

**Exploring the Relationship between Sedentary Time, Emotional Eating and Body  
Responsiveness: An Experience Sampling Study**

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## Abstract

**Objective:** Prolonged sitting is a defining characteristic of daily life and associated with detrimental (mental) health consequences. It may also foster emotional eating, which in turn could exacerbate negative health effects. Since research on this association is limited, this study aimed to investigate an association between daily sedentary time and emotional eating over time. Additionally, a moderating effect of body responsiveness was examined, as this trait may help to distinguish between physical and emotional hunger and direct eating behaviour accordingly.

**Methods:** A 9-day experience sampling study with 47 young adults ( $M_{Age} = 24.5$ , 58% female, 64% German) was conducted. Daily sedentary time was assessed using the PAST-U questionnaire. The desire for total emotional eating was assessed with two self-constructed items measuring positive and negative emotional eating respectively. Estimated marginal means were used to explore variations between individuals and over time. Associations were analysed using linear mixed models and a moderation analysis.

**Results:** Daily sedentary time was not associated with the desire for total or positive emotional eating, but was significantly associated with the desire for negative emotional eating ( $b = 0.03$ ,  $p = 0.04$ ). Body responsiveness had no moderating effect.

**Discussion:** Findings suggest that daily sedentary time and emotional eating are generally not related. However, individual differences were found, and emotional eating in relation to sedentary time may vary in those who are more vulnerable or exhibit trait like emotional eating. Future research is needed to gain a deeper understanding of the association between daily sedentary time and emotional eating.

**Keywords:** Sedentary behaviour, sedentary time, prolonged sitting, emotional eating, body responsiveness, young adults, experience sampling method

## **Exploring the Relationship between Sedentary Time, Emotional Eating, and Body Responsiveness: An Experience Sampling Study**

Sitting is a defining characteristic of modern life. Yet people spend too much time sitting, and an alarming trend of increasing sedentary behaviour has been observed (Park et al., 2020; WHO, 2020). Sedentary behaviour is defined as “any waking behaviour characterized by an energy expenditure  $\leq 1.5$  METs while in a sitting or reclining posture” (Tremblay et al., 2017, p. 5). Prolonged sitting is observed in all areas of life, such as occupation, transport, home and during leisure time (Owen et al., 2011). Examples are sitting when working or studying, driving or travelling, relaxing at home, reading, engaging in screen-based activities such as watching TV or smartphone usage, as well as sitting while meeting friends (Park et al., 2020). Sedentary behaviour is to be distinguished from physical inactivity (Tremblay et al., 2017), as physical inactivity has been identified as a global problem in its own right (Ding et al., 2016; Kohl et al., 2012). Accordingly, a person who sits a lot at work may be physically active by engaging in after-work activities, such as running or going to the gym. Similarly, a person who stands a lot in their everyday life or who is in light motion can have a low level of physical activity (Biddle et al., 2019; Tremblay et al., 2017).

Sedentary activities are hard to avoid in everyday modern life. Owen et al. (2011) emphasise environmental factors that promote SB. Workplaces may merely be traditional desks and chairs, and commutes to and from work may only be possible by car. Moreover, social norms often require people to stand. For example, it is uncommon to stand in work meetings (Owen et al., 2011). Thus, sedentary behaviour may differ depending on sociodemographic factors like occupation. High sedentary behaviour is thereby particularly common among students and office workers. Compared to non-students of the same age who sit 5.89 hours per day, university students reported sitting for 7.29 hours of their day (Castro et al., 2020). Office workers even reported sitting up to 11 hours a day on average (Smith et al., 2015). In terms of age, young adults in particular seem to engage in a lot of sedentary behaviour, since 18- to 35-year-olds were found to sit for an average of 10 hours a day (Zheng et al., 2020).

The more time spent sitting, the higher the risk of weight gain, overweight, obesity, metabolic syndrome, diabetes, cardiovascular disease, colon and rectal cancers, as well as early death (Hermelink et al., 2022; Katzmarzyk & Lee, 2012; Patterson et al., 2018; Rezende et al., 2014). Next to negative physiological consequences, sedentary behaviour is also associated with mental illness. Specifically, high sedentary behaviour has been linked to experiencing negative emotions, depressive symptomatology, low self-esteem, anxiety symptoms, loneliness, stress, poor social behaviour and even suicidal ideation (Hoare et al., 2016; Rezende

et al., 2014; Zhai et al., 2015; Zou et al., 2023). Furthermore, sedentary behaviour is typically associated with less healthy and more excessive food intake. Non-occupational sedentary behaviour such as watching TV is often associated with higher snack consumption (Lake et al., 2009; Pearson & Biddle, 2011). In students and office workers, computer-based cognitive work has been shown to increase spontaneous eating and energy intake (Chaput et al., 2011; Chaput & Tremblay, 2007; Korkut & Sevinç, 2021). Eating without physical hunger during sedentary behaviour could therefore be a common behaviour among these groups.

Consuming food without being physical hungry is also typical for emotional eating, which is defined as eating in response to emotional cues instead of physical needs (Burnatowska et al., 2022). It often serves as a coping mechanism to escape negative emotions, and is hence also referred to as “stress eating”, “comfort eating”, or “eating in the absence of hunger” (Araiza & Lobel, 2018; Bennett et al., 2013; Tanofsky-Kraff et al., 2008). Examples of negative emotions that can relate to food intake without physical hunger are anger, frustration, loneliness, anxiety, depressive mood, perceived stress or boredom, among others (Crockett et al., 2015; Konttinen, 2020; Ling & Zahry, 2021). Although emotional eating has often been investigated with a focus on negative emotions, recent research increasingly emphasises that positive emotions such as joy and excitement may also induce higher desires to eat (Barnhart et al., 2021). Healthy individuals were found to eat more in response to both negative and positive emotions in comparison to neutral mood states (Cardi et al., 2015).

Emotional eaters tend to eat so-called “comfort foods” which are usually high in calories (Araiza & Lobel, 2018; Konttinen et al., 2010; Moynihan et al., 2015). Moreover, they often lose control over their eating behaviour, and typically eat beyond energy expenditure (Lazarevich et al., 2016). Clohessy et al. (2019) found that eating to cope with work-related stress or boredom correlated positively with additional calorie intake. These behaviours make emotional eaters vulnerable to overweight and obesity (Rosenheck, 2008), which have been proven to be major health risk factors for diabetes, cardiovascular disease, and cancer, and are among the leading causes of death (Mokdad et al., 2003; Pi-Sunyer, 2009). Obese people have also been found to be vulnerable to mental illnesses such as mood and anxiety disorders as well as eating disorders (Avila et al., 2015; Pickering et al., 2011). However, emotional eating is also found in normal- or underweight individuals. In this case, compensatory behaviours such as high physical activity may prevent individuals from becoming overweight (Nguyen-Rodriguez et al., 2008). Individuals who keep their weight stable despite emotional eating are often affected by negative thoughts and psychological impairment. They usually worry about their weight, body image as well as their health (Frayn et al., 2018).

Sedentary behaviour and emotional eating have several features in common. 1) Certain sedentary behaviours and emotional eating may lead to more unhealthy food choices in terms of food quantity and quality; 2) Both sedentary behaviour and emotional eating contribute to be risk factors for obesity; and 3) Sedentary behaviour and emotional eating have been linked to experiencing negative emotions and/or psychopathology. These findings raise the question to what extent sedentary behaviour and emotional eating might be related. So far, the extent of sedentary behaviour has been studied more in terms of physical (in)activity. Costa et al. (2021) found that prolonged sitting may be a risk factor for emotional eating. The authors compared factors that are associated with emotional eating in physically active and physically inactive individuals, and found that the inactive group exhibited more emotional eating risk indicators than the active group, including higher food consumption and working for more than 8 hours per day (Costa et al., 2021). Moreover, Arnold et al. (2015) found that among a college student sample, a sedentary lifestyle was significantly associated with eating in the absence of hunger for women. However, participants had to estimate their physical activity instead of the actual amount of sedentary time (Arnold et al., 2015), and sedentary behaviour was equated with physical inactivity rather than being determined by the time spent sitting. Nevertheless, both findings indicate a possible association between sedentary behaviour and emotional eating.

In addition, a moderating effect of body responsiveness can be assumed. Body responsiveness is defined as “the tendency to integrate body sensations into conscious awareness to guide decision making and behaviour and not suppress or react impulsively to them” (Daubenmier et al., 2013, p. 781). Hence, body responsiveness is not simply being aware of inner sensations, but moreover plays an important role in self-regulating eating that is guided by internal feelings of hunger and satiety instead of by emotions. Body responsiveness has been shown to increase through regular physical activity, yoga and mindfulness practices (Aydn Sünbül & Arıcı özcan, 2022; Daubenmier, 2005; Impett et al., 2006). Moreover, body responsiveness may be a relatively stable characteristic and less prone to daily fluctuations, as self-regulating behaviour tendencies are considered to relate to personality traits (Hoyle, 2010). Some findings suggest that individual differences in body responsiveness may moderate the relationship between sedentary behaviour and emotional eating. Oswald et al. (2017) found that higher body responsiveness was linked to a higher ability to rely on internal hunger and satiety cues. Additionally, higher scores of body responsiveness were associated with lower levels of emotional, disordered and uncontrolled eating (Daubenmier, 2005; Lovan et al., 2022).

