Sit Less, Sleep Better, Be Happier: The Relationship Between Types of Sedentary Behaviour and Mood Mediated by Sleep Quality

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Abstract

A high sedentary time is common among university students but has negative consequences on their physical and mental health. The effect of sedentary time on mood is yet not certain since studies resulted in ambiguous evidence. Previous studies neither distinguished between different sedentary behaviours and positive and negative affect nor explored an explanation for their relationship. Therefore, the current study aimed at investigating the association between mentally active sedentary time, mentally passive sedentary time and positive and negative affect. Moreover, a mediation of sleep quality between these concepts was tested. A cross-sectional study design was applied with a total of 89 student participants of predominantly women (67.4%, *n* = 60), young adults between 18 and 25 years old (82.0%, *n* = 73) and Germans (74.2%, *n* = 66). The participants were asked about their sedentary times in certain activities through a modified version of the Past-Day Adults' Recall Sedentary Time-University questionnaire. Their positive and negative affect was assessed by the Positive and Negative Affect Scale past few weeks instruction and their sleep quality by the Brief Version of the Pittsburgh's Sleep Quality Index. Calculating the spearman's correlation coefficient resulted in non-significant associations between the types of sedentary time and affects. The mediation analyses using PROCESS macro were also not significant. Thus, no evidence is found for the association between mentally active and mentally passive sedentary time and positive and negative affect, nor a mediation of sleep quality. This study suggests that the conceptualisation and operationalisation of mood may be important for the association with sedentary time. Further research is needed to obtain more clarity into the relationship between sedentary time and mood.

Keywords: Sedentary Time, Sedentary Behaviour, Mood, Positive Affect, Negative Affect, Sleep Quality, Students, Cross-Sectional, Mediation Analysis

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University students are known to engage frequently in health risk behaviours, such as alcohol and tobacco consumption (Ergül-Topçu & Topçu, 2017). One unhealthy behaviour of students that is often not considered is being sedentary for a long time (Castro et al., 2020). University students typically follow a sedentary lifestyle, like sitting while studying (Castro et al., 2020). High sedentary time (ST) leads to a heightened risk of experiencing harmful consequences on physical health, including an increased chance of obesity, cardiovascular disease, and mortality (Park et al., 2020). To illustrate, ST of more than seven hours per day accounts for approximately 4% to 6% of all deaths (Patterson et al., 2018). Next to these physical health risks, high ST is associated with poorer mental health (Faulkner & Biddle, 2013). For instance, excessive ST is often associated with mood disorders, such as depression and bipolar disorder (Jiang et al., 2020; Vancampfort et al., 2016). However, only a few studies investigated the relationship between ST and non-clinical mood and this research has shown ambiguous evidence for its association (Carter et al., 2020; Endrighi et al., 2016; Giurgiu et al., 2020). To get more insights into the association between mood and ST, the current study examined the relationship between ST and mood among university students in a cross-sectional study design. As it has been shown that sleep quality, ST, and mood are associated (Bouwmans et al., 2017; Vancampfort et al., 2018), sleep quality is included as a potential mediator between ST and mood.

Sedentary Time and Sedentary Behaviour

Sedentary time is the duration spent in any sedentary behaviour (Trembley et al., 2017). Sedentary behaviour (SB) can be defined as "any waking behaviour characterized by an energy expenditure ≤1.5 metabolic equivalents (METs), while in a sitting, reclining or lying posture" (Trembley et al., 2017). Typical SBs are watching television, reading, driving, or writing while sitting (Trembley et al., 2017). SB itself can also be differentiated into several types. One option is to divide SB into mentally active SB and mentally passive SB (Hallgren et al., 2018; Kikuchi et al., 2014). Mentally active SB describes an activity that involves cognitive exertion while seated (Hallgren, Nguyen, et al., 2020), for instance, being sedentary while playing games on the computer and reading (Kikuchi et al., 2014). In contrast, mentally passive SB comprises activities that demand little cognitive exertion, such as watching television and listening to music (Hallgren, Nguyen, et al., 2020; Kikuchi et al., 2014).

Research about the effects of ST has shown that it is important to discriminate between mentally active and mentally passive SBs. To illustrate, how much time is spent in mentally

active or mentally passive SBs has different impacts on mental health (Hallgren, Dunstan, et al., 2020; Hallgren, Nguyen, et al., 2020; Hevel et al., 2021). For instance, a study has shown that mentally active SB lowered depressive symptoms whereas mentally passive SB is related to an increased chance of depression (Hallgren, Nguyen, et al., 2020). Therefore, this study differentiated between mentally active and mentally passive ST.

University students engage extensively in both mentally active and passive SB and are exceptionally sedentary. On average, students spend 9.82 hours per day sedentary and are significantly more sedentary than their peers (Castro et al., 2020). This excessive ST of university students can be explained by their lifestyle. Generally, young adults spend much time sedentary (Unick et al., 2017). University students are prone to be more sedentary than their non-student age peers since students attend classes where sitting is indispensable or engage in SB while studying (Moulin & Irwin, 2017). Specifically, studying while sitting, a mentally active SB, is the most prominent SB among students, although they also engage in high amounts of television viewing, a mentally passive SB, and talking while sitting (Rouse & Biddle, 2010). Moreover, ST is known to increase in times of stress, which is common among university students (Storrie et al., 2010; Uddin et al., 2021). ST of university students also increased by approximately 5 hours per week due the pandemic which is why high ST of university students has become an even more pressing and topical (Savage et al., 2021). Therefore, due to the university students' highly sedentary lifestyle, they are susceptible to experiencing effects of prolonged ST.

Mood

One possible effect of high ST students may experience is a poorer mood. Moods can be described as "diffuse affective states that subtly affect our experience, cognitions, and behaviour" (Wilhelm & Schoebi, 2007). Mood is an essential part of well-being and is affected by several mental health problems, such as depression and bipolar disorder (Giurgiu et al., 2019). Investigating affects is one of multiple options to operationalise mood. Inter alia, positive affect and negative affect are two dimensions which are often used to describe mood (Watson & Tellegen, 1985). In this two-factor structure, positive affect is defined as the extent to which an individual professes to enjoy life (Watson & Tellegen, 1985). Corresponding emotions to positive affect are, for instance, excitement, and enthusiasm. In contrast, negative affect is characterised as the extent to which an individual feels agitated or uncomfortably aroused (Watson & Tellegen, 1985). For negative affect, emotions like fear and distress are common. Positive affect and negative affect are not necessarily two opposites of each other, emphasising the importance to differentiate between them in research (Russell & Carroll, 1999). Research

about the relationship between positive and negative affect and sedentary time in young people is limited (Rodriguez-Ayllon et al., 2019). Nevertheless, there is some literature on ST and mood that predominantly used other operationalisations of mood.

Previous studies on ST and mood found ambiguous evidence for their association. An experimental study by Endrighi et al. (2016) has shown that more ST results in a negative mood. Moreover, in a study by Edwards and Loprinzi (2016), physically active young adults were asked to engage in more SB and less physical activity for a week which resulted in a lowered mood. In another study, ST and mood were measured on five consecutive days among university students, revealing a negative association between these two concepts (Giurgiu et al., 2019). A cross-sectional study supports this result by finding fewer positive feelings in connection to lengthy ST (Hogan et al., 2015). However, some studies did not show a relation between ST and mood. For instance, Carter et al. (2020) found no association between ST at work and mood. The study results of Aggio et al. (2017) did not point to a relationship between ST and positive and negative affect. Another previous study also did not show that ST was associated with positive affect (Maher et al., 2019). Maher et al. (2019) hypothesised that this missing relationship may be the result of lacking discrimination between different SBs. Considering these divergent findings, further studies which differentiate between forms of SBs are necessary to get more insights into the association between ST and mood.

Sleep Quality as an Explanation for the Relation Between ST and Mood

An additional way to gain more insights into the relationship between ST and mood is to explore an explanation for this association. One possible explanation could be sleep quality (Edwards & Loprinzi, 2016). Sleep quality describes the subjective perception of sleep, involving sleep duration and satisfaction of sleep (Pilcher et al., 1997). In general, it has been found that prolonged ST is related to decreased sleep quality (Vancampfort et al., 2018) and increased sleep disturbances (Yang et al., 2017). In turn, poor sleep quality is anticipated to increase negative affect whereas high sleep quality leads to a higher positive affect (Bouwmans et al., 2017). Supporting the explanation of a possible mediation of sleep quality, one study has already shown that poor sleep quality could explain the negative relation between ST and depression and anxiety in college students (Jiang et al., 2020).

