Examining the Moderating Role of Mental Activeness (Active or Passive) on the Relationship Between Sedentary Time and Mood Across Specific Contexts: An Experience Sampling Study

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Abstract

Background: Prolonged sitting, often referred to as sedentary behaviour, may have detrimental effects on the mental well-being of university students. So far, previous studies show inconsistent research on the relationship between sedentary time and mood. Since university students are more sedentary than the average adult population, they may be at higher risk for adverse effects. Therefore, this paper aimed to examine the relationship between sedentary time and mood in university students over time. Additionally, the moderating effects of behavioural context and the level of mental activeness, either active or passive, were investigated.

Methods: This study employed an Experience Sampling Method (ESM) design, which involved a longitudinal assessment over 14 consecutive days with 25 university students (M_{age} = 21.68, (SD_{age} = 2.61) years, 44% female). Specifically, participants received three daily questionnaires via the application m-Path, assessing sedentary time of a preceding 30-minute interval, state mood, behavioural contexts, and mental activeness. Linear mixed models were used to analyse the relationship between sedentary time and mood over time, considering moderating effects of mental activeness and the contexts of leisure, transportation, and occupation/study. Estimated marginal means were obtained to visualise the variables of interest, as part of an exploratory analysis.

Results: The findings revealed a statistically significant negative coefficient for the relationship between sedentary time and state mood (B = -0.024, p < .001, 95% CI [-0.038, -0.010]), indicating that increased sedentary time was associated with a decline in state mood. However, the interaction terms of behavioural context and mental activeness demonstrated no statistically significant moderation effect on the relationship between sedentary time and state mood.

Conclusion: This study revealed that, consistent with existing literature, sitting for longer periods is associated with worse mood in university students. However, although no significant interaction terms of context and mental activeness were found, exploratory analyses suggested potential effects. Practitioners should develop interventions promoting mentally active sedentary behaviours, such as socialising, over passive screen time to reduce detrimental sedentary time and maintain students' positive mood.

Keywords: Sedentary behaviour, Mood, Depression, Behavioural context, Mental Activeness, University students

Examining the Moderating Role of Mental Activeness (Active or Passive) on the Relationship Between Sedentary Time and Mood Across Specific Contexts: An Experience Sampling Study

The relationship between sitting behaviour and mental health is paradoxical. While many people engage in leisure activities such as watching TV for enjoyment and relaxation, recent studies show that a lifestyle based on extended periods of sitting is linked to depressive symptoms and reduced well-being (Walker et al., 2015). Prolonged sitting, often referred to as sedentary behaviour, is clearly distinct from physical inactivity and includes various activities that occur in different contexts such as leisure, transport and work environments (Tremblay et al., 2017; Owen et al., 2010). Despite growing evidence on the prevalence and associated health risks of sedentary behaviour in both children and adults, its impact on mental health of young adults, particularly university students, remains less explored.

In addition, emerging research has started exploring the complex interplay between sedentary behaviour and mental health, particularly with depression (Walker et al., 2015; Huang et al., 2020). However, a critical gap remains in distinguishing between mentally active and passive sedentary behaviours and their impact on mental health (Hallgren et al., 2019). This raises the need for a detailed investigation of different types of sedentary behaviour as well as specific behavioural contexts.

Therefore, this paper aims to investigate the relationship between sedentary time and mood among university students, considering the moderating effects of behavioural contexts and mental activeness. The following sections will provide a detailed analysis of relevant literature and further define and elaborate on important terms.

Defining Sedentary Behaviour

Sedentary behaviour refers to any activity during waking hours that involves minimal energy expenditure, typically 1.5 METs or less, while in a seated or reclined position, as defined by Tremblay et al. (2017). This includes everyday activities such as working or studying, watching TV, social media use, commuting, etc. It is crucial to differentiate sedentary behaviour from physical inactivity. According to Owen et al. (2010), prolonged sitting can be as harmful to health as a lack of exercise. Even if an individual meets the recommended physical activity guidelines by the WHO, they may still spend extended periods sitting (Owen et al., 2000; 2011). Owen et al. (2011) also proposed an ecological model to understand sedentary behaviour's impact, noting it often occurs in specific settings

like leisure, work, and transport. Considering these aspects is important as the they significantly influence sedentary behaviour (Sallis et al., 2008).

Furthermore, certain population groups are at higher risk of sedentary habits. University students, much like office workers, often accumulate prolonged sedentary time due to activities like attending lectures and studying (Cotten & Prapavessis, 2016). Studies show a high prevalence of sedentary behaviour among university students (Rouse & Biddle, 2010; Farinola & Bazán, 2011). Moreover, studies have examined the domains and contexts in which students engage in such habits. Carpenter et al. (2021) categorized student sedentary behaviour into recreational, educational, and social domains, finding higher risks in students with low parental education and those overweight/obese. However, research on context-specific sedentary behaviour in university students remains limited (Castro et al., 2018).

The Prevalence of Sedentary Behaviour and Its Effects on Health

According to recent reviews, adults typically spend about 8.2 hours daily in sedentary activities, ranging from 4.9 to 11.9 hours based on accelerometer data from large population studies (Bauman et al., 2017). University students, as reported by Mussi et al. (2017), spend approximately 8.3 hours daily in sedentary pursuits, a number two to three hours higher when measured with accelerometers (Clark et al., 2016). Moulin & Irwin (2017) found that students' sedentary behaviour levels are comparable to or higher than those of desk-based office workers. This is particularly concerning as lifestyle habits developed during the transition from adolescence to adulthood tend to be maintained later in life (Gordon-Larsen et al., 2004). Consequently, students with sedentary habits may continue these patterns into adulthood, facing associated health risks linked to prolonged sitting (Bellettiere et al., 2017).

As evidenced by numerous epidemiological studies, sedentary time exceeding the threshold of 7 to 8 hours is undeniably associated with an increased risk of cardiometabolic issues and overall mortality, accounting for 6% of global mortality (Chau et al., 2013; Patterson et al., 2018; Biswas et al., 2015; Wilmot et al., 2012; Park et al., 2020). The negative effects of sedentary behaviour are associated with metabolic risk markers, type 2 diabetes, adiposity, and an increased risk of cardiovascular disease and cancer (Wilmot et al., 2012; Thorp et al., 2011; Brocklebank et al., 2015; Young et al., 2016; Lynch et al., 2017).

Moreover, scholars have shifted their focus towards investigating the association between sedentary habits and psychological outcomes. Studies have found associations between sedentary behaviour and several mental health problems, including anxiety, stress, low life satisfaction, and low psychosocial well-being, (Hamer et al., 2014; Sánchez-Villegas et al., 2008; Dėdelė et al., 2019; Giurgiu et al., 2019; Buman et al., 2010). Additionally, a

connection between sedentary behaviour and depression, along with its symptoms, has been identified (Huang et al., 2020; Lucas et al., 2011).

Sedentary Behaviour and Depression in University Students

Mental disorders are now widely acknowledged as a significant health risk, affecting approximately 970 million people globally (WHO, 2019). Among these disorders, depression is one of the most prevalent, affecting 280 million people (WHO, 2017). Figures regarding university students are even more concerning, as a systematic review of over 40 countries found that more than 25% show symptoms of depression (De Paula et al., 2020). Research indicates that depression is more prevalent in university students than in the general population, with estimates ranging from 24% to 34% (Lei et al., 2016; Tam et al., 2019; Tung et al., 2018). Besides its negative impact on general health, depression in university students can lead to various adverse effects. About a third of mental health issues start before age 24, leading to poor academic performance and loss of productivity (Akhtar et al., 2020; Mokdad et al., 2016). Decreasing mental health in students is linked to stress, low quality of life, higher risk of substance abuse, low self-confidence, and suicidal thoughts (Mofatteh, 2021).

A systematic review found that people with depression were less physically active and more sedentary than non-depressed individuals (Walker et al., 2015). More in-depth studies showed a significant link between leisure-time sedentary habits, such as watching TV, and clinically diagnosed depression (Huang et al., 2020). However, some researchers did not find these statistical links, instead highlighting moderating effects of gender and socioeconomic status (Hoare et al., 2016; Teychenne et al., 2014). A 10-year longitudinal study found that total sitting time was not linked to depression, whereas physical activity had a protective effect on depression (Van Uffelen et al., 2013). Despite some research headwinds, evidence supports a biological link between sedentary habits and lowered mood. Sedentary behaviour can reduce vitamin D exposure, increase inflammatory markers, and negatively impact insulin sensitivity, all associated with decreased mood (Hallgren et al., 2020; Rethorst et al., 2014; Wirth et al., 2017; Phillips et al., 2017; Saunders et al., 2012; Wheeler et al., 2017).