To examine these relationships in the best possible way, the experience sampling methodology (ESM) was used. ESM makes use of mobile devices or other electronic means

and thus gathers information on people's experiences, behaviours and feelings near real-time within their real-world environment (Myin-Germeys & Kuppens, 2021). It typically spans over multiple days or weeks, during which participants are asked to answer questions at random or pre-determined times during the day (Hektner et al., 2007; Myin-Germeys & Kuppens, 2021). Unlike cross-sectional study designs (Arnold et al., 2015; Costa et al., 2021), ESM therefore helps to collect longitudinal data which allowed to observe how sedentary behaviour and emotional eating relate over time (Pejovic et al., 2016). This was beneficial, as sedentary time may vary throughout the week (Kirk et al., 2016; McVeigh et al., 2016), and emotional eating may change on a daily basis due to the variable nature of emotions and the effect of everyday pressures (Fowler et al., 2022). Thereby, variations could be observed both between and within individuals (Myin-Germeys & Kuppens, 2021), which provided a more comprehensive understanding of the interaction of sedentary behaviour and emotional eating within the daily life of young adults aged 18 to 35. Therefore, with the help of ESM, the aim of this study was to examine the following:

- RQ(1) To what extent is daily sedentary time associated with daily emotional eating among young adults over time?
- RQ(2) Is the relationship between daily sedentary time and daily emotional eating among young adults moderated by body responsiveness?

It was expected that higher sedentary time is positively associated with the desire for emotional eating. It was also expected that this relationship is reduced by body responsiveness, and that the effect of sedentary time on emotional eating is lower in individuals with high levels of body responsiveness. That is, people who are more responsive to their body needs may be less prone to emotional eating.

## **Methods**

### **Design**

The study was conducted in collaboration with two other bachelor's degree students who worked on related but distinct research questions. Hence, each student collected data related to specific aspects of their research, and the experience sampling study included several questionnaires, of which only those relevant to this study are explained below.

The experience sampling data was collected via the smartphone application Ethica. Ethica is an online-based application that can be downloaded to both Android and Apple

smartphones, allowing it to be used by a wide range of participants. The study itself was set up on the Ethica website (<https://ethicadata.com>). Screening, informed consent, and relevant questionnaires were all integrated into the application, which enabled researchers to collect all data within Ethica. The study was approved by the Ethics Committee of the University of Twente on April 5<sup>th</sup> 2023 (Case number: 230487). It was pilot tested for several days by the student researchers as well as by three volunteering friends, and the setup was subsequently revised on small aspects. Final data collection took place from April 24<sup>th</sup> 2023 to May 2<sup>nd</sup> 2023.

### **Participants**

The exploratory approach of this study did not require a specific sample size (Myin-Germeys & Kuppens, 2021). However, the aim was to recruit at least 19 participants, as this was found to be a median sample size for ESM studies (van Berkel et al., 2017). Participants were recruited through the University of Twente's online portal SonaSystems and through convenient and snowball sampling. Friends and family members were approached either directly, or via social media and social networks, and were asked to further spread the study. Inclusion criteria were 1) being between 18 and 35 years old; 2) being fluent in English; 3) owning and using a smartphone on a daily basis; and 4) being willing to install and use Ethica on their smartphone. Exclusion criteria were 1) not agreeing to the informed consent; and 2) not answering the baseline questionnaire. The final sample consisted of  $N = 47$  adults, was between 19 to 33 years old ( $M = 24.5$ ,  $SD = 3.4$ ), mostly female (58%), German (64%) and (70%). An overview of the sample's characteristics can be found in Table 2.

**Table 2***Summary of the Sample's Characteristics*

<b>Baseline Characteristics</b>	<b><i>n</i></b>	<b>%</b>
<i>Gender</i>		
Female	27	58%
Male	19	40%
Non-binary	1	2%
<i>Nationality</i>		
Dutch	6	13 %
German	30	64 %
Other EU	6	13 %
Other Non-EU	5	11 %
<i>Occupation</i>		
Student	25	53%
Working	13	28%
Student and Working	8	17%
Not Working	1	2%

*Note.* N = 47.**Materials*****Baseline Questionnaire*****Demographics.**

The baseline questionnaire asked for gender, age, nationality, and occupation, with occupation options being 1) full-time student, 2) full-time working, 3) student and working, 4) not working, or 5) other.

**Body Responsiveness.**

The Body Responsiveness Questionnaire (BRQ) is a seven-item self-report measure of body awareness and responsiveness to bodily sensations. It was developed by Daubenmier (2005) and has been used in research studies to assess the relationship between body awareness and health outcomes. Example items are: (a) “*I am confident that my body will let me know what is good for me*”, and (b) “*My bodily desires lead me to do things that I end up regretting*” (reverse coded). Responses were measured on a 7-point scale ranging from 1 = *not at all true about me* to 7 = *very true about me*. Higher scores indicate greater body responsiveness (BR).



Cronbach's  $\alpha$  for trait BR in the present study was .53. This was lower than other Cronbach's  $\alpha$ , which ranged from .80 to .83 (Daubenmier, 2005; Lamont, 2021) and therefore indicated acceptable but rather low internal reliability (George & Mallery, 2003, as cited in Schrepp, 2020).

### **Daily Measures**

#### **Sedentary Time.**

To capture sedentary time (ST), an adapted version of the Past-Day Adult's Sedentary Time- University (PAST-U) questionnaire by Clark et al. (2016) was used. While the original PAST version does not include questions that address the lifestyle of students (Clark et al., 2013), the adapted PAST-U includes questions about ST in the context of studying but also in the context of work. Hence, the questionnaire was equally suitable to capture ST of students as well as of working adults (Clark et al., 2016). In total, the PAST-U comprises nine questions that ask about ST for work, study, travelling, eating and drinking, watching television, using the computer, socialising and other daily activities. Example questions are "*How long were you sitting for studying yesterday?*" and "*How long were you sitting at your workplace or working from home in a paid position yesterday?*". Participants were asked to indicate their ST in minutes. Regarding validity, the PAST-U has shown a moderate correlation ( $r = .64$ ) to objective measurements of SB such as the activePAL (Clark et al., 2016). Split-half reliability of the PAST-U in the present sample was measured using the Spearman-Brown coefficient, which was found to be  $r_s(\text{DF}) = .86$  and thus indicated strong internal consistency (Akoglu, 2018).

#### **Emotional Eating.**

The desire to eat out of emotions with regard to positive and negative emotions was questioned individually, and the questions were specially constructed for this study. Participants were asked to indicate on a scale from 1 = *never* to 5 = *very often* whether they had the desire to eat due to emotions on the particular day. The final statements used to assess positive emotional eating (EE-P) and negative emotional eating (EE-N) were (1) "*Today I had the desire to eat because I felt positive emotions such as happiness/excitement/confidence*", and (2) "*Today I had the desire to eat because I felt negative emotions such as loneliness/angriness/boredom*". To ensure comprehensive assessment, participants were given hints for additional positive or negative emotions they may have experienced (e.g., "*Other positive emotions may include being content with yourself; being fascinated about something; being joyful, full of energy, relaxed, or satisfied*"). The emotions used to ask for EE-N and EE-P were drawn from standardised and validated questionnaires (Dutch Eating Behaviour

Questionnaire (DEBQ) by Van Strien et al. (1986), and Positive-Negative Emotional Eating Scale (PNEES) developed by Sultson et al. (2017)). A detailed overview of all questionnaires can be found in Appendix B. Total emotional eating scores were derived by adding item scores of EE-P and EE-N and dividing them by 2. For total emotional eating, Spearman-Brown's coefficient for split-half reliability yielded  $r_s(DF) = .62$  in this sample, indicating moderate internal consistency (Akoglu, 2018).

### **Procedure**

Participants could register in Ethica before the study started, but could not start the study until 24<sup>th</sup> April 2023. Participating and completing the study via SonaSystem granted 1.25 Sona points, which undergraduate (psychology) students of the University of Twente must collect for a total of 15 points to complete their studies. Participants received the link to the sign-up as well as further instructions either via SonaSystem or via instant messaging app. Subsequently, they had to download and install the Ethica Application to their smartphone. Participants were specifically instructed to enable permanent notifications for Ethica on their smartphone, in order to ensure the best possible study process. By using Ethica, participants could answer all questionnaires in their natural environment and everyday life. Participation in the study was completely voluntary, and participants had the opportunity to withdraw at any time without consequences or giving a reason.