The type of ST likely affects sleep quality differently. A study has found that sleep problems could explain the association between mentally passive ST and depression (Hallgren, Vancampfort, et al., 2020). Depression is often expressed by high negative affect and low positive affect (Boumparis et al., 2016). In contrast, mentally active ST may result in a higher sleep quality since engaging in cognitive effort improves sleep quality (Cerasuolo et al., 2020).

Therefore, it is plausible that sleep quality is a potential mediator for the different types of ST and positive and negative affect.

Current Study

To conclude, studies that have examined the association between ST and mood found ambivalent evidence of their association, possibly due to the fact that no distinction has been made between different forms of SB. Most of these studies also did not differentiate between positive and negative affect. Moreover, explanations for this association were not investigated. Sleep quality may explain the possible relations between ST and positive and negative affect. Investigating these relationships and potential explanations could provide additional reasons and ideas for the development of interventions for university students. To make such implications and to address these research gaps in the relationship between types of ST and positive and negative affect, this study aimed at answering the following research questions in a cross-sectional study design:

RQ1: *To what extent are mentally active sedentary time, and mentally passive sedentary time associated with positive and negative affect of university students?*

To answer this research question, the subsequent expectations have been made based on previous research:

H1A: *Mentally active sedentary time is positively associated with positive affect in university students*.

H1B: *Mentally active sedentary time is negatively associated with negative affect in university students*.

H2A: *Mentally passive sedentary time is negatively associated with positive affect in university students*.

H2B: *Mentally passive sedentary time is positively associated with negative affect in university students*.

For the investigation of the possible mediation of sleep quality, the following research question is set:

RQ2: *To what extent does sleep quality mediate the association between mentally active and mentally passive sedentary time and positive and negative affect of university students?*

Concerning this research question, the subsequent hypotheses are formulated relying on previous research:

H3A: *Sleep quality mediates the effect of mentally active sedentary time on positive affect in university student.*

H3B: *Sleep quality mediates the effect of mentally active sedentary time on negative affect in university students.*

H4A: *Sleep quality mediates the effect of mentally passive sedentary time on positive affect in university students.*

H4B: *Sleep quality mediates the effect of mentally passive sedentary time on negative affect in university students.*

For an illustration and summary of the hypotheses, hypotheses 3A and 3B are depicted in Figure 1 and hypotheses 4A and 4B in Figure 2.

Figure 1

Expected Associations Between Mentally Active Sedentary Time, Sleep Quality, and Mood

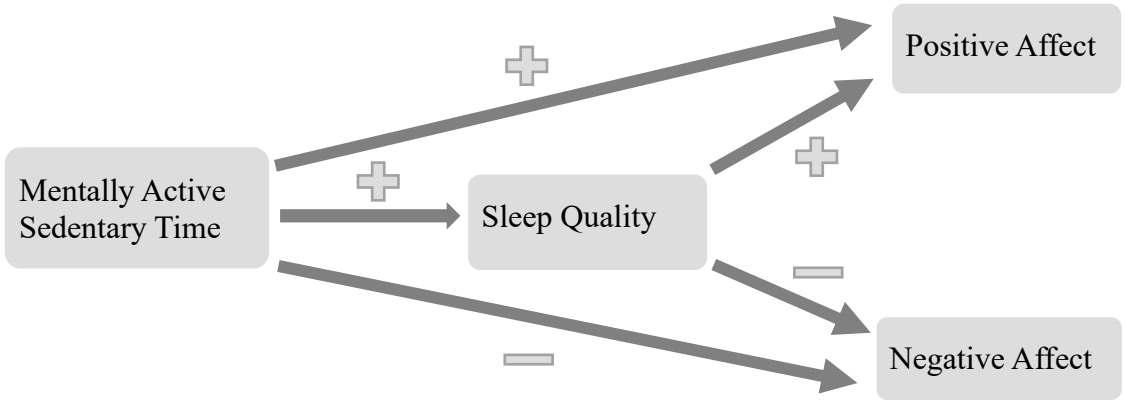
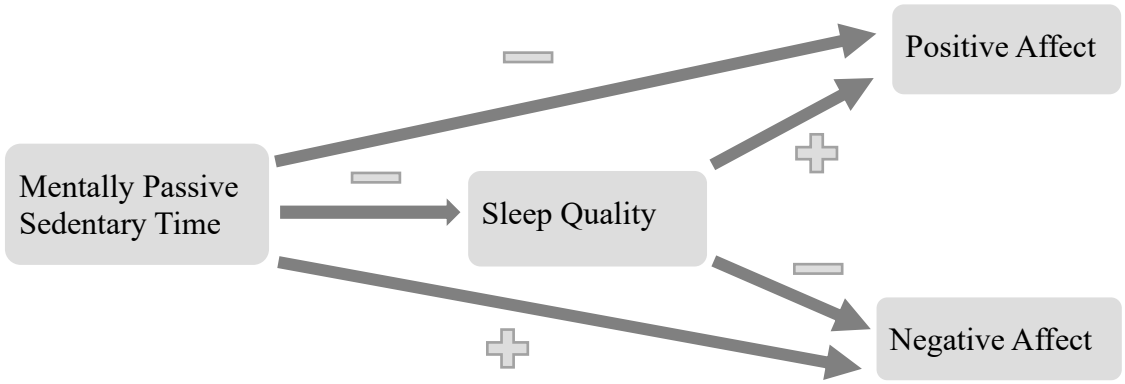


Figure 2

Expected Associations Between Mentally Passive Sedentary Time, Sleep Quality, and Mood



Methods

Design

The present study employed a cross-sectional design including one independent variable, sedentary behaviour, and one mediator, sleep quality. Sedentary behaviour as the independent variable has two variants: mentally active ST and mentally passive ST. The study has two dependent variables which are positive affect and negative affect. Ethical approval for this study was obtained by the ethics committee of the University of Twente (request number 220299). The data collection took place between the 6th of April 2022 and the 20th of May 2022. This study was part of a joint thesis project.

Participants

The participants were recruited through convenience and snowball sampling. Social media channels, such as WhatsApp and Instagram, and the Test Subject Pool BMS (SONA) of the University of Twente were used to gather participants. Participants who were recruited via SONA obtained test-subject credits. Inclusion criteria for participants were the enrolment at a university or university of applied sciences and the minimum age of 18 years. Since the questionnaires were posed in English, another inclusion criterion was the fluency in English.

A medium effect size was taken to determine the required sample size because previous studies found small to large effect sizes for the association between ST and mood (Edwards & Loprinzi, 2016; Endrighi et al., 2016). A power analysis ($\alpha = .05$ and $[1-\beta] = .80$) using the programme GPower revealed a sample size of at least $N = 84$ to find significant correlations of moderate effect size. For the mediation analyses using bootstrapping, a minimum sample size of $N = 78$ was required for moderate effect sizes (Fritz & MacKinnon, 2007).

Materials

Informed consent was provided to the participants to inform them about the study, its purpose, and the handling of their data (see Appendix A). Additionally, the informed consent included information about ensuring the participants' anonymity, their right to withdraw, and the researchers' contact information. Besides, demographic questions were asked about the participants' gender, age, nationality, and study programme (see Appendix B). Since it was a joint thesis project, questionnaires to measure the following other variables which were irrespective to this paper were included: perceived stress, social anxiety, divergent thinking, neuroticism, and extroversion. Due to the relatively high number of questionnaires, two questions were posed to see whether the participants attentively completed the questionnaires (see Appendix C), for instance: "To check whether you answer the questions attentively, please click yes."

Sedentary Time

To assess mentally active sedentary time and mentally passive sedentary time, a modified form of the Past-day Adult's Sedentary Time – University (PAST-U) questionnaire was used (see Appendix D). The PAST-U is a self-report questionnaire for university students that assesses the sedentary time of different activities of the past day (Clark et al., 2016). The original version of the PAST-U includes 9 items covering "sedentary time for work, study, travelling, eating and drinking, watching television, using the computer, socialising and other daily activities" (Clark et al., 2016). The questionnaire assesses ST in the unit of time of hours and minutes. Clark et al. (2016) have demonstrated that the PAST-U has criterion validity by comparing the objectively measured ST and ST assessed by the PAST-U ($ICC = .64$) and finding a moderate correlation between the two measurements ($r = .63$).