However, recent studies suggest that different types of sedentary behaviour, distinguished by the level of mental engagement, have varying impacts on mood (Hallgren et al., 2019).

Mentally Active vs Passive Sedentary Behaviour

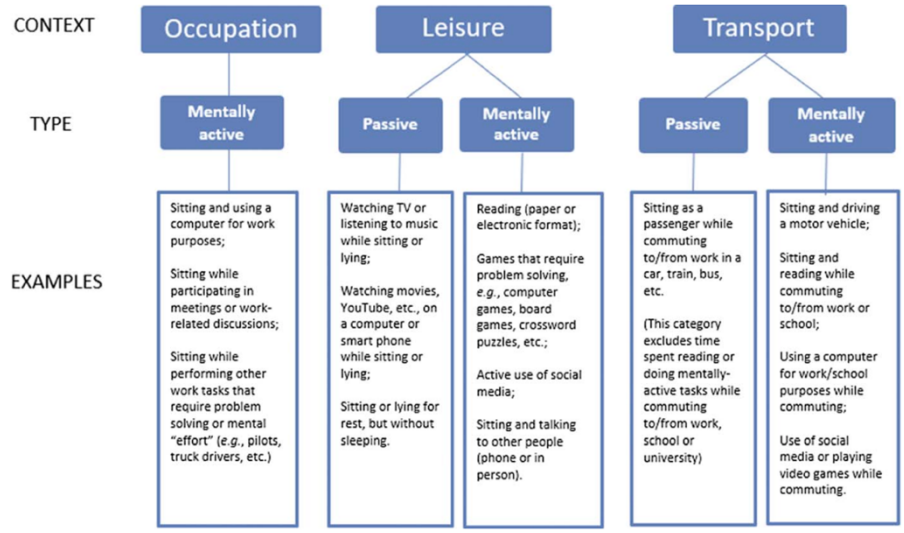
The concept of sedentary behaviour can be further categorised into two types of behaviour (Hallgren et al., 2020). Here, behaviours are distinguished by the cognitive engagement of the activity itself. One type is *mentally active* sedentary behaviour, which

includes sedentary activities that require concentration, such as computer use, reading books or newspapers, etc. The other type, *mentally passive* sedentary behaviour, refers to activities such as watching TV, or talking while sitting, as well as simply sitting around, which commonly occur during leisure time (Hallgren et al., 2020).

Hallgren et al. (2020) developed a framework categorising sedentary behaviour by context—occupation, leisure, and transport—and by mental engagement, as either active or passive (Figure 1). Studies showed that mentally passive sedentary behaviour is linked to elevated depressive symptoms, whereas mentally active behaviour is inversely associated with preventing depression (Hallgren et al. 2018; 2020).

Figure 1

Framework to evaluate sedentary behaviour in three distinct contexts: occupation, leisure, and transport, and distinguished between two types: mentally active and passive.



Note. From Passive Versus Mentally Active Sedentary Behaviors and Depression, Hallgren, M., Dunstan, D. W., & Owen, N, (2020), *Exercise and Sport Sciences Reviews*, 48(1), 20–27 https://doi.org/10.1249/JES.0000000000000211

This distinction between levels of mental engagement is generally a new concept but has been acknowledged in related fields. A study found that passive sedentary time was linked to being overweight, lower physical activity and psychological distress, while mentally active sedentary time was associated with higher physical activity levels (Kikuchi et al., 2014). Moreover, Hallgren et al. (2019) stated that replacing passive sedentary behaviour with mentally active may alleviate low mood in adults.

However, there is still a lack of differentiation between these types of behaviour in research. In particular, Hallgren et al. (2020) urge researchers to differentiate between levels of mental activeness and consider the context of sedentary behaviour (leisure, transport, occupation) to avoid misleading conclusions and inappropriate recommendations. Consequently, a methodological approach based on momentary assessments is needed to accurately measure these detailed changes and settings of sedentary behaviour over time.

Experience Sampling Methodology

Experience sampling methodology (ESM) is a systematic self-report diary used to evaluate mood, symptoms and contexts in real-time within everyday life. Participants are required to complete momentary questionnaires multiple times a day over a certain period of time (Mehl & Conner, 2012; Myin-Germeys et al., 2009). ESM is based on the concept of Barker (1968) that behaviour can only be understood within the context in which it occurs, therefore it needs to be assessed in its natural setting rather than in a laboratory. ESM enables scholars to overcome the problem of recall bias and to investigate temporal and individual variations, thereby strengthening the exploration of mental health problems from a contextual approach (Myin-Germeys et al., 2018). Several studies found that ESM measures are more sensitive than traditional methods in capturing changes in positive and negative affect as well as depressive symptoms (Myin-Germeys et al., 2018; Moore et al., 2016).

Therefore, ESM was chosen for data collection in this study to examine the associations between sedentary behaviour and mood. ESM offers a detailed understanding of daily sedentary habits, minimises recall bias, and allows for the exploration of specific contexts and behaviours, thereby enabling an investigation of the association between sedentary time and mood. Ultimately, this addresses a further gap in the literature, as there are limited ESM studies on sedentary behaviour and mood so far.

Scope of This Study and Research Questions

So far, most studies relied on cross-sectional designs and could not capture temporal changes in the associations of sedentary behaviour. However, the present study employed an ESM design to examine the association between sedentary behaviour and mood over time. Furthermore, categorising sedentary behaviour as mentally active or passive is a relatively new concept and Hallgren et al. (2019) underscore the need for further research exploring the relationships they have identified. Recent studies have tried to incorporate this concept but face limitations. In particular, Hallgren et al. (2019) did not explicitly account for important sedentary behaviours like internet and smartphone use, which is crucial given the increasing prevalence of these activities today.

Therefore, this study aims to build upon the recently discovered associations by addressing identified gaps. Specifically, the association between sedentary time and mood over time will be examined, considering behavioural contexts and mental activeness. Furthermore, this study focuses exclusively on university students, a population that has been underrepresented in previous research on sedentary behaviour so far.

The scope of this study leads to the following three research questions:

RQ1: What is the association between sedentary time and mood among university students over time?

RQ2: To what extent does mental activeness, categorised as either active or passive, moderate the association between sedentary time and mood among university students over time?

RQ3: To what extent does the behavioural context in which sedentary behaviour occurs, moderate the association between sedentary time and mood among university students over time?

According to previous studies, it can be assumed for the first research questions that sedentary time is negatively associated with mood (Walker et al., 2015; Huang et al., 2020; Hallgren et al., 2020; Rethorst et al., 2014).

For the second research question it is expected that the association between sedentary time and mood changes depending on the type of mental activeness, with increased mood levels for sedentary behaviour categorised as active and decreased mood levels of sedentary behaviour categorised as passive (Hallgren et al., 2018; 2020).

Furthermore, based on prior research it can be assumed for the third research question that the behavioural context will have a moderating effect on the relationship between sedentary time and mood, with the occupation context having a positive association with mood as employment has a positive impact on mental health by promoting a sense of autonomy, belonging, and achievement (Hallgren et al., 2020). Conversely, according to Huang et al. (2020), sedentary leisure time is associated with lower mood, whereas this association is less expected in the context of transportation (Hallgren et al., 2020).

Methods

Design

The present study used Experience Sampling Methodology (ESM) as a data collection design to measure sedentary time, state mood, behavioural contexts and levels of mental activeness. Participants completed three repeated questionnaires per day via the smartphone application m-Path for 14 consecutive days. This duration falls within the suggested range of

one to four weeks for ESM studies (van Berkel et al., 2017) and is sufficient for identifying various dynamics and fluctuations, as well as comparing individual weeks while keeping the burden on participants minimal. Moreover, this approach proved to be convenient and effective for measuring the variables of interest as smartphones are the emerging medium in ESM studies (Hernandez et al., 2016; Burgin et al., 2012). In particular, a time-contingent approach was implemented, requiring the participants to report on fixed time frames each day.

On the first day of the assessment, a baseline questionnaire was sent to the participants collecting demographical information and several trait measurements as part of a broader research project involving multiple researchers. Over the following 14 days, participants received a questionnaire at 10:00, 15:00 and 20:00 with a momentary measure that assessed sedentary time, its context and mental activeness as well as state mood of a preceding 30-minute period. The questionnaires and items were kept brief to reduce the burden on the participants.