To keep the burden on participants as low as possible and their commitment equally high, the study was conducted over a total period of 9 days. This length was considered appropriate given that ESM studies usually last from three days to three weeks (Connor & Lehman, 2012), and a meta-analysis has shown that median duration of ESM studies was 14 days (van Berkel et al., 2017). On the first day of the study (April 24<sup>th</sup>), participants were informed about the purpose and the content of the research (Appendix A). After actively giving informed consent, participants completed the baseline questionnaire which asked for demographics and trait BR. If they did not do so directly, they could still complete the baseline questionnaire until the end of the study, as it did not expire. For the remaining days, a fixed signal-contingent sampling scheme was used to prompt participants, meaning that participants received notifications each day at fixed times, asking them to complete the respective questionnaires (Myin-Germeys & Kuppens, 2021). Prompting participants to fill in the questionnaires reduced their burden of having to remember to fill in the questionnaires (van Berkel et al., 2017). At the same time, participants should not be disturbed too often and too randomly in their everyday life (van Berkel et al., 2017). It was therefore considered ethical to prompt participants twice a day at 8:00 a.m. and at 5:00 p.m. However, on the second day (April

25<sup>th</sup>), participants were prompted to answer the afternoon questionnaire only. From the third day on (April 26<sup>th</sup>), participants responded to the morning and the afternoon questionnaires. On the last day (May 2<sup>nd</sup>), they answered the morning questionnaire only. Participants had 4 hours to complete the respective questionnaires, and two additional reminders were sent to participants if they had not responded after 2 or 3.5 hours, respectively. The daily questionnaires were designed to be as short as possible and to be completed within 1 to 3 min, which again helped to reduce participants' burden (Verhagen et al., 2016). While the morning questionnaire included self-report items about ST day of the previous day, the afternoon questionnaire asked to report the desire for EE of the current day. Participants received a thank you note after completing each questionnaire; however, no final notification was sent out which indicated the end of the study. An overview of the study set-up can be found in Table 1.

**Table 1**

*An overview of the Experience Sampling Set-up*

Date	Questionnaire	Construct	Trigger	Expiry Time	Reminder
April 24 <sup>th</sup>	Informed Consent, Baseline	IC, Demographics, BR	8 a.m. (not sign-up)	Never	Onset, 2 hrs, 4 hrs, 6 hrs
April 25 <sup>th</sup>	Afternoon	EE	5 p.m.	4 hrs	Onset, 2 hrs, 3.5 hrs
April 26 <sup>th</sup> – May 1 <sup>st</sup>	Morning	ST	8 a.m.	4 hrs	Onset, 2 hrs, 3.5 hrs
April 26 <sup>th</sup> – May 1 <sup>st</sup>	Afternoon	EE	5 p.m.	4 hrs	Onset, 2 hrs, 3.5 hrs
May 2 <sup>nd</sup>	Morning	ST	8 a.m.	4 hrs	Onset, 2 hrs, 3.5 hrs

*Note.* IC = Informed Consent; BR = Body Responsiveness; ST = Sedentary Time; EE = Emotional Eating.

### Data Analysis

RStudio version 2023.03.0+386 (R Core Team, 2020) was used for data management and all statistical analysis (see Appendix C for relevant packages). The questionnaires were merged by day, and new variables for daily sedentary time in hours and for total emotional eating were obtained; the latter by adding positive and negative values for emotional eating and dividing by two. Days with a cumulative daily sedentary time of more than 24 hours were set

to missing values, after which participants with a response rate lower than 60% were removed. This lower limit was set to ensure an average response rate of around 69.6%, which was the average response rate in ESM studies reported by van Berkel et al. (2017). After reversed items b, c and d of the BRQ were recoded, subsequent descriptive analyses then included means, standard deviation, as well as absolute and relative numbers of participants' demographics, trait body responsiveness, sedentary time and emotional eating.

Linear mixed models (LMMs) with a first-order autoregressive (AR1) covariance structure were used to arrive at estimated marginal means (EMMs) of average sedentary time and emotional eating. LMMs account for the two-level structure of the present ESM data (nested within days, and nested within individuals) and for random effects of within-person differences and randomly missing data (Myin-Germeys & Kuppens, 2021). At the same time, AR1 covariance structure takes into consideration that the correlation of observation decreases as time increases (Funatogawa & Funatogawa, 2018). For example, the effect of sedentary time on emotional eating may be more influenced by the participants' sedentary time yesterday than by sedentary time one week ago. To calculate EMMs per participant, LMMs with the dependent variable being *Sedentary Time* or *Emotional Eating* and *Participant* as the predictor were run. To calculate EEMs over time, LMMs with the dependent variable being *Sedentary Time* or *Emotional Eating* and *Timepoint* as the predictor were run. A one-way anova was used to test variations of EMMs for sedentary time and emotional eating across participants and over time.

To explore RQ (1), a LMM with a maximum likelihood estimation, emotional eating as the outcome variable, daily sedentary time as the fixed covariate, and participant as random effect was run. For individual illustrations, five participants with different average levels of sedentary times were selected: Two below, one equal to, and two above the sample average. To explore RQ (2), a moderation analysis was run. Body responsiveness was added to the LMM of RQ (1) as a fixed covariate, as well as an interaction effect of daily sedentary time and body responsiveness. Any statistical significances were determined at a significance level of  $p < .05$ .

## Results

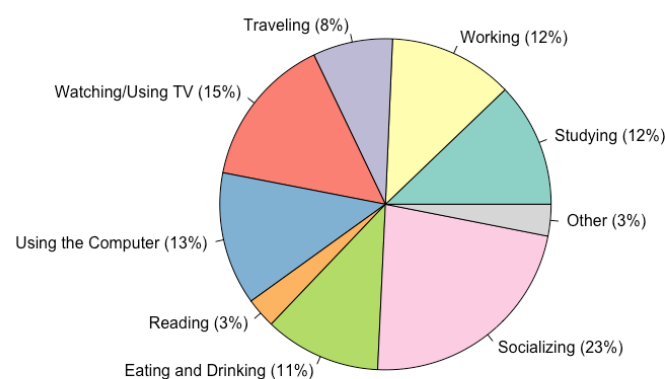
Starting from 67 participants, 20 participants were excluded as they did not provide a response rate higher or equal to 60%. The average response rate of the remaining cases was 85.4% ( $N = 47$ ), which can be considered relatively high compared to the mean response rate of 69.6% found by van Berkel et al. (2017).

### Sedentary Time

On average, participants spent 9.5 hours ( $SD = 3.6$ ) of their day sitting, ranging from 0.10 to 15.3 hours. Participants mostly reported sitting down for socializing (23%), watching/using the TV (15%), using the computer (13%), studying (12%), and working (12%), as can be seen in Figure 1. EMMs of daily ST per participant can be found in Figure 2. There was significant variation in daily ST between participants ( $F(46, 208) = 6.05, p < .001$ ), but no significant variation of ST over time ( $F(6,248) = 1.36, p = .23$ ) (see Figure 3).

## Figure 1

### *Frequency of Sedentary Activities*



## Emotional Eating

Total emotional eating scores ranged from 1 to 4.5, and were on average  $M = 2.1$  ( $SD = 0.58$ ), which is between the lower end and the neutral midpoint on a Likert scale of 1 to 5. Thus, the present sample shows a rather low tendency for emotional eating. However, there was significant variation between participants for total emotional eating ( $F(46, 246) = 4.73, p < .001$ ) (see Figure 2). Figure 3 shows the EMMs of total emotional eating scores within the sample over time. There was no significant variation of the sample's total emotional eating scores between the respective days ( $F(6,286) = 1.2, p = .33$ ). See Appendix D for a detailed description and visualization of positive and negative emotional eating.