The original PAST-U questionnaire includes questions that pertain to both mentally active and mentally passive ST in one question. Therefore, a few adjustments have been made to be able to assess mentally active ST and mentally passive ST and to create separate variables of both types of ST (see Table 1). These modifications resulted in a total number of 14 items of the modified PAST-U. To provide an example of the adjustments made, one question of the original PAST-U relates to sitting for transport. This item does not distinguish whether the participant was actively driving, a mentally active SB, or a passenger, a mentally passive SB. Consequently, the original question was reformulated by including that the participant should only estimate the time of being a passenger. Furthermore, another question was added to ask for the time of being the driver, the mentally active form of transport. Table 1 demonstrates an overview of the remaining assessed sedentary behaviours in the modified PAST-U categorised into mentally active and passive SB based on the framework of Hallgren, Dunstan, et al. (2020).

To create the sedentary time variables, minutes were converted into hours by dividing them by 60. The total daily ST was calculated for each participant by adding the hours spent sedentary of every item of the PAST-U. Mentally active and mentally passive ST was computed by adding the hours spent sedentary of the items corresponding to the categorisation as displayed in Table 1.

Table 1

Assessed Sedentary Behaviours categorised into Mentally Active Sedentary Behaviour and Mentally Passive Sedentary Behaviour

Mentally Active Sedentary Behaviour	Mentally Passive Sedentary Behaviour
Sitting for study purposes [a]	Sitting or lying while watching TV, DVD, videos-on-demand, YouTube etc. [b]
Sitting for labour purposes [a]	Sitting while eating [a]
Sitting while driving a vehicle [b]	Sitting while commuting as a passenger [b]
Sitting or lying while playing computer or video games [b]	Sitting or lying down while scrolling through social media [b]
Sitting or lying down while engaging with others via screens [b]	
Sitting or lying while reading for leisure in an electronic format [b]	
Sitting or lying while reading for leisure in paper format [b]	
Sitting while talking to other people (phone or in person) [a]	

Note. Adapted from "The Relationship Between Sedentary Behaviour and State Anxiety in University Students: An Experience Sampling Study," by J. Vorhauer, 2022, UT Student Theses Digital Archive (https://purl.utwente.nl/essays/89387).

[a] Original item from the Past-day Adult's Sedentary Time – University questionnaire.

[b] Modified item.

Mood

To measure trait positive and negative affect, the Positive and Negative Affect Schedule (PANAS) with the past few weeks instruction was employed. This scale enabled the measurement of both dimensions of affect (Watson et al., 1988). PANAS past few weeks instruction is a self-report questionnaire assessing trait positive affect and trait negative affect with 10-items per component on a 5-point Likert scale (see Appendix E). Answer options for the items are 1 = "very slightly or not at all" to 5 = "very much". Watson et al. (1988) has shown a high internal consistency for the positive affect scale (α = .87) and negative affect scale (α = .87). A high internal consistency was also found in this sample for the positive affect scale (α = .86) and the negative affect scale (α = .86). In the validation study by Watson et al. (1988),

the test-retest reliabilities for the positive affect scale (r = .58) and negative affect scale (r = .48) were found to be sufficiently large at eight weeks to assume a measurement of trait affects. Furthermore, PANAS shows convergent and external validity (Watson et al., 1988). To determine the score on positive or negative affect, the mean of the items corresponding to the respective scale was computed. Higher scores indicate a higher positive or negative affect (Watson et al., 1988).

Sleep Quality

For the measurement of sleep quality, the Brief version of the Pittsburgh's Sleep Quality Index (B-PSQI) was selected (see Appendix F). The B-PSQI includes only six items which enabled a more efficient assessment of sleep quality compared to the original PSQI (Sancho-Domingo et al., 2021). The items refer to the past month (Buysse et al., 1989). Four items are open questions, requesting the participant to estimate the time, for instance, at which they have usually gone to bed and how many hours they actually slept (Sancho-Domingo et al., 2021). If participants expressed their hours of sleep or minutes to fall asleep not in concrete numbers but as a range, the middle of the range was used to score the item. The remaining two items are assessed on a 4-point Likert scale. One of these items refers to the subjective sleep quality with the answer options from "very bad" to "very good". The other item asks about the number of sleep awakenings with the answer options from "not during the month" to "three or twice a week". All items were scored on a 0-3 scale according to the scoring scheme of Buysse et al. (1989) and were added to create sum scores. The B-PSQI has in a minimum total score of 0 and a maximum total score of 15 with higher scores indicating a poorer sleep quality. This scale has a cut-off score of >5 to distinguish between good and poor sleepers (Sancho-Domingo et al., 2021). In the validation study in a Spanish population, the B-PSQI has been shown to have a good internal consistency (α = .79) (Sancho-Domingo et al., 2021). In this sample, a good internal consistency was found (α = .74). The B-PSQI in Spanish is considered to be valid since it significantly correlated with the original validated PSQI (r = .90) and the Insomnia Severity Index (r = .67) (Sancho-Domingo et al., 2021).

Procedure

The present study was administered in Qualtrics. At first, the participants were asked to provide informed consent. After giving active consent the participants were directed to the study. The participants began by responding to questions about their demographics. Afterwards, they received the instruction to fill out the modified version of the PAST-U by estimating as good as possible the time spend sedentary on the different occasions. Next, the PANAS, B-PSQI and the attention questions were presented to the participants in a randomised sequence to prevent

a systematic influence of the questionnaires' order on the results. At the end of the survey, the participants were asked if they have any thoughts, questions, or suggestions to add. Lastly, the participants were thanked for their participation, and the contact information of the researchers was presented.

Data analysis

For the analysis of the data, the data analysis programme SPSS 25 was utilised. The gathered data was exported from Qualtrics and imported into SPSS. First, participants, who did not complete the questionnaires, had a total daily sedentary time of over 24 hours or answered both attention questions incorrectly, were removed from the dataset. In addition, participants who answered one attention question incorrectly were excluded if their variation in answers was insufficient and if the means including and excluding the participant varied substantially. Participants who were above the 90^{th} percentile of the total daily ST were excluded if the number of typical hours of sleep combined with the reported sedentary time exceeded 24 hours. The scales were checked for outliers which were excluded in case they caused substantial differences in the descriptive statistics.

Second, Shapiro-Wilk tests were conducted for the assessed scales to check the assumption of normality. The assumption of linearity was tested by creating scatterplots. The assumption of equal variance was checked with the Levene's test. In case of heteroscedasticity, Huber-White heteroscedasticity consistent standard errors were used for the mediation analyses. The assumption of independence was tested against gender, and the weekday on which the questionnaire was completed. When the assumption of independence was violated, the respective variable was added as a covariate in the mediation analyses.

Third, for continuous and ordinal variables, the means, medians, and standard deviations were determined. Frequencies and percentages were calculated for the categorical variables. Depending on the assumption tests of normality and linearity, Pearson's correlation coefficient or Spearman's correlation coefficient were calculated between mentally active ST, mentally passive ST and positive affect and negative affect to assess *H1A*, *H1B*, *H2A*, and *H2B*.

Fourth, the PROCESS macro version 4.1 by Hayes (2013) was used to perform four simple mediation analyses to test *H3A*, *H3B*, *H4A* and *H4B*. The predictor variable was mentally active ST or mentally passive ST, and the outcome variable was positive affect or negative affect. Sleep quality was the mediator for each analysis. Utilising PROCESS macro, bootstrapping was conducted to test for a significant indirect effect with 95% confidence intervals and 5,000 bootstrapped samples. All other conducted analyses used an alpha of 5% to reject the null hypotheses.