Ultimately, this design allowed for extensive longitudinal data collection regarding fluctuations and dynamics of students' mood states, context and mental activeness of sedentary time over the course of two weeks. The data was collected between the 8th and 23rd of April 2024. Approval for this study was granted by the BMS Ethics Committee of the University of Twente (reference number: 240234).

Participants

For the present study, participants were recruited through convenience sampling via the SONA system of the University of Twente, as well as through social media and the researchers' acquaintances. The inclusion criteria for filtering participants involved being at least 18 years old, being enrolled at a university or other higher education (hbo, Fachhochschule), being proficient in the English language, and having access to and be willing to use a smartphone for the period of the study.

The original sample included 41 participants. However, 16 individuals were excluded due to a response rate falling below 50% which is common practice in ESM studies (Conner & Lehman, 2012; Kang, 2013). Consequently, a final sample size of $N = 25$ was left (see Table 1) with an overall response rate of 79.8%. Among these participants, 56% were German, 28% were Dutch, and the remaining 16% from other countries. The participants' age ranged from 18 to 29 years ($M = 21.68$, $SD = 2.61$). Additionally, 56% of the participants identified as male, while 44% identified as female. A total of 24 participants were enrolled at a university, while one was enrolled at another higher education institution.

Table 1

Sample characteristics N=25

Characteristics	*n*	%
Gender		
Male	14	56
Female	11	44
Nationality		
German	14	56
Dutch	7	28
Other	4	16
Occupation		
Enrolled at a university	24	96
Enrolled at another higher education institution	1	4

Materials

m-Path

ESM requires software that allows for more complex designs and functionalities while remaining easily accessible and user-friendly for researchers and practitioners with limited programming skills. m-Path meets these requirements by providing an intuitive web interface for setting up highly customisable smartphone-based ESM protocols, as described by Mestdagh et al. (2022).

m-Path is a research application that allows for the repeated presentation of specific measurements on participants' mobile phones. After downloading the app, participants will receive notifications containing questionnaires to complete. In addition to various surveys, additional information such as informed consent (see Appendix A) and demographical data can also be obtained through m-Path.

The data collection process for this study was facilitated by the application, which allowed participants to complete all the questionnaires in their usual living environment. Participants completed all the measurements described below via m-Path on their smartphones.

Baseline Questionnaire

The baseline questionnaire (Appendix B) was scheduled on the first day of assessment and contained demographical questions about gender, age, current occupation, and if

applicable the SONA ID. These questions served to screen participants based on inclusion and exclusion criteria. Subsequently, participants were asked to complete several trait items evaluating additional psychological constructs as part of other research projects.

Repeated Questionnaires

The morning questionnaire, prompted at 10:00, included the assessment of participants' total daily sedentary time. This measure was part of other research projects, as the present study only used momentary measures that relate to the same temporal period. Therefore, participants were asked to report their sedentary time over a preceding 30-minute period. They were prompted with the question: "*Over the past 30 minutes before the notification, how many minutes have you been in a sitting or reclining position?*". Subsequently, participants were asked about the context and mental activeness of sedentary activity during this 30-minute period. Firstly, they were presented with the question: "*Over the past 30 minutes, in which context were you in?*" and could choose from the options *Leisure, Transportation*, or *Occupation/Study*. Depending on their response, a follow-up question was posed to identify the specific sedentary behaviour: "*During the past 30 minutes, what activity did you spend the most time engaged in?*". This item aimed to determine whether the behaviour was mentally active or passive. The response options for this item and the categorisation into the three contexts were derived from the framework proposed by Hallgren et al. (2020), which served as the primary basis for these items. Using this framework, context-tailored sedentary behaviours, both in mentally active and passive forms, could be formulated and presented to participants, aiming to capture the most detailed understanding of participants' sedentary activity during the 30-minute interval. These items can be found in Appendix C.

Subsequently, within the same context of the 30-minute interval, participants' mood was examined to infer potential associations between sedentary time, depression, and the role of mental activeness during these behaviours. Mood was assessed based on Watson's & Tellegen's (1985) Two-Factor Model, representing mood through the dimensions of Positive Affect (PA) and Negative Affect (NA). These facets of mood can be measured using the International Positive and Negative Affect Schedule Short Form (I-PANAS-SF) by Thompson (2007), which is an abbreviated version of the original PANAS. Participants can indicate to what extent they have experienced each item's particular affective state using a 5-point Likert scale, spanning from 'Not at all' to 'Extremely'. Items from this inventory were used to measure mood, as previous research has demonstrated their validity and reliability in

non-clinical samples, showing strong correlations between these factors and the prediction of depression (Crawford & Henry, 2004).

Moreover, to tailor the items of the I-PANAS-SF to the present study and reduce participant burden, the number of items per factor was reduced following a three-day pilot test. Items with the highest factor loadings were selected to retain as much of the psychometric properties as possible. Among these, the items that performed best in the pilot test and aligned most effectively with the context of sedentary behaviour were chosen. Ultimately, the items *attentive* and *active* for PA, with factor loadings of .77 and .74 respectively, and the items *afraid* and *upset* for NA, with factor loadings of .75 and .68 respectively, were selected for the final measurement. The wording of the items was adjusted to the momentary measurement by asking about affective states of the preceding 30 minutes: "*Over the past 30 minutes, to what extent did you feel...?*".

Furthermore, in the present sample, the tailored items demonstrated acceptable internal consistency with Cronbach's alpha showing .62 for the PA scale, and .75 for the NA scale. The final version of the tailored items can be found in Appendix C.

Procedure

All measurements were incorporated into the m-Path app, and a pilot test was conducted over three days. After successful testing, the study was published on the University of Twente's SONA System and shared with participants via text message or social media. Following registration, participants received a welcome and introductory description. The participants were instructed on how to download the m-Path app, log in to the study, and ensure that their app notifications were turned on.

On the first day of assessment, participants were given a baseline questionnaire which started with a request for informed consent (Appendix A). If consent was refused, participation was terminated. After providing informed consent, participants were asked to provide further demographic information and complete several trait measures which were part of other research projects. The baseline questionnaire had to be completed on the first day of participation. For the following 14 days, a time-contingent approach was chosen as part of the ESM design, which means that participants had to respond at specific times each day. For this study, three repeated questionnaires were scheduled per day, the first at 10:00, the second at 15:00, and the third at 20:00. One hour after the notification a reminder was sent to the participants, and all three questionnaires were available for 2 hours each. This approach allowed for an accurate measurement of sedentary time and other psychological constructs without overwhelming the participants. At the end of each questionnaire,

respondents were thanked for completion of the survey and their participation. If a participant did not respond to a questionnaire, it was coded as missing data. The complete data collection process is illustrated in Figure 2.

Figure 2

Timeline of the ESM design

Day	10:00-12:00	15:00-17:00	20:00-22:00
8-4	1		
9-4	3	3	3
10-4	2	3	3
11-4	2	3	3
12-4	2	3	3
13-4	2	3	3
14-4	2	3	3
15-4	2	3	3
16-4	2	3	3
17-4	2	3	3
18-4	2	3	3
19-4	2	3	3
20-4	2	3	3
21-4	2	3	3
22-4	2	3	3
23-4	4		

Name test	Number	Total amount
Baseline Questionnaire	1	1
Repeated Q. (PAST-U, States)*	2	13
Repeated Q. (States)**	3	14
Only PAST-U for final day	4	1

*Note.**Questionnaire including items measuring total daily sedentary time, 30-min sedentary time, state mood, context and mental activeness

**Questionnaire including items measuring 30-min sedentary time, state mood, context and mental activeness

Data Analysis

First, the data of all participants were individually exported from m-Path to Excel to create a long-format dataset. The dataset was then cleaned by excluding participants who did

not meet the inclusion criteria or did not complete the baseline questionnaire. Furthermore, any instances of misleading indications of sedentary time, where hours were mistakenly reported instead of minutes, were corrected. Moreover, the sum scores of the two scales, PA and NA, were calculated. To report on the variable state mood, the NA scale was subtracted from the PA scale, representing the momentary measure of participants' mood within a 30-minute interval (Thompson, 2007). To obtain the dichotomous variable of mental activeness, the different sedentary behaviours operationalised from the framework of Hallgren et al. (2020) were coded into dummy variables, with mentally active behaviours coded as 1 and passive behaviours as 0. Additionally, the categorical variable of context (leisure, transportation, occupation/study) was coded into dummy variables, with the presence of a context coded as 1 and the absence as 0. If participants indicated not sitting, the data point was coded as missing data.