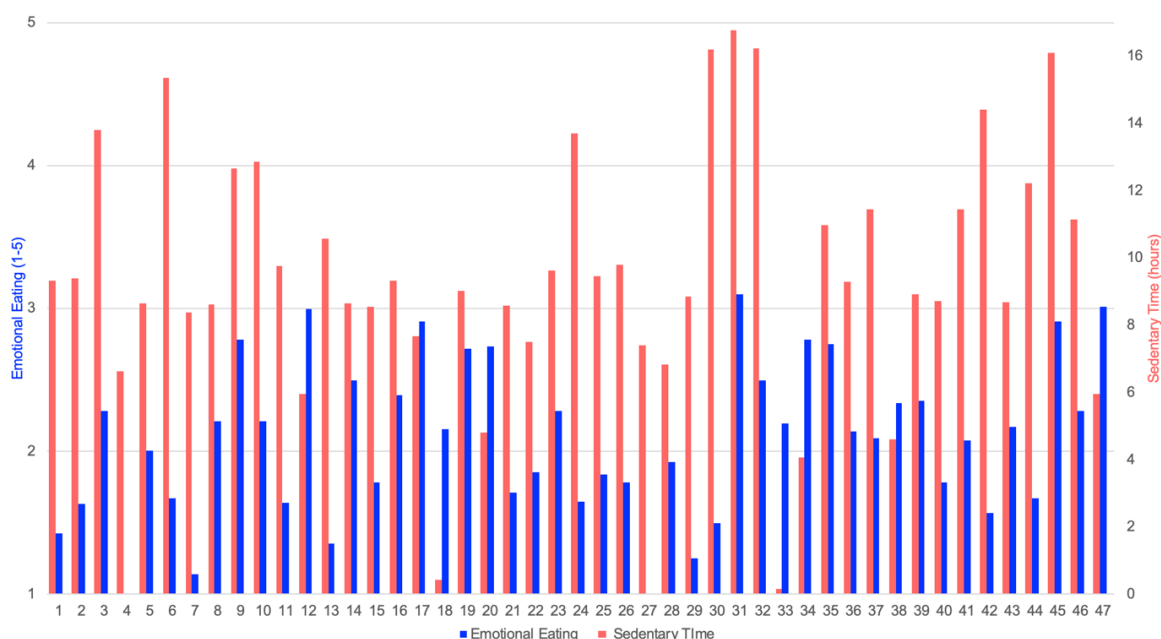
### **RQ1: Association Between Daily Sedentary Time and Emotional Eating**

No significant relationship between daily sedentary time and total emotional eating over time was found ( $b = 0.01, SE = 0.01, t = 0.94, p = .35, 95\% \text{ CI } [-0.01, 0.03]$ ). The desire for eating out of emotions did therefore not increase when sedentary time increased by one hour. For positive emotional eating, a non-significant negative association was revealed ( $b = -0.01, SE = 0.02, t = -0.75, p = .45, 95\% \text{ CI } [-0.05, 0.02]$ ). However, sedentary time and negative emotional eating revealed a slightly significant relation ( $b = 0.03, SE = 0.02, t = 2.02,$

$p = .04$ , 95% CI [0.00, 0.06]). The relationship of sedentary time and negative emotional eating was therefore also visualised and can be found in Appendix D (Figure D4).

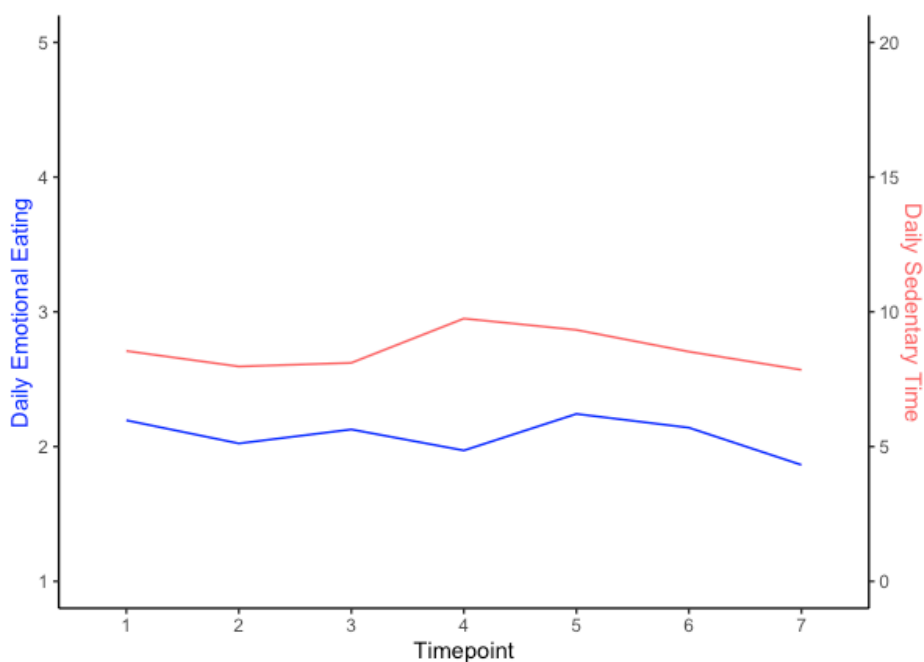
**Figure 2**

*Estimated Marginal Means of Daily Sedentary Time and Total Emotional Eating per Participant*



**Figure 3**

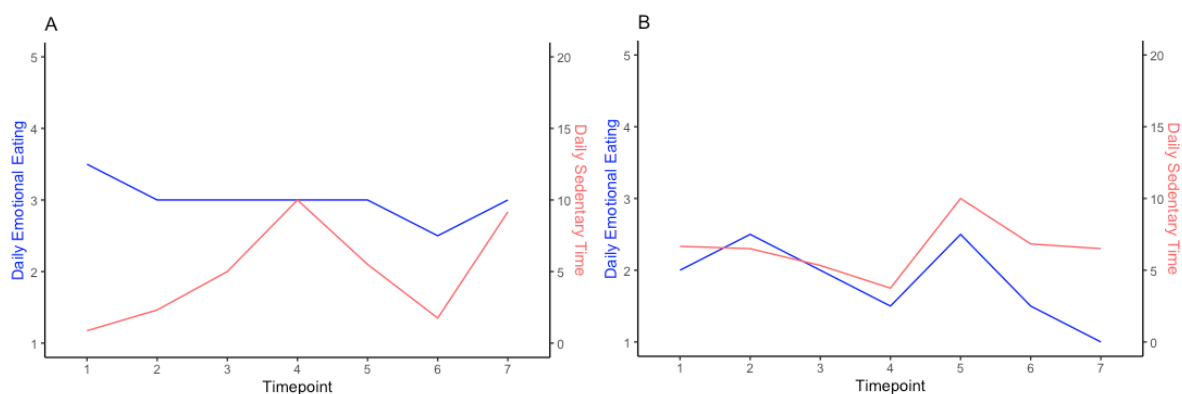
*The Relationship Between Total Emotional Eating and Sedentary Time Over Time*



To illustrate, Taylor<sup>1</sup> had lower sedentary time ( $M = 5.9$ ) than the sample average, but higher emotional eating ( $M = 3$ ) without a clear relationship between the two (see Figure 4a). Meanwhile, Noel<sup>1</sup> had higher sedentary time ( $M = 7.5$ ) than Taylor, with emotional eating ( $M = 1.8$ ) varying similarly to daily sedentary time (Figure 4b). Next, Alex<sup>1</sup> had higher sedentary time ( $M = 9.8$ ), but lower desire for emotional eating ( $M = 1.6$ ), which showed unexpected patterns: emotional eating mostly seemed to vary in the opposite direction of what was expected, and was lowest when sedentary time was highest (see Figure 5a). Charlie<sup>1</sup>, in contrast, sat on average 11.5 hours, and had average emotional eating values ( $M = 2.1$ ), but showed no variation in neither sedentary time nor emotional eating (see Figure 5b). Lastly, Manu<sup>1</sup> sat on average a lot more ( $M = 13.8$ ), and had higher emotional eating ( $M = 2.3$ ) with some in- or decrease in emotional eating coinciding with in- or decreased sedentary time (see Figure 6). The variations at the individual level thus show that sedentary time and emotional eating do not vary at all for some, for others in the opposite direction and again for others partly in the same direction.

#### Figure 4

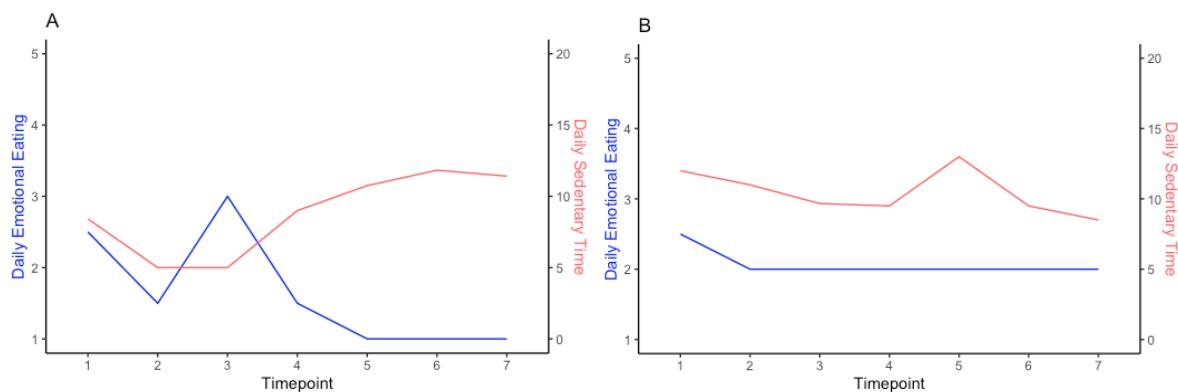
*The Relationship Between Total Emotional Eating and Sedentary Time Over Time for Taylor (A) and Noel (B)*



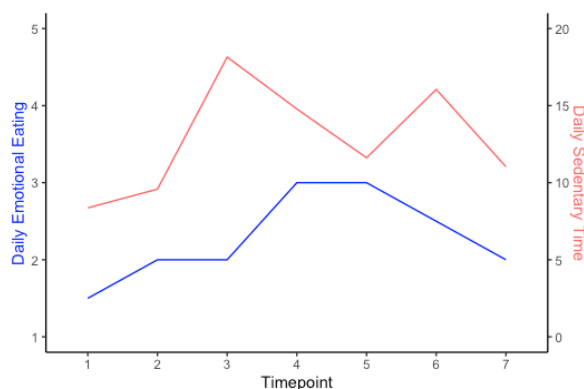
<sup>1</sup> All names mentioned are fictitious and for illustrative purposes only.