Results

In total, 139 individuals participated in this study. 29 participants had to be excluded since they did not answer the PAST-U or PANAS. Besides, 12 participants had a total daily ST over 24 hours and thus, were excluded. Another nine participants were excluded since they reported a total daily ST of more than 19 hours, the 90th percentile, and indicated a usual sleep duration that combined with their daily sedentary time exceeded 24 hours. The subsequent analyses were repeated including participants that had a total daily ST of between 19 and 22 hours. The results with a larger sample size of $N = 94$ did not differ substantially to the results of the smaller sample. Nevertheless, participants with a total daily ST over 19 hours were excluded due to their unrealistic total daily ST. This results in a sample size of $N = 89$, including predominantly female (67.4 %, $n = 60$) and German (74.2%, $n = 66$) participants (see Table 2).

Table 2

Demographic Characteristics of the Sample

Characteristic	*n*	%
Gender		
Female	60	67.4
Male	29	32.6
Age		
18 – 25	73	82.0
26 – 30	15	16.9
31 – 40	1	1.1
Nationality		
Dutch	11	12.4
German	66	74.2
Other[a]	12	13.5
Study programme		
Psychology	42	47.2
Communication science	8	9.0
Other[b]	39	43.8

Note. $N = 89$.

[a] Other nationalities were French, Swedish, Belgian, Croatian, American, Iranian, Lithuanian, and British. [b] Examples of other study programmes were International Human Resource Management, Law, and Business Administration.

Assumptions Testing

The Shapiro-Wilk test showed evidence for non-normality for the mentally passive ST scale, $W(89) = .97$, $p = .031$, for the negative affect scale, $W(89) = .95$, $p = .003$, and for the B-PSQI, $W(88) = .93$, $p < .001$. The Q-Q plot for mentally passive ST seemed roughly normal while the Q-Q plots for the negative affect scale and B-PSQI seemed to violate normality (Appendix G). The Shapiro-Wilk test did not show evidence for a violation of normality for the mentally active SB scale, $W(89) = .97$, $p = .109$, and for the positive affect scale, $W(89) = .99$, $p = .461$. Besides, weak linearity was found (see Appendix H).

The Levene's test showed evidence for non-equal variance for positive affect, $F(16, 26) = 4.99$, $p < .001$, negative affect, $F(16, 26) = 2.52$, $p = .018$ and sleep quality, $F(16, 25) = 3.58$, $p = .024$. Therefore, Hubert-White standard errors were used for the mediation analyses. The assumption of independence for the residuals of the models with positive affect seemed to be violated for the weekday which the questionnaire was completed (see Appendix I) and thus, the weekday of participation was added as a covariate in the mediation analyses.

Descriptive Statistics

On average, the students sat for a total of 12.9 (SD = 3.3) hours a day. Table 3 demonstrates the descriptive statistics for the used scales. The participants spent more time sedentary while being mentally active (Mdn =7.2) than being mentally passive (Mdn = 4.5). The positive affect scale (Mdn = 3.2) showed a slightly heightened positive affect, and the median of negative affect scale (Mdn = 2.4) reflected an average negative affect. Considering the B-PSQI cut-off point of >5 to be a poor sleeper, most participants tended to be moderate sleepers (Mdn = 4.0). The largest part of mentally active ST was sitting while studying and the predominant SB for mentally passive ST was watching TV, videos-on-demand etc. as it can be seen in Appendix J.

Table 3

Descriptive Statistics for the Studied Variables

Scale	*M*	*Mdn*	*SD*	*Minimum*	*Maximum*
Sedentary time					
Total daily	12.9	13.3	3.3	7.2	18.8
Mentally active	7.7	7.2	3.1	2.0	15.7
Mentally passive	4.9	4.5	2.0	0.9	10.5
Mood					
Positive affect	3.1	3.2	0.7	1.5	4.8
Negative affect	2.6	2.4	0.8	1.3	4.7
Sleep quality	4.1	4.0	2.8	0.0	12.0

Note. $N = 89$. For sleep quality, $n = 88$. Sedentary times are indicated in hours. Positive and negative affect were measured on a 5-point Likert scale. A higher affect score means a higher affect. Sleep quality was measured as a sum score of five items scored from 0 to 3. A higher sleep quality score means a poorer sleep quality.

Hypotheses Testing

To test hypotheses 1A, 1B, 2A and 2B, Spearman's correlation coefficients were computed between positive affect, negative affect, mentally active ST, and mentally passive ST. As reported in Table 4, the correlations relevant to these hypotheses are not significant and thus, hypotheses 1A to 2B are rejected.

Table 4

Spearman's Correlations Coefficients Between the Studied Variables

Scale	1	2	3	4
Sedentary time				
1. Mentally active	–			
2. Mentally passive	–.24*	–		
Mood				
3. Positive affect	.08	–.10	–	
4. Negative affect	.07	.10	–.40**	–

Note. * $p < .05$, ** $p < .01$.

Simple Mediation Analyses

The simple mediation analyses were conducted using PROCESS macro, 5,000 bootstrapping samples and 95% confidence intervals. The mediation analyses predominantly resulted in non-significant results as Table 5 reports. While controlling for mentally active ST or mentally passive ST, sleep quality could predict positive affect and negative affect. Since a higher score on the B-PSQI means a poorer sleep quality, a better sleep quality led to an increased positive affect and a decreased negative affect. The indirect effect of mentally active ST on positive affect was not significant since the confidence interval contained zero, 95% CI [–0.01; 0.01]. For the same reason, the indirect effect of mentally active ST on negative affect was not significant, CI [–0.02; 0.01]. The indirect effect of mentally passive ST on positive affect is not significant as the confidence interval involves zero, CI [–0.02; 0.03], which is also true for the indirect effect of mentally passive ST on negative affect, CI [–0.03; 0.03]. Therefore, hypotheses 3A to 4B are rejected. Figure 3 summarises the results of the mediation of sleep quality between mentally active ST and positive and negative affect. In Figure 4 the results are compiled of the mediation of sleep quality between mentally passive ST and positive and negative affect.

Table 5

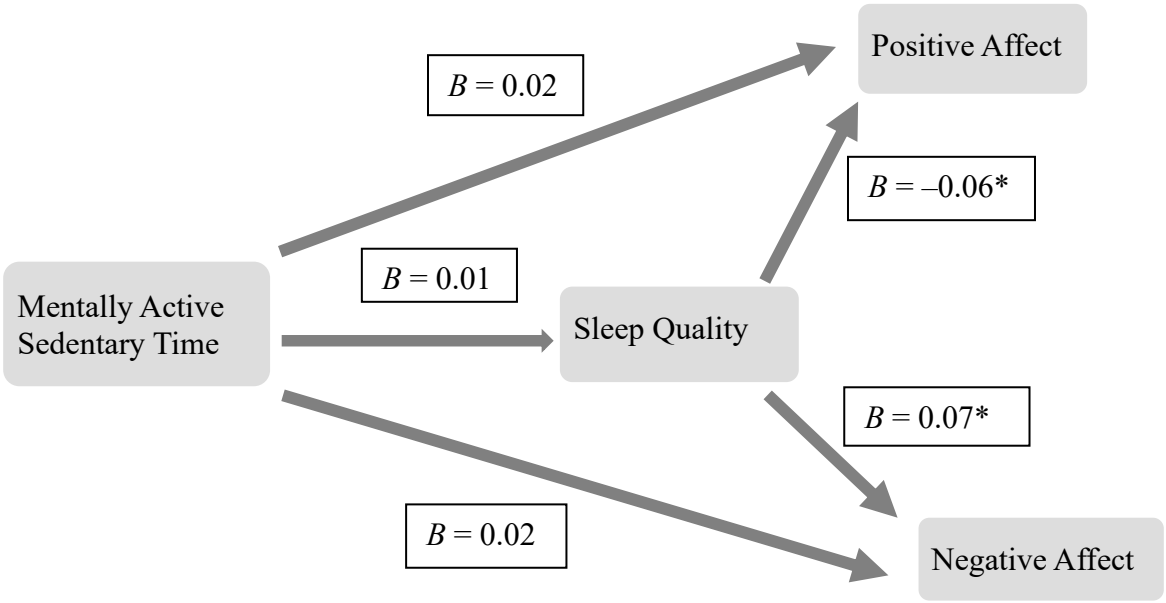
Simple Mediation Analyses: Types of Sedentary Time and Affects Mediated by Sleep Quality