In order to conduct analyses, the dataset was then imported to the 29th version of SPSS. Subsequently, descriptive statistics were reported as means, standard deviations, and value ranges for the variables of 30-minute sedentary time, context, mental activeness, and state mood. As part of descriptive analyses, exploratory visualisations of four individual participants with the highest response rates were illustrated. This qualitative approach allowed for the analysis of individual variations and changes in the variables of interest, considering behavioural contexts and levels of mental activeness.

Moreover, Linear Mixed Models (LMMs) were employed to investigate the research questions regarding their association coefficients and statistical significance. LMMs with a first-order autoregressive covariance structure (AR1) were conducted, as this approach accounts for the nested data of ESM studies as well as for missing data points (Park & Chung, 2022). LMMs handle missing data by obtaining Estimated Marginal Means (EMMs), thereby estimating participants' most likely scores at the missing entries based on Restricted Maximum Likelihood (REML). The first-order autoregressive covariance structure also considers that the correlation of measurements within participants decreases as time increases (IBM, 2019). Furthermore, EMMs were visualised in graphs to investigate variations and fluctuations in sedentary time and state mood across all participants and timepoints. LMMs were used to investigate the direct associations of the first research question, as well as the interaction terms of the second and third research questions. For all models, state mood was set as the dependent variable, and the variables of 30-minute sedentary time, mental activeness, and the three contexts were set as covariates, depending on the model respectively. Lastly, to enhance the investigation, personal mean and personal mean-centred

scores for the variable of 30-minute sedentary time were calculated and integrated into LMMs, allowing for analysis of both between-person and within-person effects (Curran & Bauer, 2011).

Results

Descriptive Statistics

Table 2 presents the characteristics of the responses of the university students in this sample. The average sedentary activity of the students was 21.36 minutes per assessed 30-minute interval (*SD* = 10.96). A total of 824 of these 30-minute bouts were examined, further highlighting the scope and depth of this data collection.

In addition, within the aforementioned 30-minute intervals, participants were also asked to report on their behavioural context and mental activeness during periods of sedentary time (see Table 2). During the assessment, 55.7% of the time university students were engaged in the context of Leisure, 9.5% in the context of Transportation, and 34.8% in the context of Occupation/Study. At the period of measurement, 55.2% of sedentary time was mentally active, and 25.8% were mentally passive. Additionally, 18.9% of the time, students reported not being sitting. In summary, it can be said that during the observed periods, university students in this sample engaged in the majority of their sedentary activities during their free time, and were also mentally active.

Furthermore, Table 2 also presents the mood scores of the participants. The mean mood level in this sample was 1.82 (*SD* = 2.36). This value was obtained by subtracting the sum score for the NA state (*M* = 3.14, *SD* = 1.56) from the sum score for the PA state (*M* = 4.96, *SD* = 1.88). This resulted in a possible range of -8 to 8 in the variable state mood. Overall, it can be said that the mood in this sample was generally close to the scale's centre of 0, indicating neither a particularly positive nor negative mood profile.

Table 2

Measured variables among university students

Variables	*M*	*SD*	Range*	Frequency	%
Sedentary time of a preceding 30-minute period	21.36	10.96	0 — 30	824	
Context					
Leisure				459	55.7
Transportation				78	9.5
Occupation/Study				287	34.8
Mental Activeness					
Active				455	55.2
Passive				213	25.8
Not sitting				156	18.9
State Mood	1.82	2.36	-8 — 8		
PA Scale	4.96	1.88	2 — 10		
NA Scale	3.14	1.56	2 — 10		

Note. *Possible range of values

Figure 3 illustrates the estimated marginal means (EMMs) of sedentary time and state mood within 30-minute bouts throughout 42 timepoints. Over two weeks, with three measurements per day, the EMMs for state mood in this sample showed minimal variation. The highest EMM of state mood was at the last measurement on day 2 (timepoint 6), with a value of 2.93, and the lowest EMM of state mood was at the first measurement on day 13 (timepoint 37), with a value of 0.38. Considering the range of -8 to 8 for state mood in this sample, the observed variation is relatively limited.

In addition to state mood, Figure 3 also represents the sedentary time of the assessed 30-minute intervals. However, compared to state mood, noticeable fluctuations are observed in this variable over the two-week period, although the variation remains modest. The duration of sedentary time was highest with 27.53 minutes at the last measurement on day 6 (timepoint 21), while the lowest sedentary time with 14.7 minutes was recorded at the first measurement on day 13 (timepoint 37). Nevertheless, when comparing the corresponding days within the two-week period (e.g., Wednesday of the first week with Wednesday of the second week), no consistent patterns are observed in either sedentary time or state mood.

Figure 3

EMMs for sedentary time and state mood across all 42 timepoints

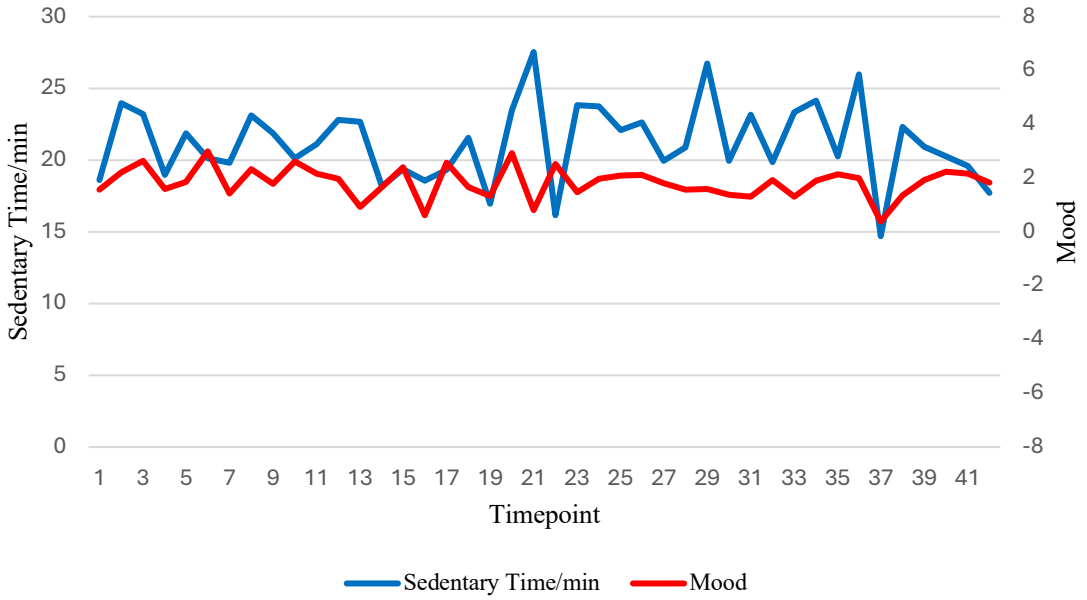


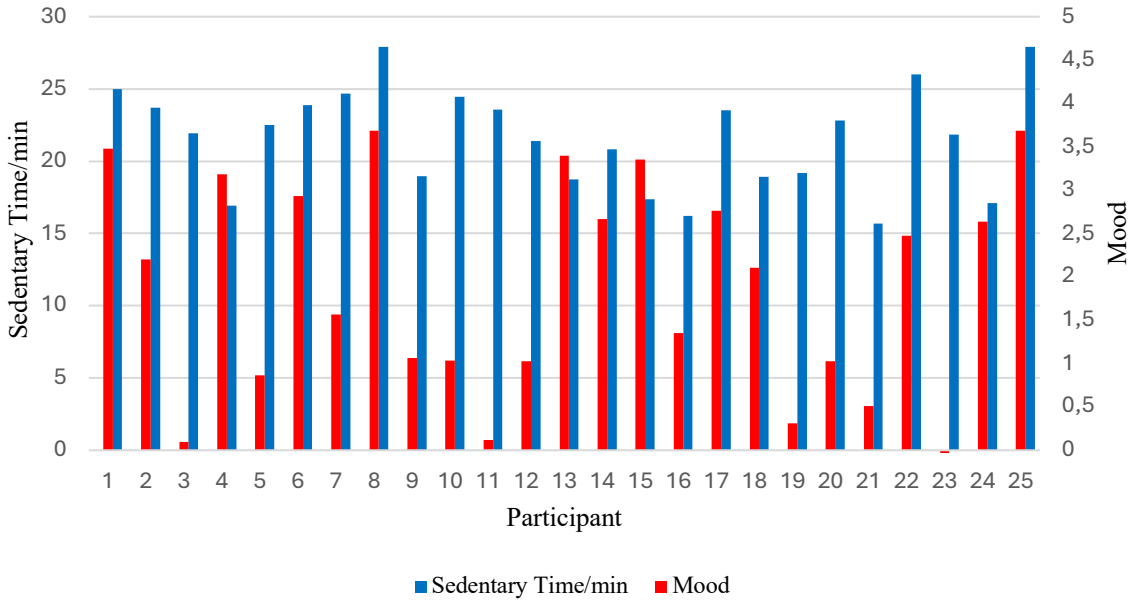
Figure 4 displays the EMMs for sedentary time and state mood per participant. Through this illustration, fluctuations and differences in variables among all 25 participants are evident. The lowest EMM for state mood was recorded at -0.51 for participant 23, while the highest EMM was observed for participants 8 and 25, with a value of 3.68. Overall, it can be observed that the mood scores of individual participants varied more compared to the variation of mood scores over time in this sample.