**Figure 5**

*The Relationship Between Total Emotional Eating and Sedentary Time Over Time for Alex (A) and Charlie (B)*

**Figure 6**

*The Relationship Between Total Emotional Eating and Sedentary Time Over Time for Manu*



## **RQ2: Moderating Role of Body Responsiveness**

The Shapiro-Wilk test of normality showed that the distribution of trait body responsiveness was approximately normal ( $W = .98, p = .58$ ). Body responsiveness scores ranged from 2.6 to 6.1, with a mean score of  $M = 4.7$  ( $SD = 0.72$ ), indicating that, on average, participants considered themselves moderately well able to recognise and listen to body signals. An overview of the distribution of trait body responsiveness can be found in Appendix D (Figure D5).

The moderation analysis showed that the main effect of sedentary time on emotional eating was non-significant ( $b = 0.05, SE = 0.08, t = 0.58, p = .56, 95\% CI [-0.12, 0.21]$ ). The main effect of body responsiveness was negative but non-significant as well ( $b = -0.18, SE = 0.20, t = 0.85, p = .40, 95\% CI [-0.59, 0.24]$ ). The interaction effect of body responsiveness was also found to be negative but non-significant ( $b = -0.01, SE = 0.02, t = -0.44, p = .66,$



95% CI [-0.04, 0.03]). Hence, body responsiveness did not moderate the relationship between sedentary time and emotional eating. Therefore, the desire for emotional eating did not change for people with higher sedentary time and higher body responsiveness scores within this sample.

### **Discussion**

The present study examined the association between daily sedentary time and emotional eating in young adults aged 18 – 35 using experience sampling methodology. This research was led by literature indicating similarities in negative health consequences and eating behaviours of sedentary people and emotional eaters. Contrary to the expectation that higher sedentary time would be associated with a higher desire for emotional eating, no significant association was found. However, when divided into positive and negative emotional eating, negative emotional eating was found to be slightly significantly associated with sedentary time. While it was also expected that the relationship between sedentary time and emotional eating is moderated by body responsiveness, the relationship between the respective constructs did not change when body responsiveness was introduced as a moderator. Hence, the level of emotional eating did not change for people with higher body responsiveness scores.

### **Main Findings**

The lack of relationship suggests that sedentary time and emotional eating are not related and may contradict the findings of Arnold et al. (2015) that a sedentary lifestyle was associated with more eating without physical hunger. In Arnold et al.'s (2015) study, though, a sedentary lifestyle was assessed as physical (in)activity. Thereby, it remains unclear how much daily sedentary time marks a sedentary lifestyle. In the present study, daily average of reported sedentary time was 9.5 hours. Given that the majority of participants were students (70%) and considering that Castro et al. (2020) reported a mean of sedentary time of 7.29 hours in university students, the current mean value could be considered comparatively high. Moreover, Costa et al. (2021) reported working or studying for more than 8 hours as being a risk factor for emotional eating in inactive individuals. However, while it may be reasonable to assume that students and workers spend a great proportion of their day studying or working, participants spent the majority of their sedentary time socializing, followed by watching or using the TV. This may be due to two national holidays in Germany and the Netherlands within the measurement period (Kingsday on April 27<sup>th</sup> in the Netherlands, and Labour Day on May 1<sup>st</sup> in Germany). In general, sedentary behaviour across the week was difficult to interpret: the peak of sedentary time was on Friday (day 4), although other studies found that Thursday often marks an unofficial start of the weekend, with Thursday to Saturday being spent less sedentary

compared to other days (McVeigh et al., 2016). Furthermore, total emotional eating in this sample was quite low ( $M = 2.1$ ), which may be striking given the large proportion of students, as these are particularly prone to emotional eating due to many stressful events and life changes (Bennett et al., 2013). The present findings therefore remain somewhat ambiguous; however, they may support the findings of Martinez-Avila et al. (2020) that sedentary behaviour was inversely and not positively associated with binge and uncontrolled eating, which are common among emotional eaters (Arnou et al., 1995; Meule et al., 2021; Ricca et al., 2009). Irrespective of the fact that the present study did not measure explicit eating behaviour, but only desires, such an inverse relationship could partially be observed in Alex.

Although emotional eating and sedentary time were generally not associated, separate investigation of the relationship between positive or negative emotional eating and sedentary time yielded different findings. In general, average values for positive emotional eating ( $M = 2.4$ ) were higher than those for negative emotional eating ( $M = 1.8$ ), and the difference of average values supports previous research that both negative and positive emotions can be associated with an increased desire for eating (Barnhart et al., 2021; Cardi et al., 2015; Sultson et al., 2017). However, positive emotional eating and sedentary time were not associated over time, meaning that sitting did not seem to have played a role in this context. Yet, a small positive and significant effect of sedentary time on negative emotional eating was found. This may indicate that prolonged sitting was rather associated with negative than positive emotions, giving support for Zou et al.'s (2023) findings that high sedentary behaviour is associated with the experience of negative emotions. Subsequently, there was a slightly higher desire for eating out of negative emotions the more people sat. It should be noted, however, given a Likert scale of 1 to 5, the participants' mean scores for negative emotional eating were on average low ( $M = 1.8$ ). Therefore, participants in general did not indicate a large tendency towards negative emotional eating. Moreover, the significant effect of sedentary time on the desire for negative emotional eating was very small ( $b = 0.03$ ). The complexity of LMMs makes it difficult to determine the effect size of fixed effects (Nakagawa & Schielzeth, 2013), however, considering that the desire for negative emotional eating increased by only 0.03 units with each additional hour of sitting, the practical significance may likewise be regarded as marginal.

Individual differences could explain the small but significant effect. For some, emotional eating levels partly varied with the actual time sat (e.g., Noel and Manu). Subsequently, while there was no consistent pattern across the sample, emotional eating in relation to sedentary time may vary more due to fundamental individual differences. Some researchers assume that emotional eating is a trait-characteristic itself (Boggiano et al., 2015;

Robinson et al., 2021), or that emotional eating relates to certain character traits. A higher tendency to eat in response to negative emotions has been found, for example, in people with bipolar disorder, schizophrenia, trait anxiety and depression (Lazarevich et al., 2016; Schneider et al., 2010; Tuncer & Çetinkaya Duman, 2020). Emotional eating also plays an important role in the maintenance of Binge Eating Disorder and Bulimia Nervosa (Arnou et al., 1995; Meule et al., 2021; Ricca et al., 2009). Hence, emotional eating in relation to sedentary time might possibly vary more for vulnerable individuals who generally tend to regulate their emotions with food. Conclusively, emotional eating may therefore be less state but more trait dependent.

Moreover, body responsiveness did not moderate the relationship between sedentary time and emotional eating ( $b = -0.01$ ,  $p = .66$ ). However, average trait body responsiveness within this sample was rather high ( $M = 4.7$ ), suggesting that participants were relatively good at listening and responding to bodily cues. This could link to the sample's general low tendency for emotional eating ( $M = 2.1$ ). Mindfulness interventions that focused on teaching to listen to bodily signals have proven that individuals ate more in response to hunger and satiety and less emotion-driven than before the intervention (Schnepper et al., 2019), and individuals with higher ability to detect internal signals were found to be less likely to report emotional eating (Robinson et al., 2021). Therefore, participants may have been generally good in detecting both emotional and physical hunger and in responding accordingly. At the same time, the reliability coefficient for body responsiveness was rather low ( $\alpha = .53$ ), which in turn weakens these considerations.

### ***Strengths and Limitations***

A clear strength of the present study is the experience sampling methodology, which enabled insights into everyday behaviour and desires of the participants over a period of 9 days. The final sample size of 47 participants as well as the high response rate of 85.4% are also high compared to respective median data on ESM studies (van Berkel et al., 2017). Adopting a fixed signal-contingent sampling technique and using two questionnaires per day only may have benefited in attaining the high response rate, as participants knew exactly when to expect the questionnaires and where interrupted comparatively little during their day (Palmier-Claus et al., 2011). Nevertheless, the study also features some methodological limitations, specifically in regard to reliability and validity.