Predictor Variable(s)	Outcome Variable	*B*	*SE*	*t*	*p*	95% CI for B	
						LL	*UL*
Hypothesis 3A							
Path a							
Mentally active ST	Sleep quality	0.01	0.09	0.06	.954	–0.18	0.19
Paths b and c’							
Mentally active ST	Positive affect	0.02	0.02	0.86	.394	–0.02	0.06
Sleep Quality		–0.06	0.03	–2.24	.028	–0.11	–0.01
Hypothesis 3B							
Paths b and c’							
Mentally active ST	Negative affect	0.02	0.03	0.60	.553	–0.04	0.07
Sleep quality		0.07	0.03	2.04	.045	0.002	0.13
Hypothesis 4A							
Path a							
Mentally passive ST	Sleep quality	–0.04	0.16	–0.27	.786	–0.37	0.28
Paths b and c’							
Mentally passive ST	Positive affect	–0.03	0.03	–1.09	.278	–0.09	0.03
Sleep quality		–0.06	0.03	–2.19	.031	–0.11	–0.01
Hypothesis 4B							
Paths b and c’							
Mentally passive ST	Negative affect	0.04	0.04	1.06	.293	–0.04	0.11
Sleep quality		0.07	0.03	2.18	.032	0.01	0.13

Note. Huber-White standard error was used. Higher sleep quality scores mean poorer sleep quality. Higher affect scores mean higher affect. The weekday on which the questionnaire was completed was as a covariate. ST= sedentary time, CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

Figure 3

Associations Between Mentally Active Sedentary Time, Sleep Quality, and Mood

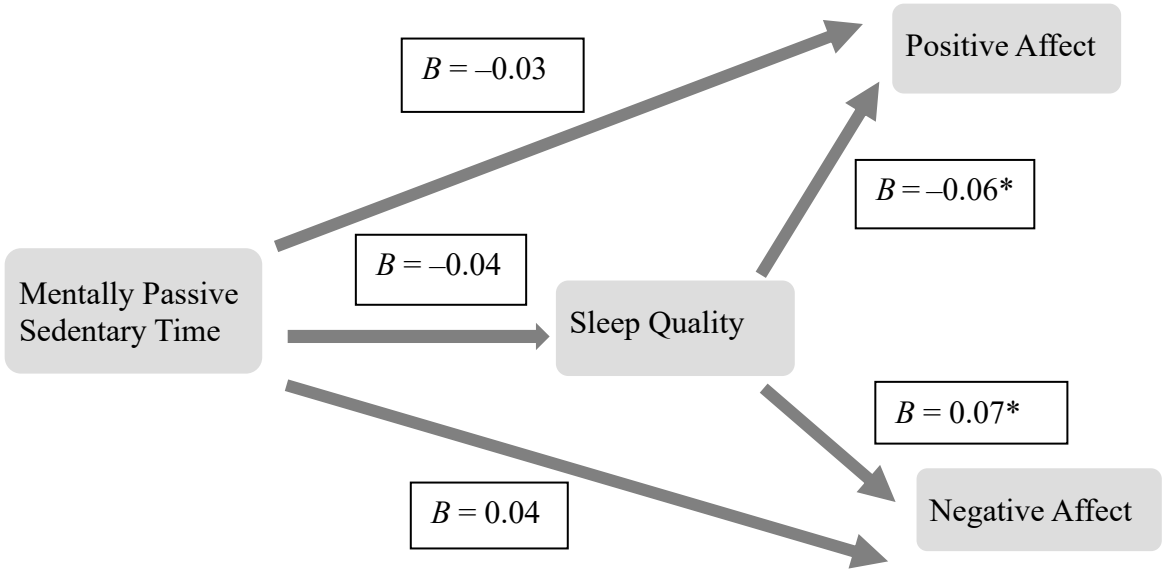


Note. A higher score on sleep quality indicates a poorer sleep quality. A higher score on affect indicates a higher affect.

* p < .05.

Figure 4

Associations Between Mentally Passive Sedentary Time, Sleep Quality, and Mood



Note. A higher score on sleep quality indicates a poorer sleep quality. A higher score on affect indicates a higher affect.

* p < .05.

Discussion

The current study aimed at investigating the research question to what extent mentally active ST, mentally passive ST and positive affect and negative affect are related. The aim was to get more insight into the relationship between ST and mood. To explore a possible explanation for these possible associations, a second research question was included about the extent to which sleep quality mediates the associations between the types of ST and positive and negative affect. To answer the research questions, no evidence was found for an association between mentally active ST, mentally passive ST and positive and negative affect, nor for a mediation of sleep quality. However, sleep quality predicted positive and negative affect, but only to a small extent.

Relationship between Types of Sedentary Time and Positive and Negative Affect

Considering these findings, the hypotheses about the associations between mentally active ST, mentally passive ST and positive and negative affect have to be rejected. In line with the current findings, some other studies also lacked significant associations between ST and mood (Aggio et al., 2017; Carter et al., 2020). However, in contrast to this study, Endrighi et al. (2016) and Giurgiu et al. (2019) found that a higher ST was associated with negative mood.

A possible explanation for finding results that contradict but are also in line with previous studies may be that different conceptualisations and operationalisations of mood were applied. Studies that found a significant association used measurements of mood which defined it by different dimensions than positive and negative affect. For instance, the Profile of Mood States (POMS) assesses psychological distress composed of six dimensions: fatigue- inertia, vigour-activity, tension-anxiety, depression-dejection, anger-hostility, and confusion-bewilderment (Curran et al., 1995). In contrast, the current study and previous studies that did not show a relationship, utilised a mood questionnaire defining mood by positive and negative affect, such as the PANAS. By comparing the dimensions, it becomes apparent that the conceptualisations of mood differ in terms of the energetic arousal. Energetic arousal describes perceptions of energy and vigour (Thayer, 1990). On the higher end, it leads persons to be physically active while on the lower end, it involves sensations of fatigue and inactivity (Thayer, 1990). Energetic arousal covers a few of the dimensions of the POMS, such as fatigue and vigour, but it is only a small part of positive and negative affect. This leads to the assumption that ST may solely be associated with mood when mood is conceptualised by levels of energetic arousal. This is reasonable considering that high energetic arousal leads to physical activity, and this is in contrast to being sedentary. Therefore, this conceptualisation of mood might also

explain the negative relationship between ST and mood in the studies that found a significant association.

Another reason may be the nature of a cross-sectional study design since most of the studies finding a significant effect measured mood daily and after a longer time of being sedentary (Carter et al., 2020). Employing a cross-sectional design could have prevented uncovering the true association between ST and mood because of recall bias and the tendency of mood to fluctuate greatly (Carter et al., 2020). To illustrate, a significant disparity was found in the answers of participants stating their current mood on a daily basis over a week as opposed to recalling their mood of the complete past week once at the end of the survey (Terry et al., 2005). Moreover, it has been shown that the mood state in the moment of completing the mood questionnaire influences the answers, although the items pertain to the mood of the past week (Terry et al., 2005). Consequently, factors or events that influenced the mood at the time of participation might have impacted the affects more than ST did (Carter et al., 2020). In contrast, studies that use daily measurements can assess and take into account the context while completing the questionnaire, such as the time of the day (Trull & Ebner-Priemer, 2009). However, previous Bachelor studies which measured ST and mood on a daily basis could not show significant associations between ST and mood, although the daily measurements reduced effects of recall bias and took into account the fluctuations of mood (Masch, 2021; Skupin, 2022). Though, these Bachelor studies utilised a version of the PANAS similar to this study. This may imply that the conceptualisation and operationalisation of mood might have played a greater role in not finding a significant relationship than the lack of a daily measurement of the constructs, although the variability of mood and recall bias likely also affected this study's results.

Mediation of Sleep Quality between Types of Sedentary Time and Positive and Negative Affect

Apart from that, it was found that sleep quality did not mediate the relationship between mentally active and mentally passive ST and positive and negative affect which is in contrast to the hypotheses. These results contradict previous studies. It has been shown that low sleep quality mediated the association between ST and depression (Jiang et al., 2020) and that sleep problems could account for the relationship between mentally passive ST and major depressive disorder (Hallgren, Vancampfort, et al., 2020). Although sleep quality mediates the relation with depression, and depressive symptoms are marked by decreased positive affect and increased negative affect (Boumparis et al., 2016), sleep quality may not be able to explain the relation between types of ST and affects. A reason for that may be that sleep difficulties are listed as a

criterion, for instance, for diagnosis of a major depressive episode (American Psychiatric Association, 2013, as cited in Tolentino & Schmidt, 2018). Thereby, a mediation of sleep quality between ST and depression may be more likely than between ST and affects.