Similarly, the average sedentary time varied noticeably between participants compared to sedentary time across all timepoints. Sedentary time ranged from 15.68 minutes for participant 21 to 27.9 minutes for participants 8 and 25. Thus, as with state mood, participants 8 and 25 showed the highest values.

No relationship was observed between participants' average sedentary time and their average state mood. Like participants 8 and 25, participants 1, 7, 10, and 22, also had high EMMs for sedentary time but showed varying mood values. Furthermore, there were participants with both high sedentary time and high mood (1, 8, 17, 25), as well as participants with high sedentary time and low mood (3, 10, 11, 20). Simultaneously, those with an average sitting time, comparable to the sample mean ($M = 21.36$), displayed mood values ranging from -0.512 to 2.66. Thus, no clear associative relationship between sedentary time and mood among individual participants was evident.

Figure 4

EMMs for sedentary time and state mood of all 25 participants



Individual Visualisation

To gain a more comprehensive and detailed analysis, the variables sedentary time, state mood, contexts, and mental activeness were represented graphically for four selected participants (Figures 5 to 8). Participants 1, 24, 23, and 22 were chosen due to having the four highest response rates within the sample, at 100%, 98%, 98% and 95%, respectively, and thereby being the most reliable across all timepoints. Individual values were plotted across timepoints, whereas each bar represents a single timepoint within the two-week period. The colour of the bars indicates the context, and the pattern—solid for mentally active or striped for mentally passive—indicates the type of mental activeness. These individual visualisations allowed for an in-depth analysis of temporal variation and associations among variables of interest.

Sedentary activities were mainly distributed between the Leisure and Occupation/Study contexts, whereby participants were rarely engaged in the Transportation context. Moreover, distinct daily structures were identified for some participants. Specifically, participant 1 primarily engaged in the Occupation/Study context during the morning and afternoon questionnaires, while shifting to the Leisure context during the evening questionnaire. Besides that, weekends were clearly recognisable in participant 1 and 24, featuring exclusively the Leisure context. Mentally passive sedentary time occurred

mostly in the Leisure context, while the Occupation/Study context was predominantly mentally active on working days.

Associations between state mood and sedentary activities were noted for participants 1, 22, and 24, with mood declining during passive sedentary time in Leisure contexts and generally increasing during active sedentary time in the Occupation/Study context. However, participant 23 showed no clear patterns between state mood and other variables.

To summarise, the visualisations revealed distinct patterns and similar dynamics across participants. Common trends included high/increasing moods associated with mentally active sedentary time in the Occupation/Study context and low/declining moods with mentally passive sedentary time in the Leisure context.

Figure 5

Sedentary time, state mood, contexts and mental activeness across all timepoints of participant 1

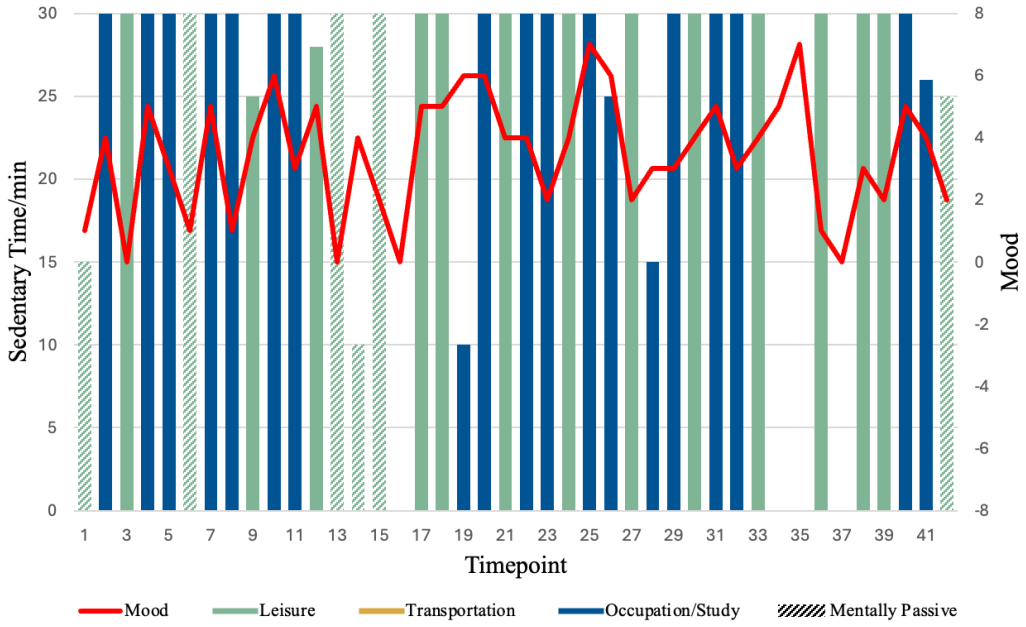


Figure 6

Sedentary time, state mood, contexts and mental activeness across all timepoints of participant 24

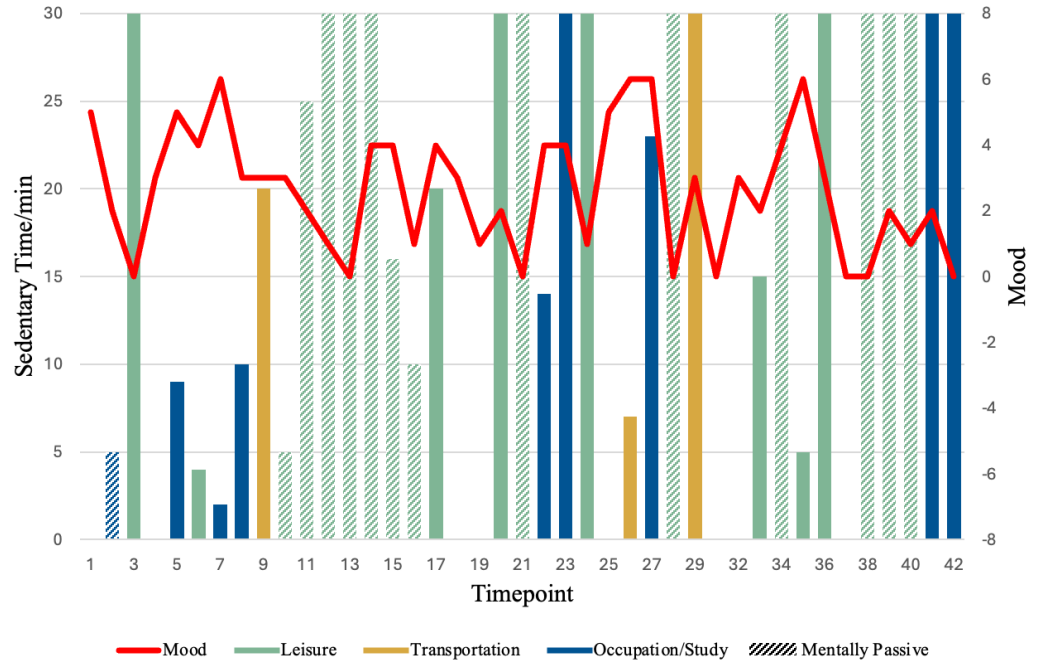


Figure 7

Sedentary time, state mood, contexts and mental activeness across all timepoints of participant 23

