive eating was associated with lower depressive symptoms in postmenopausal women. Thus, there may be
differences in factors related to depression that are unique to the various stages of menopause. Though intuitive eating was not associated with lower depressive symptoms in postmenopausal women, there is a need to explore other potential causes of depression in this population. Those working in the fields of nutrition and mental health should pay particular attention to concerns regarding changes to body composition and body image in pre- and perimenopausal women and consider using intuitive eating principles to foster a healthy relationship with food and the body as potential interventions to reduce depressive symptoms. Given the unique changes faced by women during and prior to menopause, which may affect mental health, longitudinal studies are needed to further validate these findings and identify the biological or psychosocial mechanisms behind them, including body image, perceptions towards aging, and hormonal fluctuations common in menopause.
References


**Table 1.** Characteristics of study participants (n = 111)*

<table>
<thead>
<tr>
<th>Participant characteristic</th>
<th>Frequency (%) or mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>52.4 ± 6.2</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>71.8 ± 14.8</td>
</tr>
<tr>
<td>Total percent body fat, %</td>
<td>37.2 ± 7.8</td>
</tr>
<tr>
<td>BMIb (kg/m$^2$)</td>
<td>26.7 ± 5.2</td>
</tr>
<tr>
<td>Normal weight (BMI 18.5–24.9 kg/m$^2$)</td>
<td>50 (45%)</td>
</tr>
<tr>
<td>Overweight (BMI 25–29.9 kg/m$^2$)</td>
<td>36 (33%)</td>
</tr>
<tr>
<td>Obese (BMI &gt;30 kg/m$^2$)</td>
<td>24 (22%)</td>
</tr>
<tr>
<td>Menopause status, %</td>
<td></td>
</tr>
<tr>
<td>Premenopause</td>
<td>24 (22%)</td>
</tr>
<tr>
<td>Perimenopause</td>
<td>25 (23%)</td>
</tr>
<tr>
<td>Postmenopause</td>
<td>59 (55%)</td>
</tr>
<tr>
<td>Annual household income, %</td>
<td></td>
</tr>
<tr>
<td>Less than $75,000</td>
<td>17 (17%)</td>
</tr>
<tr>
<td>Over $75,000</td>
<td>86 (83%)</td>
</tr>
<tr>
<td>Highest education attained, %</td>
<td></td>
</tr>
<tr>
<td>Completed high school and/or associate degree</td>
<td>15 (14%)</td>
</tr>
<tr>
<td>Bachelor’s degree or graduate degree</td>
<td>96 (86%)</td>
</tr>
<tr>
<td>Race and ethnicity</td>
<td></td>
</tr>
<tr>
<td>Identify as White</td>
<td>107 (96%)</td>
</tr>
<tr>
<td>Identify as Hispanic</td>
<td>1 (1%)</td>
</tr>
<tr>
<td>Identify with more than one race</td>
<td>1 (1%)</td>
</tr>
<tr>
<td>Race and ethnicity not specified</td>
<td>2 (2%)</td>
</tr>
<tr>
<td>IES score</td>
<td>3.2 ± 0.6</td>
</tr>
<tr>
<td>Depression score (CES-D)</td>
<td>6.6 ± 6.6</td>
</tr>
<tr>
<td>Not depressed</td>
<td>102 (92%)</td>
</tr>
<tr>
<td>Depressed</td>
<td>9 (8%)</td>
</tr>
<tr>
<td>Number of comorbidities</td>
<td>0.8 ± 0.9</td>
</tr>
<tr>
<td>Physical activity, %</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>23 (21%)</td>
</tr>
<tr>
<td>Moderate</td>
<td>32 (29%)</td>
</tr>
<tr>
<td>High</td>
<td>56 (50%)</td>
</tr>
</tbody>
</table>

*Missing data: BMI (n = 1), comorbidities (n = 10), menopause status (n = 3), and income (n = 8).

bBMI, body mass index; IES, intuitive eating scale; CES-D, Center for Epidemiological Studies – Depression; PSQI, Pittsburgh Sleep Quality Index.
### Table 2. Associations between intuitive eating and depression by menopause status