The reliability of both sedentary time and emotional eating might be flawed, given that the study relied on self-reports, which are subjective and susceptible to cognitive biases (Ross & Wing, 2018). Thereby, individual feedback from participants revealed that they had difficulties reporting their sedentary time in minutes. Both the upper limit of 22.7 hours and the

lower limit of 0.10 hours of recorded daily sedentary time do not seem realistic; however, these values were included in the analysis because a fixed limit of a daily minimum or maximum of sedentary time could not have followed a logical cut-off point. Moreover, Spearman's Brown coefficient for sedentary time indicated reliable data, indicating only little fluctuation of sedentary time between weekdays and weekend, although variations are to be expected (Kirk et al., 2016; McVeigh et al., 2016). In addition, due to the two holidays, the study period was perhaps not representative of a typical week of participants.

In terms of validity, measuring emotional eating with two self-constructed items may have been inadequate given that emotional eating is a highly complex phenomenon (Ljubičić et al., 2023). Moreover, total emotional eating scores were simply formed from the scores of the respective items, which may be a rudimentary statistical method, considering that emotional eating from negative and positive emotions may represent two different dimensions (Sultson et al., 2017, 2022). Furthermore, the wording of the items may have led to item response bias (Bogner & Landrock, 2016), and studies on sensitive topics such as emotions are likely to elicit socially desirable responses (Krumpal, 2013), thereby reducing validity of emotional eating. In addition, convenience and snowball sampling may have induced a sampling bias. 70% of participants within the final sample were university students, most of whom were either German or Dutch. However, socio-economic and cultural differences in both sedentary time and emotional eating exist (Castro et al., 2020; Ljubičić et al., 2023; Owen et al., 2011), and the association of sedentary time and emotional eating may be different in other (sub-)populations. Hence, the findings cannot be generalized to the larger population of young adults.

### ***Implications and Future Research***

This study was the first to conduct research on the relationship between daily sedentary time and the desire for emotional eating over time. Given the somewhat ambiguous findings and limitations, further studies are needed to make well-founded assumptions about how these constructs are associated. Since both high sedentary behaviour and emotional eating can lead to negative (mental) health consequences, this study may therefore be useful for future researchers in order to expand knowledge on how sedentary time affects emotional eating, and to develop potential prevention strategies and interventions for more vulnerable individuals.

Ideally, future ESM studies should include wearable technologies to monitor sedentary time, since measuring devices of sedentary behaviour have been found to yield more accurate measures of sedentary time compared to self-reports (Prince et al., 2020). Moreover, future studies should be conducted in a period with a greater number of week- and working days, to capture more representative daily rhythms of participants. As the results point to individual

differences in emotional eating, focus should be on particular groups or traits that may be more prone to emotional eating. For example, a distinction could be made between people with and without a mental disorder, since emotional eating often occurs as a concomitant or secondary symptom in people with certain mental illness (Lazarevich et al., 2016; Meule et al., 2021; Schneider et al., 2010; Tuncer & Çetinkaya Duman, 2020). Thereby, assessing people's regular eating behaviours and possible trait emotional eating would provide a more comprehensive picture of how sedentary time may lead to changes in emotional eating desires. Measuring daily emotional eating with several items, or in relation to certain emotions could also yield more insight into the experience of sedentary related emotions and related emotional eating behaviours. As increased sitting may be more related to negative and not positive emotional eating, focus could be on specific negative emotions. Stress, for example, can lead to both increased or decreased desire to eat (Araiza & Lobel, 2018; Hyldelund et al., 2022). While the role and relationship of body responsiveness in this context is not yet entirely clear, this trait may help to guide eating behaviour and would therefore be of interest to be re-examined.

### **Conclusion**

The findings of the present study suggest that, on average, sedentary time and emotional eating are not related in young studying or working adults. While young adults spent much of their day sedentary, sedentary time per se does not appear to increase the desire to eat. However, this showed to be different at the individual level, and daily fluctuations of emotional eating in relation to sedentary time may occur more in those who generally tend to regulate their emotions with food. While the role and relationship of body responsiveness in this context is not yet entirely clear, it may reduce the desire for emotional eating. Not least because of the small but significant effect of sedentary time on negative emotional eating, further research is needed to gain more clarity on the relationship between sedentary time and emotional eating.

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## **Appendix A: Informed Consent**

Dear participant,

you are asked to participate in a study conducted by Theodora Buzulica, Hannah C. Schäfer, and Luisa Wiggeshoff from the psychology department of the University of Twente. The study is part of an undergraduate project, and we thank you for taking the time to participate in our study! You may participate in this study if you are 18 to 35 years old, and proficient in English. Please read the information below about the details of our study.

### **Purpose**

The purpose of this study is to investigate the relationship between daily sitting time and emotional eating, mood states and feelings of social anxiety. By participating in this study, you will help us contribute to the scientific knowledge about sitting and its relationship to mental health.

### **Procedure**

The study will be conducted over a period of nine days. On the first day of the study (April 24th), you will be asked to complete a baseline questionnaire, which will take about ten minutes to fill out. Starting the following day (April 25th), you will receive one afternoon survey at 5:00pm. From April 26th on, you will receive two daily questionnaires: one morning survey at 8:00am, and one afternoon survey at 5:00pm. On the last day, May 2nd, you will receive the morning survey only.

Each survey should take no longer than 3 and 1 minute(s), respectively, and can be completed within 4 hours. For example, the first questionnaire can be answered from 8:00am until 12pm. All surveys will be completed via the Ethica App. Please make sure that permanent notifications for Ethica are enabled on your device.

### **Participant Rights**

Your participation in this study is completely voluntary. If you wish to withdraw from this study, you may do so at any time without giving a reason. To withdraw from participation after the study, please inform the researchers via email within 10 days of your participation.

### **Risks or Discomforts**

Participation in this study should not pose any risks. One possible consequence is an increased awareness of your daily feelings, behaviors, and/or emotions. If you are sensitive to these



issues, or if you are suspected of having or have been diagnosed with a mood and/or anxiety disorder, or an eating disorder, please consider your participation in this study carefully.

### **Confidentiality**

Your responses will be kept confidential: All personal data will be anonymized and will not be published and/or shared with third parties. The data will only be used for this study, and will be kept in locked files. Only research personnel will have access to these files.

The study has been approved by the ethics committee of the University of Twente. If you have any questions or concerns before, during or after your participation, please do not hesitate to contact the researchers:

t.buzulica@student.utwente.nl (Theodora Buzulica)

h.c.schafer@student.utwente.nl (Hannah Schäfer)

l.wiggeshoff@student.utwente.nl (Luisa Wiggeshoff)

(g.schaap@utwente.nl) (Gerko Schaap, supervisor)

**After having read the information above, do you agree with the following statements and at the same time confirm that you are participating in this study and that your data will be used for research as described?**

I understand that my participation is voluntary and that I am free to withdraw my participation, without explaining, until 10 days after participation.

I understand that any information given by me may be used in future reports or presentations by the researcher/s, but that my data will not be identifiable.

I understand that anonymized data will be kept according to university guidelines for up to 10 years after the end of the study.

I agree to take part in the study.

## Appendix B: Questionnaires – Baseline Questionnaire

### Demographics

- How do you identify?
  - Female
  - Male
  - Other
  - Prefer not to say
- What is your age? (In numbers)
- What is your nationality?
  - Dutch
  - German
  - Other-EU
  - Other Non-EU
- What is your current occupation? Please consider what applies most to you.
  - Full-time student
  - Full-time working
  - Student and working
  - Not working
  - Other

### Body Responsiveness

In the following, we would like to know more about you and your **body sensations**.

On a scale from 1 (not at all true about you) to 7 (very true about you), please indicate to what extent the following statements are true about yourself.

1. I am confident that my body will let me know what is good for me.
2. My bodily desires lead me to do things that I end up regretting.
3. My mind and my body often want to do different things.
4. I suppress my bodily feelings and sensations.
5. I 'listen' to my body to advise me about what to do.
6. It is important for me to know how my body is feeling throughout the day.
7. I enjoy becoming aware of how my body feels.

**Appendix B: Questionnaires –Past-day Adults’ Sedentary Time – University  
(PAST-U)**

Good morning, we hope you had a great start of the day! ☀️

The following questions aim to assess your sitting time **of the past 24 hours**. Please consider the amounts of time spent sitting while being **awake**. Please report the amounts in **minutes**.

For example, if you've watched television while sitting on the couch for 1 hour, please fill out '60'.