Next to that, it is worth noting that the studies by Hallgren, Vancampfort, et al. (2020) and Jiang et al. (2020) had a much larger sample size compared to this study, namely more than 30,000 participants. Moreover, the coefficients and odd ratios found in these studies corresponded to rather small effect sizes (Hallgren, Vancampfort, et al., 2020; Jiang et al., 2020). Consequently, it may be possible that this study's sample size was too small to find a mediation of sleep quality when it is compared to the large sample sizes of the previous studies, and as it aimed at medium effect sizes. However, this also raises the question to what the extent this mediation of sleep quality is relevant to investigate and of practical usage (Hill, 1988).

Considering the individual components of the mediation, it becomes apparent that a missing prediction of types of ST on sleep quality might partly cause the non-significant mediation of sleep quality as sleep quality could predict the affects. A plausible reason for finding no relationship between ST and sleep quality is that the current study did not control for physical activity since only studies that accounted for physical activity could find an association between ST and sleep disturbances as shown in the meta-analysis by Yang et al. (2017). Nevertheless, sleep quality could predict positive and negative affect, yet only to a small extent. This may point to the possibility that a mediation of sleep quality between types of ST and mood becomes apparent when physical activity is controlled for, and mood is conceptualised and operationalised in terms of energetic arousal levels.

Limitations and Recommendations for Future Research

This study has strengths and limitations. A considerable strength is that this study filled a research gap through investigating mentally active and mentally passive ST in relation to positive affect and negative affect. While studies either distinguished between mentally active and mentally passive ST or positive and negative affect, no previous study specified both concepts. However, the distinction between mentally active and mentally passive ST is important since there is evidence that different SBs have different effects on mental health concepts (Hallgren, Dunstan, et al., 2020). The differentiation between positive and negative affect is also important since positive affect and negative affect are not necessarily the opposite of each other (Russell & Carroll, 1999) which also can be seen in the correlations found in this study. Furthermore, this study adds value to research because it tested the possible explanation of sleep quality for the association between types of ST and positive and negative affect. Apart from that, the scales for positive affect, negative affect, and sleep quality had an acceptable to

good internal consistency, implying that the results are reliable. The required sample size was also achieved wherefore it would have been possible to detect an association of a moderate effect size and a mediation.

Next to these strengths, this study has several limitations. It is uncertain whether the modified version of the PAST-U is reliable and valid. There are indications that the modified PAST-U is unreliable and thus, this study's results may not be replicable. Self-report measures of ST are generally prone to random error (Clark et al., 2016) and are significantly different to objective measures of ST (Castro et al., 2020). More importantly, about 20% of the original sample was excluded due to an unrealistic high total daily ST. Furthermore, the average ST of 12.9 hours found in this study is noticeably higher than the self-reported ST of 7.3 hours and objectively measured ST of 9.8 hours found in the meta-analysis by Castro et al. (2020). Therefore, there was likely the general tendency of overreporting the total daily ST which also raises doubt about the validity of the modified PAST-U. A plausible reason for this overreporting is that the participants reported the time spent sedentary twice in case they engaged in multiple SBs at the same time which was also acknowledged by Clark et al. (2016). The extension of the PAST-U for the differentiation of the SBs likely raised the tendency of overreporting (Clark et al., 2016).

To mitigate the mentioned limitations of the modified PAST-U, it is advised to reduce the number of items (Clark et al., 2016). In addition, it may be helpful to provide the participant a calendar page of one day on which they can drag and drop the SBs and indicate the duration they were occupied with the SB. Besides, future research is generally required to develop a valid and reliable questionnaire assessing mentally active ST and mentally passive ST.

Apart from that, the cross-sectional research design brings some limitations. No conclusions can be drawn about the temporal relationship and causality and thus, bidirectional relationships are possible and the possibility of confounders cannot be ruled out (Carlson & Morrison, 2009). Due to the risk of confounders, it may be advisable to control for the most prominent factors influencing ST, sleep quality, and mood. For instance, physical activity should be controlled for as it influences the connection between ST and sleep quality (Buman et al., 2015). Moreover, as aforementioned, a limitation of a cross-sectional study is recall bias (Carter et al., 2020). To reduce recall bias and to obtain more reliable data, a better alternative could be to employ experience sampling in future studies (Trull & Ebner-Priemer, 2009).

Another limitation is that this study's results may not be generalisable to and representative of all university students. The sample consisted of more women than men, predominantly Germans and almost the half of the participants studied psychology which likely

is the result of the convenience and snowball sampling. Nevertheless, some representativeness can be assumed since this sample showed a presumably high ST and almost poor sleep quality which corresponds with previous studies' findings with a university or college students' sample (Castro et al., 2020; Dinis & Bragança, 2018). Furthermore, the most predominant SBs in this study, namely studying, engaging in social interactions, and watching television, comply with the findings of Rouse and Biddle (2010).

Despite the required sample size for a moderate effect size was achieved, it is questionable whether expecting moderate effect size was appropriate for the purpose of this study. On the one hand, studies that investigated the relationship between ST and mood found partly only small effect sizes (Endrighi et al., 2016). Furthermore, as aforementioned, mediation analyses with sleep quality or problems revealed rather small effect sizes (Hallgren, Vancampfort, et al., 2020; Jiang et al., 2020). On the other hand, Edwards and Loprinzi (2016) found a large effect size for the relationship between ST and mood. Moreover, expecting a medium effect size and thus, aiming at a smaller sample, compared to the required sample size for expecting a small effect size, is considered to be acceptable when taking into account the scope of this study with its limited resources (Hill, 1988). Nevertheless, it is advisable for future research to expect a small effect size.

Next to the suggestions for improving the study composition and questionnaires, there are further recommendations for future research in terms of content. Due to the ambiguous evidence of the relationship between ST and mood, it is valuable to explore other conceptualisations of mood, such as psychological distress or the dimensions of energetic arousal, tense arousal and hedonic tone (Matthews et al., 1990), as this study suggests that the conceptualisation may play an important role in the association between ST and mood. To show evidence for this assumption, it could be tested in one study whether psychological distress and positive and negative affect are differently associated with ST by comparing the PANAS with the POMS. Since the mediation of sleep quality might have been non-significant due to the conceptualisation of mood, it is reasonable to include sleep quality as a mediator. This is supported by the fact that lower sleep quality predicts a higher fatigue (Bouwmans et al., 2017) which correspond to a lower energetic arousal (Thayer, 1990). Apart from that, this study revealed a small significant negative association between mentally active and mentally passive ST. Thus, research is required to explore which factors determine whether a student is rather sitting mentally active or mentally passive. A possible reason could be perfectionism since perfectionist students study more (Brown et al., 1999), possibly leading to a higher mentally active ST.

Implications

Despite the limitations of the study, some practical implications can be drawn. Although no relationship was shown between the types of ST and positive and negative affect, studies indicate that high ST is harmful for the physical and mental health (Faulkner & Biddle, 2013; Park et al., 2020). Therefore, this sample's presumably high ST which was also reflected in other student samples (Castro et al., 2020) stresses that interventions targeting university students' excessive ST are important. Besides, considering that this study supports the general trend that university students suffer from a lower sleep quality (Dinis & Bragança, 2018) and sleep problems are linked to physical and mental illnesses (Vancampfort et al., 2018), interventions focusing on students' sleep quality may be necessary. In general, the university students' excessive ST and suboptimal sleep quality raise the need for further research about these topics due to their adverse consequences.

Apart from that, positive implications might be drawn from this study's findings. When there is no association between ST and negative affect in students, a causal connection cannot be inferred. Thus, students' high daily ST may not make them more vulnerable to experience high negative affect. This can be considered positive because students cannot avoid a high ST to some extent due to their lifestyle (Moulin & Irwin, 2017). In turn, having a high negative affect may not lead to higher ST. This is beneficial considering that students already experience a lot of psychological distress (Stallman, 2010) and have high ST.