<table>
<thead>
<tr>
<th></th>
<th>All Participants (n = 111)</th>
<th>Premenopause* (n = 24)</th>
<th>Postmenopause (n = 59)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β (95% CI)</td>
<td>p-value</td>
<td>β (95% CI)</td>
</tr>
<tr>
<td>IES</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>-0.39 (-0.71, -0.08)</td>
<td>0.013</td>
<td>-0.91 (-1.58, -0.25)</td>
</tr>
<tr>
<td>Adjusted</td>
<td>-0.44 (-0.78, -0.09)</td>
<td>0.015</td>
<td>-0.99 (-1.78, -0.20)</td>
</tr>
<tr>
<td>EPR Subscale</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>-0.17 (-0.36, 0.02)</td>
<td>0.078</td>
<td>-0.27 (-0.71, 0.17)</td>
</tr>
<tr>
<td>Adjusted</td>
<td>-0.17 (-0.39, 0.05)</td>
<td>0.126</td>
<td>-0.20 (-0.75, 0.35)</td>
</tr>
<tr>
<td>RHSC Subscale</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>-0.32 (-0.61, -0.02)</td>
<td>0.036</td>
<td>-0.66 (-1.49, 0.17)</td>
</tr>
<tr>
<td>Adjusted</td>
<td>-0.30 (-0.64, 0.04)</td>
<td>0.089</td>
<td>-0.70 (-1.56, 0.16)</td>
</tr>
<tr>
<td>UPE Subscale</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>-0.28 (-0.55, -0.01)</td>
<td>0.039</td>
<td>-0.58 (-1.04, -0.13)</td>
</tr>
<tr>
<td>Adjusted</td>
<td>-0.31 (-0.59, -0.04)</td>
<td>0.026</td>
<td>-0.60 (-1.11, -0.08)</td>
</tr>
</tbody>
</table>

*Missing menopause status (n = 3).

*Mean ages for menopausal status groups are premenopausal (45.3 ± 3.4 years) and postmenopausal (56.4 ± 4.8 years).

*IES, intuitive eating scale; EPR, eating for physical reasons; RHSC, reliance on hunger and satiety cues; UPE, unconditional permission to eat.

*Associations presented are unstandardized β coefficients for log-transformed depression. The decrease in depression symptoms can be calculated by exponentiating the coefficient, subtracting 1 from this number and multiplying by 100. This gives the percent decrease in the depression symptom score for every one unit increase in mean intuitive eating score. For example, a one unit increase in mean intuitive eating score is associated with a 47% decrease in depression symptoms score.

*Model adjusted for total percent body fat and number of comorbid conditions. Adjusted model (n = 99). Missing data: total percent body fat (n = 2) and comorbidities (n = 10).
**Figure 1.** Menopause status as a moderator in the association between intuitive eating and depression

![Graph showing the relationship between intuitive eating score and depression score, with two lines representing premenopause and postmenopause, indicating different slopes and intercepts.]
EXTENDED LITERATURE REVIEW

Introduction

Stress and eating behaviors can influence the health of midlife women, a population at risk for weight gain and redistribution of fat to the abdominal area related to menopause and aging (1). Women may be at greater risk of health consequences related to stress than men. Indeed, women report higher stress and more emotional and physical side effects from stress than men and are more likely than men to engage in emotional eating in response to stress (2–4). Higher stress is associated with negative health outcomes such increased abdominal adiposity, depression, and chronic diseases such as cardiovascular disease (5,6). In addition to stress, women may be more vulnerable to depression as depression rates are higher in women than in men, with the greatest difference between groups occurring between the ages of 15-50 (7). Thus, there is a need for research to better understand the impact of stress and depression on eating behaviors to improve health outcomes such as adiposity among midlife women.

Changes to Body Composition in Midlife

The transition to menopause for midlife women is accompanied by health changes which can impact both quality of life and risk of chronic disease. Research suggests that menopause is associated with weight gain and increased total and abdominal adiposity (8,9). Increased adiposity in midlife is associated with chronic diseases including type 2 diabetes, cardiovascular disease, and several types of cancer (10,11).
Furthermore, increased abdominal fat, independent of obesity, has been associated with increased mortality in postmenopausal women (12).

Compounding age-related changes to body composition are behavioral factors that promote weight gain and adiposity. Maladaptive eating behaviors, such as dieting and emotional eating, are more common among women than men (13,14). Dieting and emotional eating can result in weight gain, which may further contribute to abdominal fat deposition and disease risk in midlife women (15–17). Further, the desire to lose weight and prevalence of body dissatisfaction is high among midlife women (18) and research suggests that this age group demonstrates lower adaptive behaviors such as intuitive eating than younger women (19).