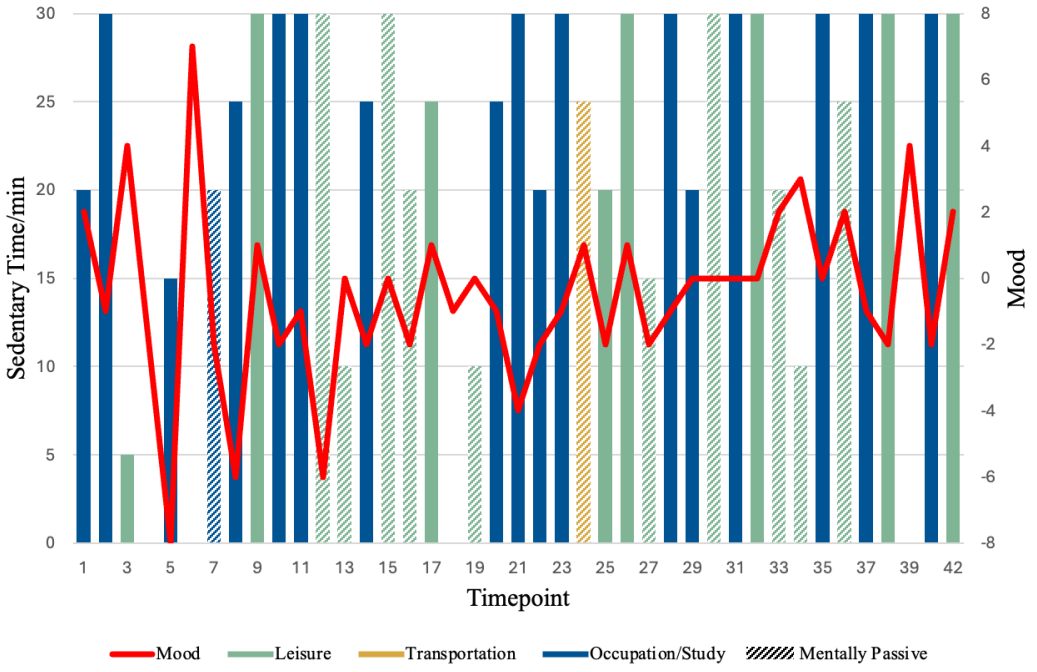
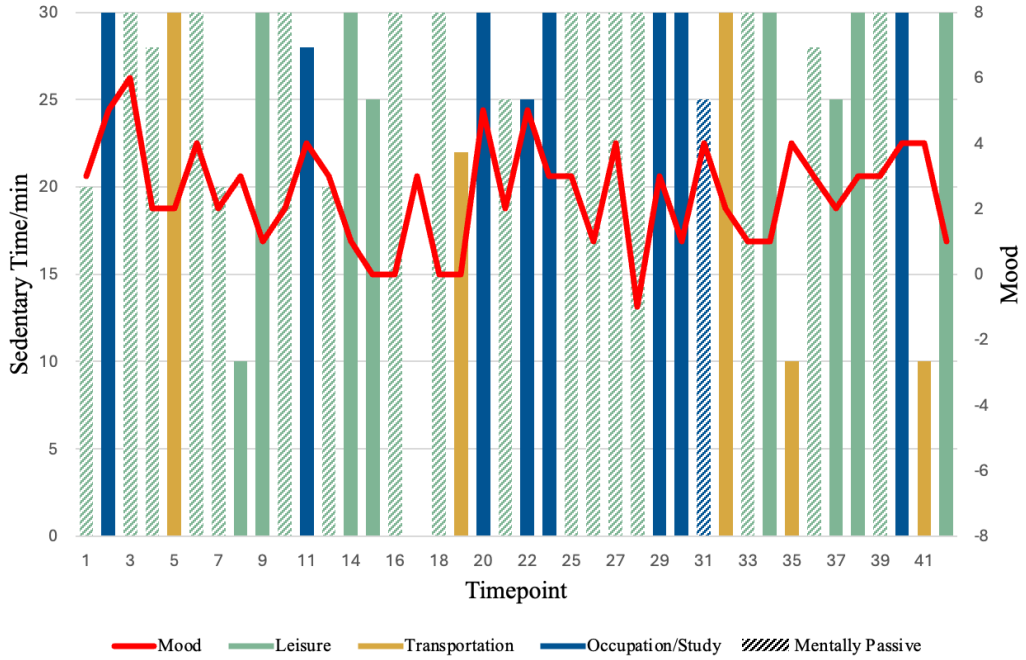


Figure 8

Sedentary time, state mood, contexts and mental activeness across all timepoints of participant 22



Inferential Statistics

To analyse the association of sedentary time, as well as behavioural contexts and mental activeness with state mood, six distinct linear mixed models were employed (Table 3), thereby ultimately addressing the research questions.

To address the first research question, the direct association between sedentary time and state mood was examined in the first model. In particular, a statistically significant negative coefficient (B = -0.024, SE = 0.007) was revealed, suggesting that state mood declines by 0.024 units for every additional minute in sedentary time, with the narrow CI range indicating a more precise estimate, 95% CI [-0.038, -0.010].

In addition, between-person and within-person associations were analysed using a disaggregated multilevel model. The positive coefficient (B = 0.056, SE = 0.030) for between-person sedentary time suggests that, on average, individuals with higher levels of sedentary time tend to report slightly higher levels of state mood. However, this association is not statistically significant, further underscored by the narrow CI which slightly includes zero, 95% CI [-0.003, 0.116]. The significant negative coefficient (B = -0.029, SE = 0.007) for within-person sedentary time indicates that when an individual's sedentary time deviates from their own average, there is a significant negative association and a decline of 0.029 units

in state mood at that timepoint. The narrow CI indicates a high level of precision in the estimate, 95% CI [-0.043, -0.014].

No moderating role of mental activeness on the relationship between sedentary time and state mood was found in the third model ($t(602) = -0.068$, $p = .946$). Similarly, mental activeness was not significant as a direct predictor, but had a positive coefficient ($B = 0.481$, $SE = 0.580$) indicating that being mentally active (compared to passive) is associated with an estimated increase of 0.481 units in state mood. The rather wide CI suggests a less precise estimate, 95% CI [-0.658, 1.620].

Linear mixed models 4, 5 and 6 were used to address the third research question by analysing the association of sedentary time and state mood alongside the three context moderators of Leisure, Transportation and Occupation/Study. No significant moderating effect was found for the Leisure context ($t(744) = -0.411$, $p = .681$). Interestingly, as a single predictor, Leisure had a non-significant negative coefficient ($B = -0.346$, $SE = 0.349$, 95% CI [-1.032, 0.340]), suggesting that being in the context was associated with a decline in state mood by 0.346 units. Furthermore, no moderation effect of the Transportation context was found in model 5 ($t(731) = -0.482$, $p = .630$). As a single predictor, the context demonstrated a non-significant positive coefficient ($B = 0.299$, $SE = 0.470$, 95% CI [-0.624, 1.222]), indicating that being in the context of Transportation is associated with an increase of 0.299 units in state mood. Lastly, model 6 showed that the Occupation/Study context had no moderating role ($t(742) = 0.598$, $p = .550$). In the same model, Occupation/Study had a non-significant positive association with state mood ($B = 0.269$, $SE = 0.403$, 95% CI [-0.522, 1.061]). This suggests that being in the context of Occupation/Study is associated with an increase of 0.269 in state mood.

Table 3

Estimates for Fixed Effects for Linear Mixed Models

Linear Mixed Models	*B*	*SE*	*t*	*p*	95% CI
Model 1					
Intercept	2.355	0.184	12.808	**<.001**	[1.994, 2.717]
Sedentary Time	-0.024	0.007	-3.367	**<.001**	[-0.038, -0.010]
Model 2					
Intercept	0.631	0.652	0.969	.334	[-0.653, 1.916]
Between-person Sedentary Time	0.056	0.030	1.880	.061	[-0.003, 0.116]
Within-person Sedentary Time	-0.029	0.007	-3.918	**<.001**	[-0.043, -0.014]
Model 3					
Intercept	1.256	0.463	2.716	.007	[0.348, 2.165]
Sedentary Time	-0.001	0.018	-0.068	.946	[-0.037, 0.035]
Mental Activeness	0.481	0.580	0.829	.407	[-0.658, 1.620]
Sedentary Time * Mental Activeness	0.009	0.023	0.416	.678	[-0.035, 0.054]
Model 4					
Intercept	2.565	0.279	9.183	**<.001**	[2.017, 3.114]
Sedentary Time	-0.022	0.011	-1.952	.051	[-0.043, 0]
Context Leisure	-0.346	0.349	-0.991	.322	[-1.032, 0.340]
Sedentary Time * Context Leisure	-0.006	0.014	-0.411	.681	[-0.034, 0.022]
Model 5					
Intercept	2.305	0.200	11.498	**<.001**	[1.912, 2.699]
Sedentary Time	-0.022	0.008	-2.889	**.004**	[-0.037, -0.007]
Context Transportation	0.299	0.470	0.635	.525	[-0.624, 1.222]
Sedentary Time * Context Transportation	-0.012	0.024	-0.482	.630	[-0.060, 0.036]
Model 6					
Intercept	2.316	0.204	11.341	**<.001**	[1.915, 2.717]
Sedentary Time	-0.030	0.008	-3.601	**<.001**	[-0.047, -0.014]
Context Occupation/Study	0.269	0.403	0.669	.504	[-0.522, 1.061]

Sedentary Time * Context Occupation/Study	0.010	0.016	0.598	.550	[-0.022, 0.041]

Note. Dependent variable: State mood.