**Please note:** you can enter the minutes directly using the mobile phone keypad, you do not have to use the arrows.

1. **How long** were you sitting while **studying** yesterday? (include the time in minutes at university, during lectures, tutorials, meetings, group discussions, self-study, study from home, etc.)
2. **How long** were you sitting at your **workplace** or **working from home** in a paid position yesterday (in minutes)?
3. Please estimate the **total** time that you spent **sitting** to **travel** from one place to another. Please **include sitting and waiting** for transport in minutes. Do **not** include any time you were standing up while travelling or waiting.
4. Please estimate the **total time** you spent sitting or lying down to **watch TV** or DVDs or **play games** on the TV, such as PlayStation/Xbox yesterday (in minutes). This includes if you watch TV in bed.
5. Please estimate the **total time** yesterday that you spent sitting or lying down and **using the computer**. (For example, include time spent playing games on your iPhone/Ipad/tablet, using the internet or activities that **were not for studying or working purposes**, like Facebook, Twitter, Skype, YouTube, online-shopping, etc. Please indicate the time in minutes.)
6. Please estimate the total time yesterday that you spent sitting or lying down while **reading during your leisure time**. Include reading in bed but do not include time spent reading for paid work or for study. Please estimate the time in minutes.
7. Please estimate the total time yesterday that you spent sitting down for **eating and drinking**, including meals and snack breaks, in minutes.

8. Please estimate the total time yesterday that you spent sitting down to **socialize with friends or family**, regardless of location (at university, at home or in a public place), in minutes. Include time on the telephone.
9. We are interested in any other sitting or lying down that you may have done that you have not already told us. For example this could include; **hobbies** such as doing art and craft, playing board games; listening to music or for religious purposes.  
Again thinking of yesterday, please estimate the **total time** that you spent sitting or lying down in minutes, **NOT** including time that you have told us about in the previous answers

## Appendix B: Questionnaires – Emotional Eating

Good afternoon!

Now, we would like you to indicate to what extent the following statements apply to you.

1 = Never, 5 = Very often.

1. Today I had the desire to eat because I felt **positive** emotions such as happiness/excitement/confidence.

Other positive emotions may include being *content with yourself*; being *fascinated* about something; being *joyful, full of energy, relaxed* or *satisfied*.

2. Today I had the desire to eat because I felt **negative** emotions such as loneliness/angriness/boredom.

Other negative emotions and feelings may include being *irritated, depressed, discouraged, anxious, tense, afraid, disappointed, emotionally upset, restless*, or *worried*.

They may also include eating because of expecting something *unpleasant to happen*, having *nothing to do* or because someone *disappointed* you.

### **Appendix C: Data Analysis**

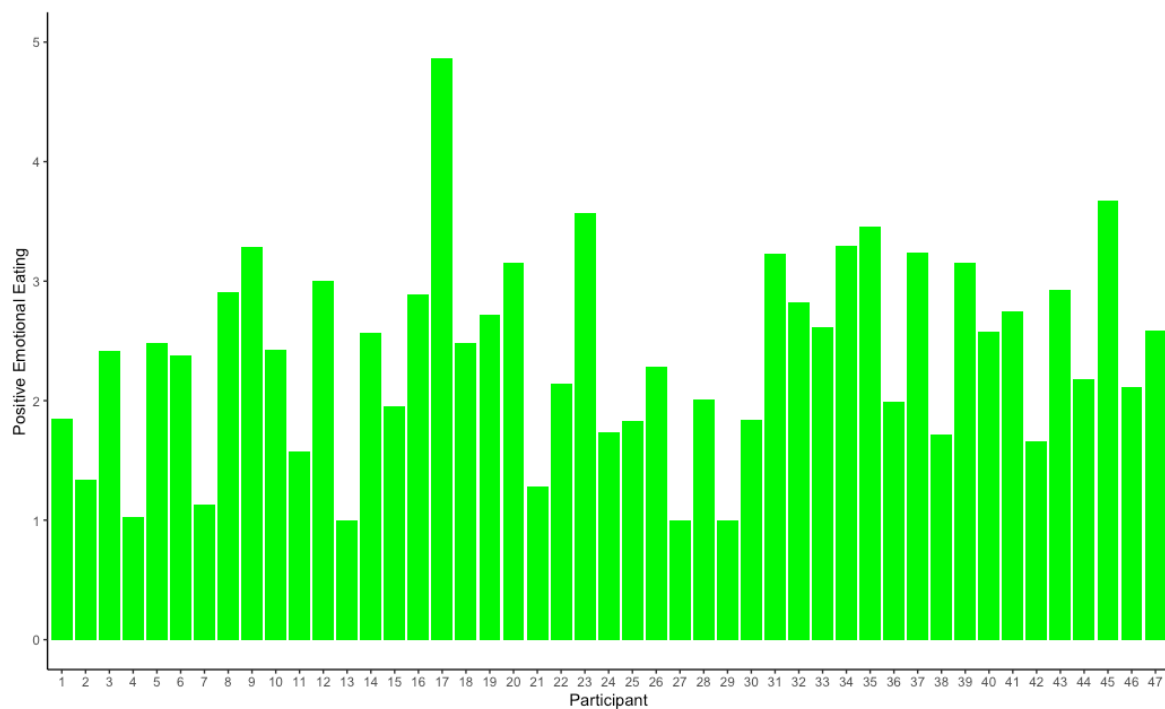
Statistics were done using the packages dplyr (v1.1.2; Wickham et al., 2023), emmeans (v1.8.5; Lenth, 2023), ggplot2 (v3.3.6; Pederson, 2022), lme4 (v1.1.33; Bates et al., 2015), lmerTest (v3.1.3; Kuznetsova et al., 2020), modelr (v0.1.11; Wickham, 2023), nlme (v3.1.162; Pinheiro & Bates, 2023), psych (v2.3.3; Revelle, 2023), splithalf (v2.2.0; Pronk et al., 2021) and tidyverse (v2.0.0; Wickham et al., 2023).

## Appendix D: Results

The mean score for positive emotional eating was 2.4 ( $SD = 0.93$ ) and the mean for negative emotional eating was 1.8 ( $SD = 0.67$ ). The slightly higher scores for positive than for negative emotional eating can be seen in Figure D1 and D2, respectively. There was significant variation between participants for positive emotional eating ( $F(46, 246) = 4.27, p < .001$ ), and for negative emotional eating ( $F(46, 246) = 2.86, p < .001$ ), but no significant variation of positive and negative emotional eating over time ( $F(6,286) = 1.7, p = .12$  and  $F(6,286) = 0.9, p = .50$ , respectively). See Figure D3 and D4 for the visualisation of EMMs for positive emotional eating and negative emotional eating respectively, over time. Figure D4 also shows the small yet significant association between negative emotional eating and daily sedentary time over time.