**Stress Can Affect Health Outcomes for Women**

Stress may also play a role in poor health outcomes of women and is an increasing problem among American adults. Women report higher stress and more emotional and physical side effects from stress than men (2) and midlife adults experience different stressors than other age groups. Stressors affecting midlife adults include occupational stress, caregiving, financial concerns, and emergence of chronic health conditions (20). Sometimes referred to as the “sandwich generation,” midlife adults often balance caring for aging parents as well as their own children. Midlife women may be more affected by these stressors than men due to traditional caregiving roles. For example, at least two-thirds of unpaid caregivers are women (20). The impact of occupational stress on women was demonstrated in a study which found that psychosocial work stress was associated with a higher risk of developing type 2 diabetes in women but
not in men (21) and a systematic review revealed positive associations between stress and cardiovascular disease in midlife women (22).

Several methods to measure stress exist and some examples include psychological stress, often measured as perceived stress, stressful life events, and biological stress hormones, including cortisol (23). Cortisol is a glucocorticoid hormone released by the hypothalamic-pituitary-adrenal (HPA) axis in response to stress (6,24,25). It is typically released in a circadian pattern with levels peaking shortly after waking and declining throughout the day; however, it’s patterns can be influenced by disrupted sleep, stress, hormone levels, and obesity (26). Cortisol is used frequently in research as a measure of psychological stress due its ability to objectively measure the body’s response to acute and chronic stress (5). Cortisol sampling methods commonly used in the literature include hair cortisol, serum fasting cortisol, and salivary cortisol. Researchers can further analyze salivary cortisol to assess the cortisol awakening response (CAR), diurnal cortisol slope, and cortisol responses to laboratory stress tests. Salivary cortisol is seen as a more reliable measure than serum cortisol due to its free or unbound status, and as such it is used frequently in research as a biomarker to measure stress (26).

Current cortisol research trends include examining the diurnal cortisol rhythm versus looking only at fasting levels (5) Natural cortisol release follows a circadian diurnal rhythm, rising to its peak about 30 to 45 minutes after waking and gradually decreasing throughout the day resulting in a negative diurnal slope (27). Cortisol rises acutely in response to psychological stress and exposure to stress over time can accumulate, disrupting normal cortisol release (5). This may manifest as cortisol levels
that remain elevated throughout the day or as a blunted cortisol response, both of which result in flatter diurnal cortisol slopes and are associated with several poor health outcomes including depression, obesity, cancer, and mortality (Adam et al., 2017). However, variations in cortisol methodology exist, making results and conclusions difficult to generalize.

Research suggests that dysregulations in the HPA-axis are associated with continuous stress, states of high stress, and perceived stress (28). Stress is associated with negative health outcomes such as depression, obesity, cardiovascular disease, and diabetes (5,29). Though there is conflicting evidence supporting the association between total body adiposity and cortisol, the association between increased cortisol release in response to stress and abdominal adiposity is more consistent (30). It is hypothesized that manifestations of the stress response, including elevated cortisol, drive for intake of palatable food, and alterations in appetite-regulating hormones result in abdominal fat deposition (24,31). Thus, dysregulations in the HPA-axis resulting from chronic stress are associated with increased abdominal adiposity through mechanisms that include eating behaviors.

Indeed, studies in adults have found associations between increased stress, adiposity, and maladaptive eating behaviors. Several eating behaviors, including emotional eating, are frequently studied in the context of stress and adiposity (32–35). Findings suggest that emotional eating is associated with a higher cortisol response to acute stress (32,33,36) and that these findings are often associated with higher food intake in participants with greater adiposity (33,36). Finally, a study of premenopausal women found that women with the highest self-reported stress demonstrated higher
emotional eating, higher waist circumference, and lower diurnal cortisol (37). Thus, individuals who engage in eating behaviors such as emotional eating may be more vulnerable to the effects of stress on adiposity.