Conclusion

To conclude, the current study provided more insights into the relationship between types of sedentary time and positive and negative affect, although no significant associations or mediation of sleep quality in university students have been found. Reasons for this may be the conceptualisation and operationalisation of mood. Therefore, further research is needed to achieve clarity whether more sedentary time results in a worse mood or whether specific sedentary behaviours may also enhance mood. Apart from that, the current sample corresponds with previous research that students are highly sedentary and sleep rather poorly, raising the need for interventions. This also emphasises that students engage extensively in behaviours harming physical and mental health, stressing the importance of research about university students' risk health behaviours, such as spending a lot of time in sedentary behaviours.

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Appendix A

Informed Consent Form

Thank you very much for your interest in participating in this study on sitting behaviour. Please read the following information carefully.

We, a group of 3rd-year-psychology students, created this study as part of our Bachelor theses under the supervision of Gerko Schaap. We are interested in investigating the relationship between sitting behaviour and mental health concepts, such as anxiety, mood, and stress among university students. Sitting behaviour also includes activities in a reclining position or lying down. Examples of sitting behaviours are watching television, reading, driving, or studying while sitting.

The study will take approximately 30 minutes. You are asked to answer several questionnaires which will help us to analyse the relationship between sedentary behaviour and concepts of mental health. As a potential risk and/ or benefit, it may be that you become aware of, for instance, your stress, positive or negative mood, and how much you sit.

By taking part in this study, no personally identifiable information will be gathered, and your privacy will be ensured at any times. The results that we gather will be stored safely and are only available to the researchers and the supervisor. After we completed our theses, the data will be deleted. Your answers to the questionnaire stay completely anonymous. Participation is fully voluntary in this study. In case you participate, you can withdraw at any time without a reason or negative consequences. In case you have any questions or concerns about this study, feel free to contact the researchers.

Through clicking on that you give consent to this study, you confirm that you are at least 18 years old, enrolled at a research university or university of applied science and have sufficient use of English to answer the questionnaires. Additionally, by giving consent you indicate that you understood everything, and voluntarily agree to take part in this study.

Yes, I consent
No, I do not consent

Appendix B

Demographic Questions

1. What is your gender?

    a. Female

    b. Male

    c. Non.binary/ third gender

2. Please indicate your age below:

    a. 18 – 25 years
    b. 26 – 30 years
    c. 31 – 30 years
    d. 41 – 50 years
    e. 51 years or older

3. What is your nationality?

    a. German

    b. Dutch

    c. Other

4. What is your study program?

Appendix C
Attention Questions

1. To check whether you answer the questions attentively, please click “4”.
   1
   2
   3
   4
   5
2. To check whether you answer the questions attentively, please click “yes”.
   Yes
   No

Appendix D

Modified Version of the Past-day Adult's Sedentary Time – University (PAST-U) questionnaire

We are going to ask you about particular activities you did yesterday while sitting down or lying down. Please note that this does not include sleeping, either in bed or if you fell asleep while doing another activity, for example watching television.

We are going to ask you about different times when you may be sitting or lying down: when studying, working, travelling, watching TV, using the computer, and doing other activities. For each of these, **only count the time this was your main activity.** For example, if you watched TV and ate dinner at the same time, this might be TV or meal time, but not both. Your answers can be given in hours and minutes. Try to report only the time you spent sitting or lying down and do not take into account the time you spent getting up for breaks (e.g. coffee, bathroom).

Sitting for study

ST 1. **How long** were you **sitting** while studying yesterday? (include the time at university, during lectures, tutorials, meetings, group discussions, self-study, study from home, etc.)

		hours			minutes

Sitting for work

ST 2. **How long** were you **sitting** at your workplace or working from home in a paid position yesterday? (Examples: babysitting, sitting at the reception, minding a stall/ shop, data entry/ administrative paper work, tutoring, etc.)

		hours			minutes

Sitting for Transport

ST 3A:

Thinking again of yesterday, please estimate the **total** time that you spent **sitting** to travel from one place to another **only as a passenger**. Please **include sitting and waiting** for transport. Do **not** include any time you were standing up while travelling or waiting.

		hours			minutes

ST 3B:

Thinking again of yesterday, please estimate the **total** time that you spent sitting to travel from one place to another while you were the driver?" This does **not** include physically active driving, such as bicycling.".

		hours			minutes

Television Viewing

ST 4. Please estimate the total time you spent sitting or lying down to watch TV or DVDs or watch videos-on-demand, YouTube etc. on your computer/tablet/phone or other electronic devices yesterday? This includes if you watch TV in bed.

		hours			minutes

Computer, Internet, Electronic Games

ST 5a. Please estimate the **total** time yesterday that you spent sitting or lying down and playing computer or video games using the computer or any other electronic devices (e.g. Xbox, Playstation, etc.).

		hours			minutes

ST 5b. Please estimate the **total** time yesterday that you spent sitting or lying down and scrolling through social media (e.g. Instagram, Facebook, Twitter, TikTok, etc.).

		hours			minutes

ST 5c. Please estimate the **total** time yesterday that you spent sitting or lying down while engaging with other people directly via screens (e.g. by using WhatsApp, Facebook messenger, or other messenger apps).

		hours			minutes

ST 5d. Please estimate the **total** time yesterday that you spent sitting or lying down while reading **during your leisure time** on a smartphone, tablet or any other electronic device (e.g. reading on a kindle). Include screen-based reading in bed but do not include time spent reading for paid work or for study.

		hours			minutes

ST 5e. Please estimate the **total** time yesterday that you spent sitting or lying down and using screens that were **not** described above and that were **not** for studying or working purposes (e.g. online shopping, etc.).

		hours			minutes

Sitting for reading

ST 6. Please estimate the **total** time yesterday that you spent sitting or lying down while reading paper-based books **during your leisure time**. Include reading in bed but do not include time spent reading for paid work or for study.

		hours			minutes

Sitting for eating

S7. Please estimate the total time yesterday that you spent sitting down for eating and drinking, including meals and snack breaks.

		hours			minutes

Sitting for socializing

ST8Please 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). Include time on the telephone.

		hours			minutes

Sitting/lying for other purposes

ST 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 **NOT** including time that you have told us about in the previous answers.

		hours			minutes

Appendix E

Positive And Negative Affect Schedule (PANAS) Past Few Weeks Instruction

This scale consists of a number of words that describe feelings and emotions. Read each item and then select the answer that best matches your experience in the space next to that word. **Please indicate to what extent you have felt this way the past few weeks.** Use the following scale to record your answers**.**

	1-Very slightly or not at all	2-A little	3-moderately	4-quite a bit	5-extremely
Interested					
Distressed					
Excited					
Upset					
Strong					
Guilty					
Scared					
Hostile					
Enthusiastic					
Proud					
Irritable					
Alert					
Ashamed					
Inspired					
Nervous					
Determined					
Attentive					
Jittery					
Active					
Afraid					

Appendix F

Brief version of the Pittsburgh' Sleep Quality Index (B-PSQI)

The following questions relate to your usual sleep habits during the past month *only*. Your answers should indicate the most accurate reply for the *majority* of days and nights in the past month. Please answer all questions.

1. During the past month, when have you usually gone to bed at night?
2. During the past month, when you have usually gotten up in the morning?
3. During the past month, how long (in minutes) has it usually taken you to fall asleep each night?
4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spend in bed.)