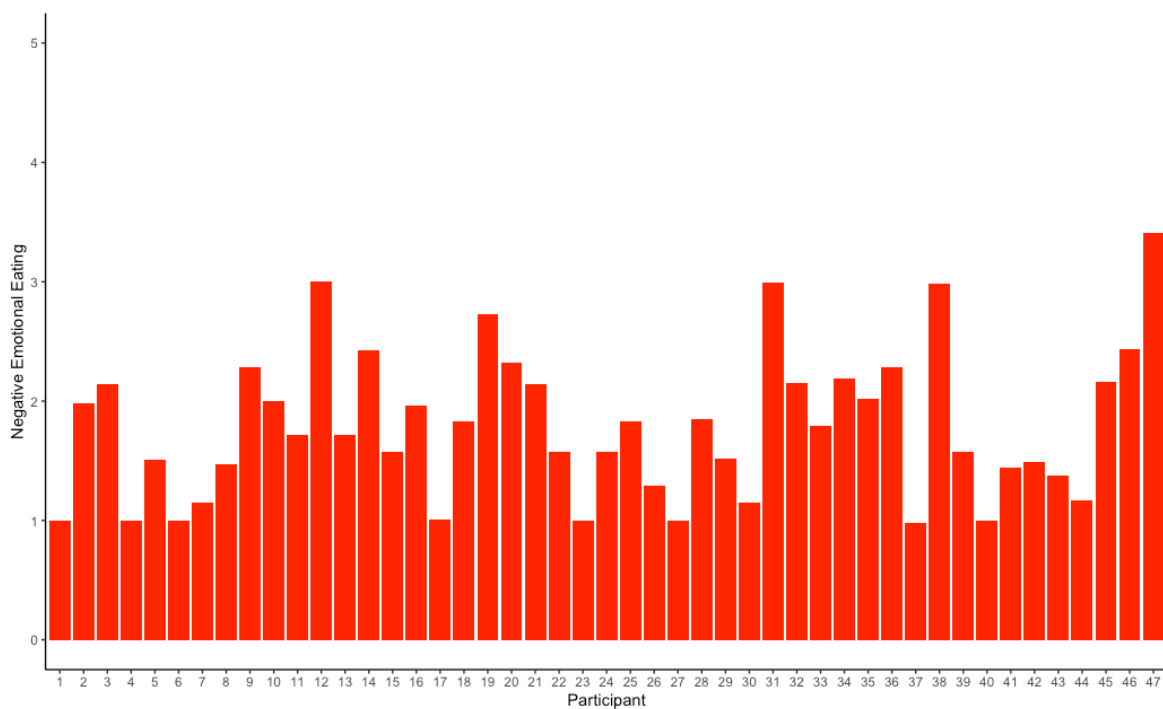
### Figure D1

Estimated Marginal Means of Daily Positive Emotional Eating Across Participant

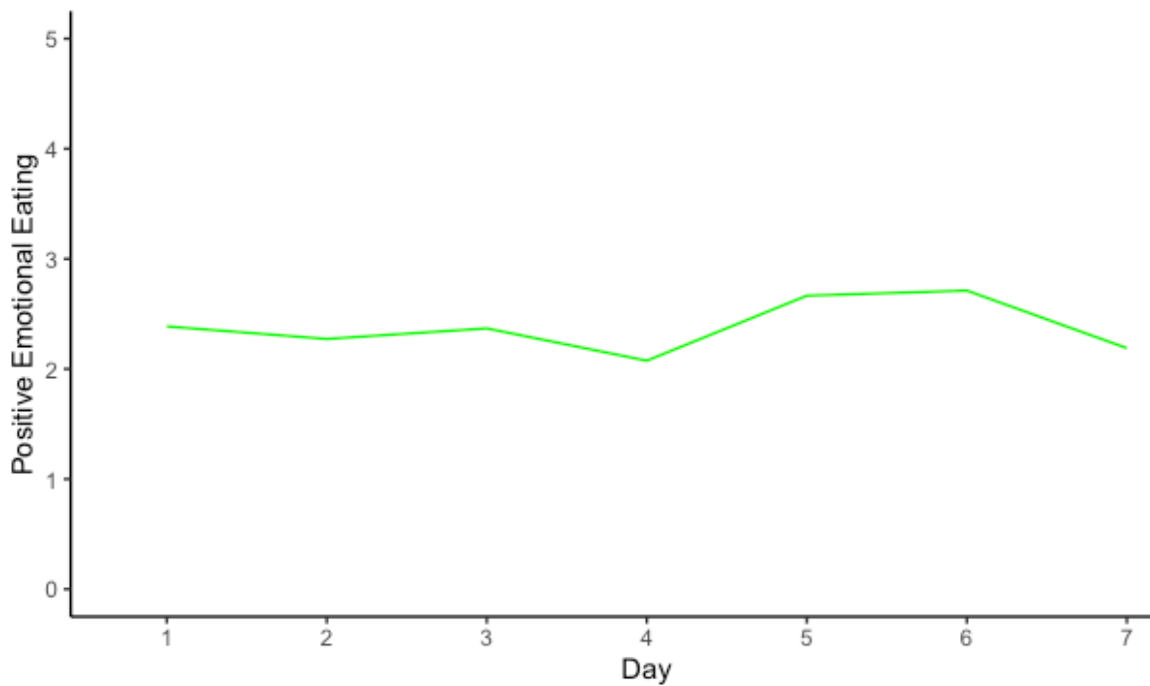


**Figure D2**

*Estimated Marginal Means of Daily Negative Emotional Eating Across Participants*

**Figure D3**

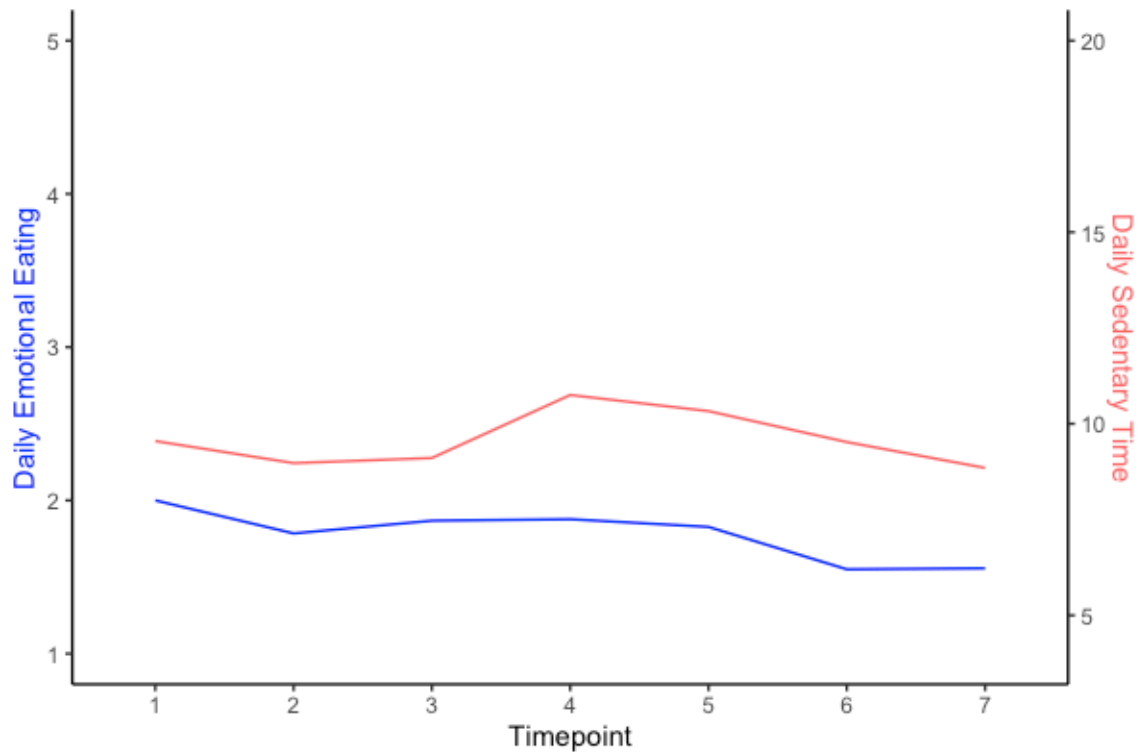
*Estimated Marginal Means of Daily Positive Emotional Eating Over Time*



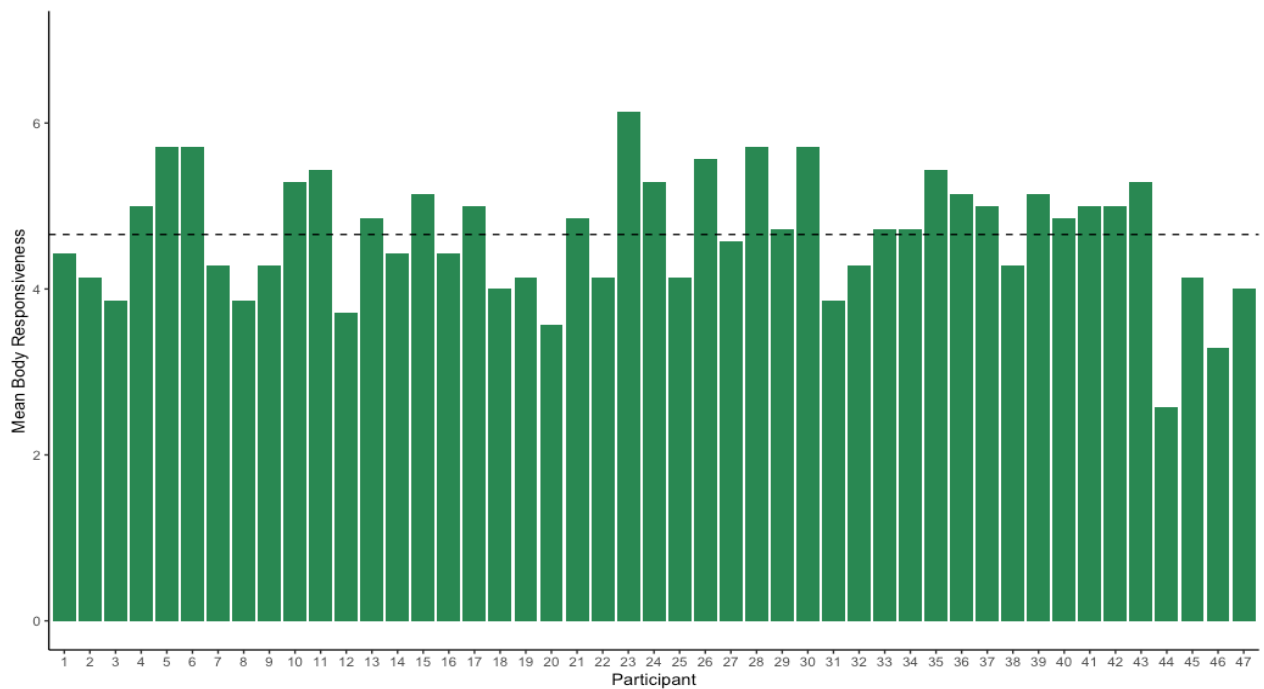


**FigureD4**

*The Relationship Between Negative Emotional Eating and Sedentary Time Over Time*

**FigureD5**

*Body Responsiveness Scores of Participants*



*Note.* The dashed line represents the mean of trait Body Responsiveness within the sample ( $M = 4.7$ ).