**Midlife Women are Vulnerable to Depression**

Depression rates in women are higher than in men, with the greatest difference between groups occurring between the ages of 15-50 (7). Not only do women suffer from depression at higher rates than men, but it is also one of the leading reasons for disease-related disability in women (7). It further estimated that depression rates are higher during specific periods of life for women including perimenopause and postmenopause (38–41). The literature suggests a “window of vulnerability” for depression in women of reproductive age and this is thought to be related to hormonal changes including estradiol variability (42) but may also be influenced by lifestyle factors such as changes to family and work demands or overall health (7). Depression is also associated with maladaptive eating behaviors, obesity, poor sleep, and lower energy levels which can further contribute to overall health risk and quality of life (43,44). Schreiber and Dautovich (2018) demonstrated in a sample of midlife women that depressive symptoms predicted greater stress eating and subsequently higher BMI (45). Further, they found a significant association between stress eating and depressive symptoms in postmenopausal women but not in premenopausal women. Other factors that influence eating behaviors, including body image and weight concerns have also been found to predict depressive symptoms in perimenopause (46). Thus, it is critical to determine whether there are modifiable health behaviors, such as eating behaviors,
associated with decreased depressive symptoms in midlife women, specifically during menopause.

**Innovations are Needed to Address Adiposity, Stress, and Depression in Women**

The concept of intuitive eating (IE) was introduced in 1995 by Tribole and Resch as an eating framework developed to promote physical and mental health through increased attention to body awareness, physiological hunger and satiety cues, and removing rules associated with food intake (47). The framework consists of ten principles, emphasizing the connection between body and mind. Some of the principles include reject the diet mentality, honor your hunger, make peace with food, feel your fullness, cope with your emotions with kindness, and honor your health – gentle nutrition (47).

The Intuitive Eating Scale (IES) was developed by Tylka in 2006 and validated in a population of college women (48). The scale measures three primary constructs: unconditional permission to eat, eating for physical rather than emotional reasons, and reliance on internal hunger and satiety cues (48). The scale was later updated to the Intuitive Eating Scale-2 (IES-2), which includes an additional subscale measuring Body-Food Choice Congruence and was validated across a population of college men and women (49).

The unconditional permission to eat (UPE) subscale explores the rules one associates with eating and avoidance of certain foods which may override the internal physiological hunger and satiety cues. The underlying theory for this construct is that individuals who are deprived of food, either by amount or type of food, through
restriction, will become preoccupied which may eventually lead to overeating, thus having an impact on weight (48). This scale includes questions such as: “I try to avoid certain foods high in fat, carbohydrates, or calories” and “I have forbidden foods that I don’t allow myself to eat”.

Eating for physical rather than emotional reasons (EPR) measures an individual’s ability to eat in accordance with internal physiological hunger cues versus eating to satisfy emotions. This concept is based upon research suggesting those who do not diet will eat to satisfy hunger and cease eating when satiety is achieved and are less susceptible to eating when anxious or upset (48). This subscale includes questions addressing these concepts, such as: “I find myself eating when I am stressed out, even when I’m not physically hungry” and “I use food to help me soothe my negative emotions.”

The reliance on internal hunger and satiety cues (RHSC) subscale focuses on trusting the awareness of hunger and satiety cues of when and how much to eat. Though this awareness is innate, over time it can be superseded by external societal rules regarding eating behaviors, leading to an inability to self-regulate and a disconnect from internal awareness (48). This subscale includes questions, such as: “I trust my body to tell me when to eat,” “I trust my body to tell me what to eat,” and “When I’m eating, I can tell when I am getting full.”

Intuitive eating is proposed as a weight-neutral and more positive eating behavior than dieting, focusing on adaptive eating behaviors and reliance on internal cues of when and how much to eat (48). Emerging eating behavior research is shifting towards concepts such as IE due to the limited long-term weight maintenance outcomes
associated with dieting. Research suggests that IE is associated with benefits to psychological health (50) and a lower BMI (51,52).

Intuitive eating has been widely promoted in clinical use and in the general population and a recent meta-analysis found that interventions using IE were consistently associated with increased IE over time, increased body image and body appreciation, and decreased disordered eating (53). However, more research is needed given the small number of studies included in the analysis (n = 9) and the homogeneity of sample populations studied. In terms of improved diet quality, a systematic review found that IE interventions (n = 17) resulted in a trend towards improving or maintaining diet quality; however, there was wide variability in diet quality outcome measures (54). Additionally, like many studies in the field of IE, the participants were mostly female participants from Western countries.