Discussion

The main objective of the current study was to investigate the association between sedentary time and mood across distinct behavioural contexts and levels of mental activeness among a sample of *N*=25 university students over a period of 14 days. Specifically, three research questions were initially formulated based on existing literature. The first research question aimed to explore the direct association between sedentary time and mood over time. Overall, analyses revealed a significant negative association between sedentary time and mood. Additionally, the second and third research questions aimed to investigate the moderating role of mental activeness and the behavioural contexts of leisure, transportation and occupation/study on the relationship between sedentary time and mood over time. However, the relationship between sedentary time and mood did not seem to depend on the type of mental activeness or the behavioural context. Despite these statistical findings, clear trends became apparent through individual visualisations and exploratory analyses.

To address the first research question, the relationship between sedentary time and mood was investigated. Importantly, statistical analyses revealed a significant negative association ($p < .001$), indicating that as university students' sedentary time increases, their mood decreases. Next to that, exploratory visualisations and statistical analyses suggested a significant within-person variation ($p < .001$) and less between-person variation in the variables of sedentary time and mood. This implies that the fluctuations in sedentary time and mood are more pronounced within the same person over time rather than when comparing different people. Previous research has also found that sedentary activities are associated with a lowered mood (Van Uffelen et al., 2013, Walker et al., 2015). However, research in this area is not yet consistent. For instance, Aggio et al., (2017) did not find such associations, whereas other ESM studies identified negative associations between sedentary time and mood (Giurgiu et al., 2019; Elavsky et al., 2016). Consequently, while the overall relationship between sedentary time and mood over time remains unclear, the present study proposes a negative association. Although the items used to measure mood correlate with the prediction of depression, it is difficult to infer depressive states in the present sample (Crawford & Henry, 2004). In general, the sample appeared to be experiencing a neutral or slightly positive mood and none of the participants exhibited a consistently low mood.

In order to address the second research question, the moderating effect of mental activeness on the relationship between sedentary time and mood was investigated. When excluding non-sedentary activities, university students in this sample demonstrated more mentally active (68.11%) than passive sedentary behaviour (31.89%). This high level of mentally active behaviour could be attributed to the nature of university students' activities, which often involve active sedentary tasks such as studying, writing assignments, and attending lectures and tutorials (Castro et al., 2020). Furthermore, participants' individual visualisations showed that the type of mental activeness was to some extent associated with other variables such as mood and context. In particular, it was evident that mentally passive sedentary behaviour occurs almost exclusively in the leisure context and is more frequent on weekends. However, statistical analyses revealed a non-significant moderating effect of mental activeness. Similarly, a positive but non-significant association was found for the main effect of mental activeness. Regardless of the lack of statistical significance, the coefficient suggests that students' mood increases when they engage in mentally active behaviours compared to mentally passive behaviours. These findings are in line with existing literature. For instance, studies by Hallgren et al. (2018, 2020) also found that mentally passive sedentary behaviour is linked to elevated depressive symptoms and that replacing passive sedentary behaviour with active behaviour can reduce feelings of depression in adults (Hallgren et al., 2019). However, research on this distinction is not yet consistent. On the one hand, Rethorst et al. (2014) suggest that sedentary activities which involve mentally demanding tasks, such as reading and problem-solving, are inherently rewarding. In contrast, prolonged TV watching lacks these inherently rewarding aspects (Rethorst et al., 2014). On the other hand, Teychenne et al. (2014) investigated prospective associations between sedentary activities such as TV watching (mentally passive), and the risk of depression. During the three-year follow-up period, no significant association was found between any sedentary behaviour and depression (Teychenne et al., 2014). However, although the present sample demonstrated more mentally active habits which appeared to have a positive association with mood, the overall relationship between sedentary time and mood remained negative. Therefore, the positive impact of mentally active behaviour may not be as protective in this sample as scholars such as Hallgren et al. (2019) suggest.

To ultimately address the third research question, the three behavioural contexts of leisure, transportation, and occupation/study, originally conceptualised by Owen et al., (2011), were examined for their moderating effects on the relationship between sedentary time and mood. Exploratory visualisations of individual participants revealed that the

contexts in which university students engage in sedentary activities may change according to certain patterns. For instance, the leisure context was predominantly associated with weekends and evenings, accounting for nearly 56% of the time participants spent sitting. The occupation/study context, with 34.8%, was mainly observed during weekdays, in the mornings and afternoons. The transportation context, representing 9.5%, was scarcely represented and therefore had no recognisable pattern. Moreover, clear trends and associations were identifiable. For instance, mood was generally lower/decreasing when university students were engaged in the leisure context. During the occupation/study context, mood tended to be higher/increasing. These associations were partially confirmed by statistical analyses, which indicated that the occupation/study context was positively associated with mood. However, the moderation effect of this context on the relationship between sedentary time and mood was not statistically significant. Besides that, the leisure context was negatively associated with mood, suggesting that when students are in a leisure context, their mood tends to decline. Nevertheless, there was no statistically significant moderating effect of leisure on the relationship between sedentary time and mood. Lastly, although the main effect of the transportation context was positive, the interaction term appeared to be insignificant. However, despite the lack of statistical significance of all three context moderators, their coefficients align with previous research. For instance, recent studies suggest that occupational sitting positively influences mood, while leisure-time sitting negatively impacts mood (Hallgren et al., 2018; Hallgren et al., 2020, Huang et al., 2020). In particular, Hallgren et al. (2020) state that sedentary time spent in socially isolating activities, such as watching TV, can withdraw people from mood-enhancing social interactions. Moreover, Hallgren et al. (2020) explain that the occupational environment positively influences mood, as employment has a positive effect on mental health by promoting a sense of autonomy, belonging and achievement. In contrast, a recent study by Kanning et al. (2021) found that participants felt less well and less calm during occupational sitting compared to leisure sitting, which is also consistent with other studies (Kanning, 2013). However, these findings considered whether sedentary time occurred in the presence of others or alone, which might be a notable factor that has potential for future research. Overall, research on this categorisation is still not in agreement, possibly due to its relatively new nature. Nonetheless, the present findings support previous insights and underscore the need for further research that considers additional factors such as social context.

In conclusion, this study explored the relationship between sedentary time and mood among university students across various contexts and levels of mental activeness. Mentally

passive sedentary time during leisure was associated with declining mood, whereas mentally active sedentary time in the study/occupation context was linked to improved mood. Despite these context-specific effects, the overall association between sedentary time and mood remained negative. This contradiction highlights the need for further research to identify additional factors influencing the impact of sedentary time on mood.

Strengths and Limitations

The strengths of the present study include the advanced and precise application of the Experience Sampling Methodology (ESM), which was well-suited to the specific requirements of this field of research. This study design enabled a high degree of accuracy and depth in data collection. Notably, the study was conducted over two weeks, with three measurements per day, resulting in an exceptionally large and detailed dataset that meets the demands of this scientific scope. Moreover, this methodology allowed for the precise capture of temporal fluctuations in the associations of sedentary time, mood and various variables within specific sedentary bouts over the two-week period. Furthermore, the design allowed for the observation of variables at the individual level (within-person effects) over time, which would not have been possible with a cross-sectional design. Additionally, the variables were conceptualised based on the recently developed framework by Hallgren et al. (2020), which categorises sedentary behaviour into contexts and distinguishes between mental engagement. The ESM design facilitated the investigation of these contexts and distinctions across temporal and individual variations. In contrast to other studies such as Hallgren et al. (2019), the present study incorporated the latest media developments among the possible behaviours of university students, such as watching Netflix, using computers, smartphones, and the internet, and engaging in social media use. This enhanced accuracy of this study, as these habits are increasingly common among university students (le Roux & Parry, 2017).

However, there were limitations associated with the operationalisation of Hallgren et al.'s (2020) framework into the items used in this study. In particular, given the preliminary nature of the framework, it lacks some detail and depth. This may have resulted in items that did not capture all possible behaviours exhibited by university students. For example, occasions where multiple behaviours were exhibited simultaneously, such as socialising while watching television. Moreover, the framework did not consider mentally passive behaviours in the occupational context. Consequently, there is a high likelihood that some behaviours were not captured due to the incompleteness of the items.