There is an abundance of cross-sectional research on IE and given that IE principles encourage respecting one’s body, there has been an increased emphasis on research examining the relationship between IE and body image, body appreciation, and even internalized weight stigma. A recent study by Braun et al. found that in a sample of stressed adults, IE moderated the relationship between internalized weight stigma and a higher BMI, such that the positive relationship between internalized weight stigma and BMI was weakened with increased IE (55). This study provides important preliminary evidence towards the use of IE as a useful tool in fostering a healthier relationship with one’s body. Other research has found that higher IE is associated with lower body dissatisfaction in samples of young adult women (56),
greater appearance satisfaction and body appreciation in older women (57), and lower weight concern and disordered eating in adults (58).

Though the IES has been found to be a valid and reliable instrument in young, primarily White women and men, its validity in adolescents and diverse racial identities and ethnicities has been questioned (59,60). Furthermore, there is a lack of diversity in the IE literature where most cross-sectional studies examining IE have consisted primarily of White women, university-aged students, or overweight/obese women, limiting its generalizability (50,61). Though there is a paucity of research examining IE in more racial, ethnic, gender, and socioeconomic-diverse samples, more studies have sought to address these gaps. In a study exploring relationships between psychological well-being, IE, and body appreciation and differences by race, Romano and Heron found that body appreciation was positively associated with all IE subscales in all participants (62). They found that there were differences in associations between psychological well-being and the IE subscales by race, specifically, that higher well-being was associated with lower unconditional permission to eat in participants who identified as White but no association in participants who identified as Black (62). Modica and DiLillo examined the acceptance model of IE in a sample of Black, Hispanic, and White young adult women and found that while total IE scores did not differ between groups, there were differences by race and ethnicity in subscales where Black women had higher eating for physical rather than emotional reasons than White women and higher body-food choice congruence than Hispanic women, and finally that White women had higher unconditional permission to eat than Black women (63). Finally, Burnette et al.
examined longitudinal associations between food insecurity and IE in adolescents and emerging adults and found that persistent food insecurity was associated with lower IE over time (64). Though these cross-sectional studies provide preliminary evidence that there may be differences in IE by race, ethnicity, and socioeconomic status, more research is needed to examine IE interventions in more diverse populations.

In prospective studies, bidirectional relationships have emerged between IE and several outcomes related to body image. A study by Linardon found that higher IE predicted increases in body appreciation over time but also that greater body appreciation was associated with increased IE over time in a sample of over 3000 adult women (65). A prospective study by Messer et al. using the same sample found that while greater baseline body dissatisfaction predicted lower IE over time, other aspects of body image including overevaluation, fear of weight gain, and preoccupation did not (66). Further analyses demonstrated that higher body appreciation predicted greater decreases in eating disorder pathology and binge eating through increased scores on the unconditional permission to eat subscale (67). Taken together, these findings suggest that by promoting IE and greater appreciation for the body while reducing body dissatisfaction may help promote healthier relationships with food and body image and that these relationships are reciprocal in nature.

Two recent studies have examined IE among parents and children (68,69). Burnette et al. found that dyads where both parents and emerging adult children were intuitive eaters were more likely to be of higher socioeconomic status than dyads who did not eat intuitively (69). Further, the dyads who ate intuitively were more likely to perceive their weight as “about right” whereas the non-intuitive eating dyads
perceived their weight as “overweight” (69). The authors also found that differences between discordant dyads based on parent perceptions of their children’s weight. For example, where only the parent was the intuitive eater, both the parent and child were more likely to perceive the child’s weight as “overweight.” Rodgers et al. found associations between higher maternal IE and a more healthful home food environment. The specific aspects of the home food environment associated with maternal IE were having more fruits and vegetables available, less salty snacks and soda available, more time and energy to prepare meals, and serving fruit and vegetables at meals (68). These studies provide examples of how IE practices in parents can shape their children’s ability to eat intuitively. Additionally, they provide important insight regarding how parental weight perceptions of children may influence IE which is an interesting area of future research.

**The Need to Understand the Relationship Between Stress, Intuitive Eating, and Adiposity**

Though there is an increased abundance of research supporting IE’s association with psychosocial benefits and lower BMI, there is a dearth of evidence of the mechanisms linking IE to these correlates, particularly adiposity. Whereas maladaptive eating behaviors involve emotional or environmental influences to guide food intake, often resulting in excessive calorie intake and increased adiposity, IE promotes reliance on internal cues to regulate food intake. Thus, following the principles of IE should result in a more physiologically appropriate intake of calories guided by internal needs. However, a better understanding of how IE relates to adiposity is critical to justify promoting interventions using IE.
Consistently IE has been found to be associated with a lower BMI (51,52) and more weight stability (70); however, there is limited research examining the relationship between IE and adiposity. One recent trial testing lifestyle and psychosocial interventions in women with gestational diabetes found that higher IE was associated with lower fat mass and specifically the eating for physical reasons subscale was associated with lower fat mass and visceral adipose tissue (71). However, this is currently the only study exploring IE and its relationship to more objective measures of adiposity.

Adherence to a healthier diet and higher diet quality is one potential mechanism through which IE may be related to lower BMI and adiposity; however, the literature is inconsistent and primarily relies on cross-sectional studies limiting the ability to establish causal mechanisms. A systematic review by Grider et al. of dietary interventions using mindful eating and IE found no evidence that these interventions influence energy intake or diet quality (72). However, a recent study by Christoph et al. found higher intuitive eating was associated with higher fruit and vegetable intake in both men and women (73), though overall energy intake was not measured. Horwath et al. examined diet quality and IE subscales and found modest associations between higher UPE and worse diet quality and small associations between EPR and RHSC and higher diet quality (74). Overall, the evidence supporting a relationship between IE and diet quality and energy intake is limited and inconsistent. Thus, more quality research is needed to determine the relationship between IE and energy intake and future research should examine other mechanisms to support the relationship between IE and lower BMI or adiposity.
Poor mental health and increased stress may be one mechanism that could interfere with IE and promote adiposity, as both depression and stress have been associated with obesity (30,75,76) and maladaptive eating behaviors (3,43,76). Recent research supports a possible temporal relationship between IE and depression. Hazzard et al. conducted a longitudinal study in a cohort of adolescents and found that higher baseline IE and increased IE over time predicted lower odds of depression (77). Carrard et al. also demonstrated a relationship between higher IE and lower depression in a sample of women ages 60-75 years (78). Though these studies in both young adults and older women have demonstrated associations between higher IE and lower depression, there is a paucity of research examining the association in midlife women, who carry a higher risk of both increased depression and adiposity than other subsets of women.

Thus far, research on the relationship between IE and stress is limited to two studies examining self-reported psychological stress (34,35) and one study examining discrimination as a form of stress (79). Järvelä-Reijonen et al. found that higher perceived stress was associated with lower IE and higher emotional eating in a population of overweight and obese adults (34). In this study, lower scores on the reliance on hunger and satiety cues and eating for physical reasons subscales were associated with higher perceived stress; however, the unconditional permission to eat subscale was not (34). Further, Jayne et al. used two questions from the eating for physical reasons subscale to examine emotional eating and found that perceived stress was associated with BMI through emotional eating behaviors; however, this study did not test the total IE scale or all IE subscales in their model (35). Finally, Yoon et al. 
demonstrated that high and moderate levels of everyday discrimination were associated with lower IE in a sample of emerging adults (79). While these studies provide preliminary support of a relationship between higher stress and lower IE, none have examined stress using a biomarker as cortisol, which is known to disrupt appetite and influence abdominal adiposity.

**Conclusion**

There are significant gaps in the literature regarding the relationships between IE, depression, stress, and adiposity. First, there is a paucity of research examining how IE and its subscales relate to total body adiposity and abdominal adiposity. Second, though previous literature suggests a relationship between stress and IE, thus far there are no studies which have examined IE’s relationship to stress using a biomarker, such as cortisol. Additionally, no studies have examined whether adaptive eating behaviors emphasizing the reliance on internal cues such as IE may mediate the relationship between stress and adiposity. Further, literature on IE is largely focused on university-aged women and may not be generalizable to midlife women. There are limitations in understanding how IE relates to depression, specifically in midlife women undergoing menopause, a risk factor for depression. Midlife women have different life stressors and are at risk of increased adiposity due to aging as well as maladaptive eating behaviors to cope with stress. Thus, innovations and strategies are needed to target behaviors which reduce excess adiposity in midlife women.
References