Furthermore, using all items of the I-PANAS-SF might have increased accuracy by better capturing state mood across other affective states such as enthusiasm, determination, or

distress (Thompson, 2007). This limitation is also reflected in the reduced Cronbach's alpha of the PA and NA scales, which, although still acceptable, indicate decreased reliability. Apart from that, other measures could have been used to assess state mood, such as a mood slide scale which is commonly used in ESM designs and available in the m-Path app. Overall, state mood could be captured more accurately and user-friendly with additional methods.

Lastly, another limitation is that self-report measures, compared to objective measures, are prone to recall bias (Aggio et al., 2017). Using self-report measures for assessing sedentary behaviour can offer valuable insights into specific behavioural contexts. However, these measures may be less accurate than objective methods in quantifying time spent in physical activity or sedentary behaviour, which might have resulted in a less precise measurement of sedentary time in this sample (Aggio et al., 2017). Research indicates that it is more common for individuals to underestimate their sedentary time, as they may not be aware of all instances of sedentary behaviour or may not consider short bouts of sitting as significant (Prince et al., 2020). Given this tendency of underestimation, it is likely that the self-reported measures in this study may have resulted in a lower reported sedentary time.

Recommendations for Future Research

In order to gain a more detailed understanding of the association between sedentary time and mood as well as factors that could affect this relationship, further research is required. In contrast to the findings of this study, Kanning et al. (2021) demonstrated how the commonly proposed negative influence of the leisure context could be reversed when social context is considered, particularly when investigating whether sedentary time occurs alone or with others. This assumption is also supported by further research, such as Leask et al. (2015), who suggest that the accumulation of socially isolated sitting time during leisure might contribute to detrimental health outcomes. Consequently, future research should, next to behavioural contexts, also investigate potential factors of the social environment.

Next to that, a meta-analysis by Rhodes et al. (2012) has shown that gender might play a role in the engagement of sedentary activities. Moreover, environmental factors such as access to recreational facilities, urban design, and socioeconomic status have been shown to influence sedentary behaviour patterns (Hoare et al., 2016; Teychenne et al., 2014). By further investigating these variables, future research may gain a more in-depth understanding of sedentary behaviour in university students.

Furthermore, to enhance the precision in capturing sedentary time, mood and other variables, a study design incorporating multiple measures is recommended. By using self-report measures to accurately capture contexts, alongside objective measures that can

continuously detect bodily movement or measure time spent in sitting or lying postures, such as inclinometers, the associations of sedentary time and mood can be investigated thoroughly (Colley et al., 2019).

Conclusion

In conclusion, despite various limitations, this study demonstrated notable strengths and identified a statistically significant negative association between sedentary time and mood. However, no significant interaction terms of behavioural context and mental activeness were statistically confirmed, although they became apparent through exploratory analyses. This study aligns with existing literature, highlighting the detrimental impact of sedentary time on the mood of university students. Based on these findings, it is crucial for policymakers and other stakeholders to develop applications aimed at reducing detrimental sedentary time among university students, as this group is at high risk for prolonged sitting periods. Specifically, educational programs and interventions at universities should promote mentally active sedentary behaviours, such as socialising or reading, over passive behaviours like excessive leisure screen time, to help maintain a more positive mood among students. To better understand and investigate these relationships in the future, further studies should address the limitations identified in this study and consider additional important factors such as gender and social context.

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Appendices

Appendix A

Informed Consent

Informed Consent

Dear participant,

We would like to thank you for taking part in our study!

This study is conducted by Roos A.S. Kruk, Paula H. Naber, Ariya Solan, Edgar G. Avanisian and Mats O. Tebarth, and supervised by Gerko Schaap from the Department of Psychology, Health & Technology at the University of Twente.

The scope of this study is to investigate the relationship between **daily sitting time** and several variables including **mood, stress and anxiety**. You will help us address research gaps and contribute to a growing body of evidence regarding associations between sitting time and well-being.

To participate, you need to be at least 18 years old, enrolled in a university or other higher education institution (HBO, Fachhochschule), and have proficient English language skills. Additionally, you need to be able to stand for at least 30 minutes a day and have access to and be willing to use a smartphone capable of running an app for the duration of the study.

For this study, we ask you to respond to four daily questionnaires for a duration of 14 consecutive days. On the first day of assessment, you will be asked to complete a baseline questionnaire. For the following days, you are required to respond to daily repeated questionnaires, scheduled at 10:00, 14:00, 18:00, and 21:00, each open for 2 hours. Specifically, the questionnaire at 10:00 will ask you to retrospectively report on your sitting time from the previous day, while the remaining three questionnaires will ask you about specific conditions such as mood, stress, and anxiety. All questionnaires will be completed via the m-Path app.

There are no physical risks associated with this research project. Regarding the time period of two weeks, you may have timely constraints and not enough energy to constantly fill in the questionnaires. If any of these cases apply, you may withdraw at any given time as your participation in this study is voluntary. In the case of additional complaints, you can contact the researcher(s).

Keep in mind that in the case of early withdrawal, you will **not be granted any SONA credits**.

All personal data will be anonymised and kept confidential. The data will only be used for the purpose of this study and will be stored on researchers' devices for a period of two years. Please do not hesitate to contact the researchers if you have any questions or concerns before, during or after your participation:

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Contact Information for Questions about Your Rights as a Research Participant

If you have questions about your rights as a research participant or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee Information & Computer Science: ethicscommittee-CIS@utwente.nl

Do you agree to all of the above-mentioned statements and confirm that you consent to take part in this study and for your data to be used for future research as described?

Please select one of the following options:

○ I agree
○ I disagree

Appendix B

Baseline Questionnaire

Demographics	Question	Answer options
Item 1	What is your gender?	1) Female 2) Male 3) Other 4) Prefer not to say
Item 2	What is your age?	Numerical value
Item 3	What is your nationality?	1) Dutch 2) German 3) Other, please specify:
Item 4	What is your current occupation?	1) Enrolled at a university 2) Enrolled at another higher education institution (HBO, Fachhochschule) 3) Other
Item 5	Are you able to stand for 30 minutes at a time without any support?	1) Yes 2) No
Item 6	If you are participating via Sona, please indicate your SONA ID	Numerical value

Appendix C

Repeated Questionnaire

For clarification:
In this survey, we are only interested in behaviour while you were sitting or lying down and being awake! Standing or other positions are not of interest here! Furthermore, sport in a seated position is also not of interest here as we are investigating sitting behaviour without physical activity!

30-min Sedentary Time	Questions	Answer options
Item 1	Over the past 30 minutes before the notification, how many minutes have you been in a sitting or reclining position?	Numerical value
Context		
Item 1	Over the past 30 minutes, in which context were you in?	1) Leisure 2) Transportation 3) Occupation/Study
Mental Activeness		
Item 1 (Follow-up Leisure)	During the past 30 minutes, what activity did you spend the most time engaged in?	- Playing games like video games, board games, etc, or reading a book, newspaper, or something else. - Actively using social media or socializing and talking with people (Phone or in person). - Watching TV, movies, YouTube, Netflix, etc, or listening to music, or just resting in a seated or reclined position without sleeping. - Eating and drinking while in a seated or reclined position - Not sitting
Item 2 (Follow-up Transportation)	During the past 30 minutes, what activity did you spend the most time engaged in?	- Sitting and driving a motor vehicle. - Sitting and reading or using a

		computer/smartphone for work/university purposes while commuting/travelling. - Using social media or playing video games while commuting/travelling - Just sitting as a passenger, or eating/drinking while commuting/travelling - Not sitting
Item 3 (Follow-up Occupation/Study)	During the past 30 minutes, what activity did you spend the most time engaged in?	- Sitting and using a computer for work or study purposes. - Sitting while participating in a meeting, tutorial, or other work/study-related event. - Sitting in your work/study environment but not engaged in work or study-related tasks (e.g., socializing, eating/drinking etc). - Not sitting
State Mood		
Item 1	Over the past 30 minutes, to what extent did you feel active?	1) Not at all 2) A little 3) Moderately 4) Quite a bit 5) Extremely
Item 2	Over the past 30 minutes, to what extent did you feel upset?	1) Not at all 2) A little 3) Moderately 4) Quite a bit 5) Extremely
Item 3	Over the past 30 minutes, to what extent did you feel attentive?	1) Not at all 2) A little 3) Moderately 4) Quite a bit 5) Extremely

Item 4	Over the past 30 minutes, to what extent did you feel afraid?	1) Not at all 2) A little 3) Moderately 4) Quite a bit 5) Extremely