5. During the past month, have you had trouble sleeping because you wake up in the middle of the night or early morning?

    a. Not during the past month
    b. Less than once a week
    c. Once or twice a week
    d. Three or more times a week

6. During the past month, how would you rate your sleep quality overall?

    a. Very good
    b. Fairly good
    c. Fairly bad
    d. Very bad

Appendix G

Q-Q Plots for the Assumption of Normality

Figure G1

Q-Q plot for Mentally Passive Sedentary Time

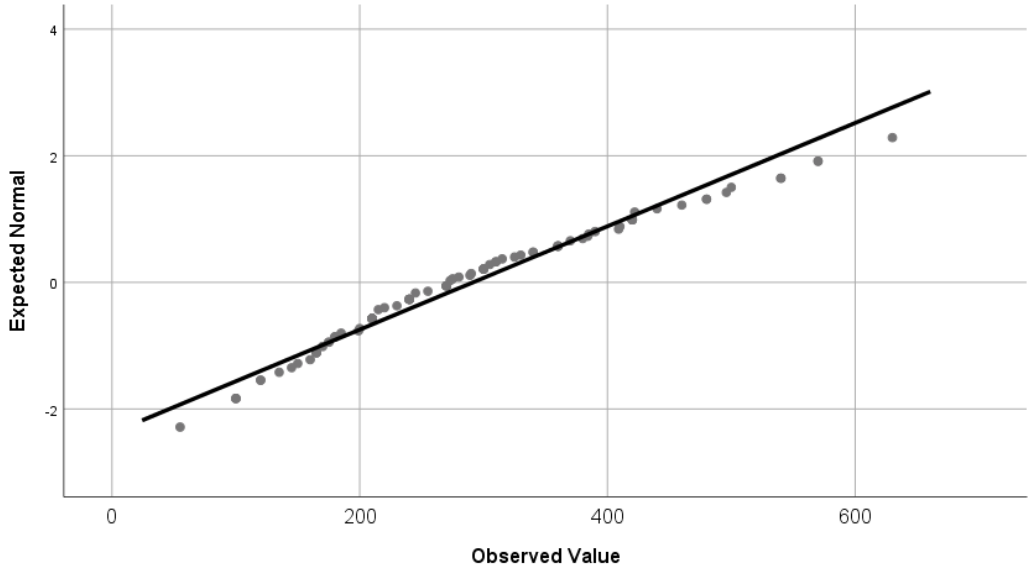


Figure G2

Q-Q Plot for Negative Affect

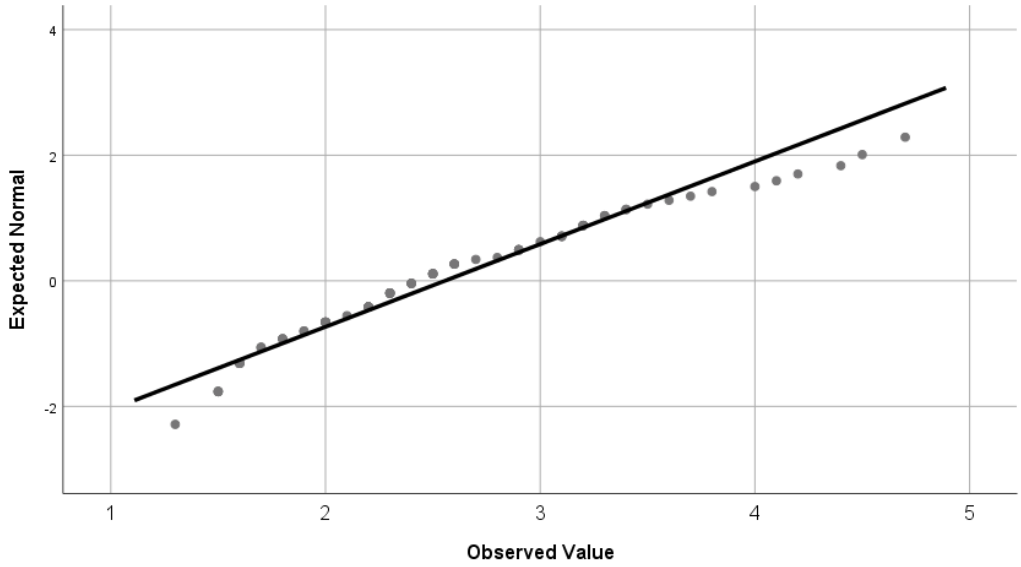
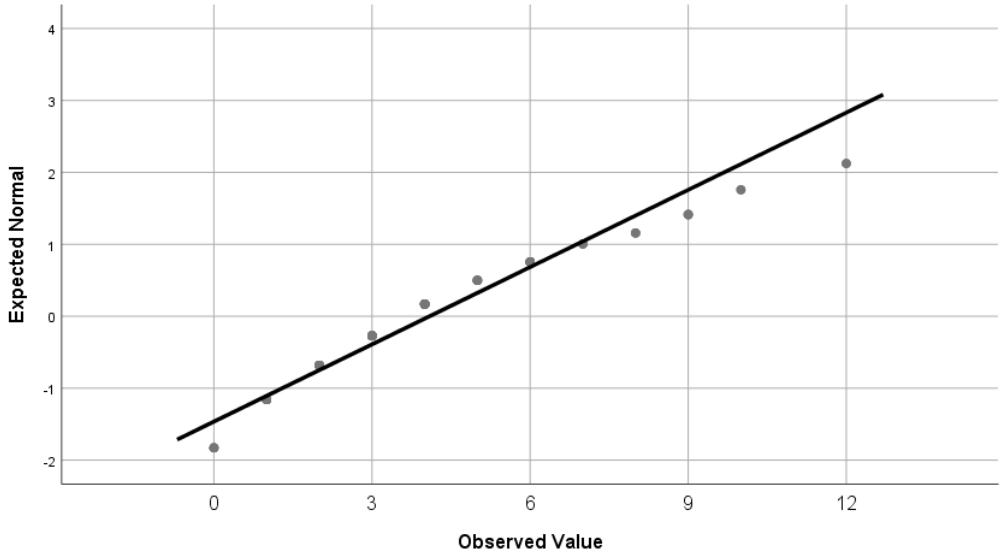


Figure G3

Q-Q Plot for Brief Version of the Pittsburgh' Sleep Quality Index



Appendix H

Assumption of Linearity

Figure H1

Assumption of Linearity Check for Positive Affect and Mentally Active Sedentary Time

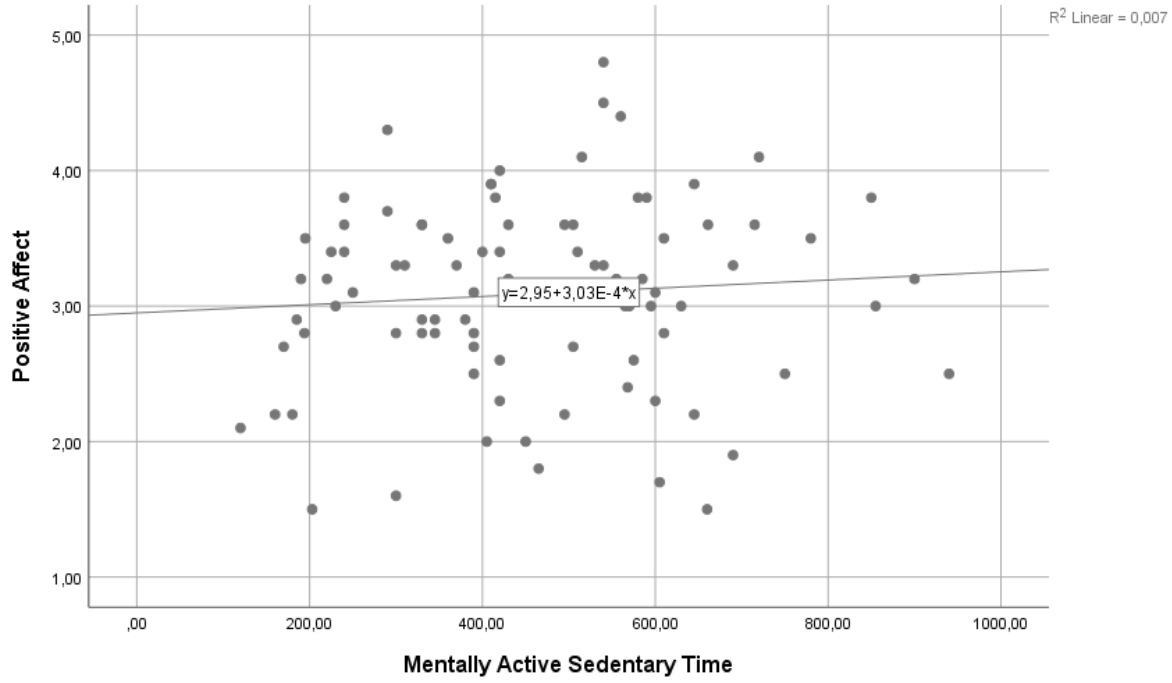


Figure H2

Assumption of Linearity Check for Negative Affect and Mentally Active Sedentary Time

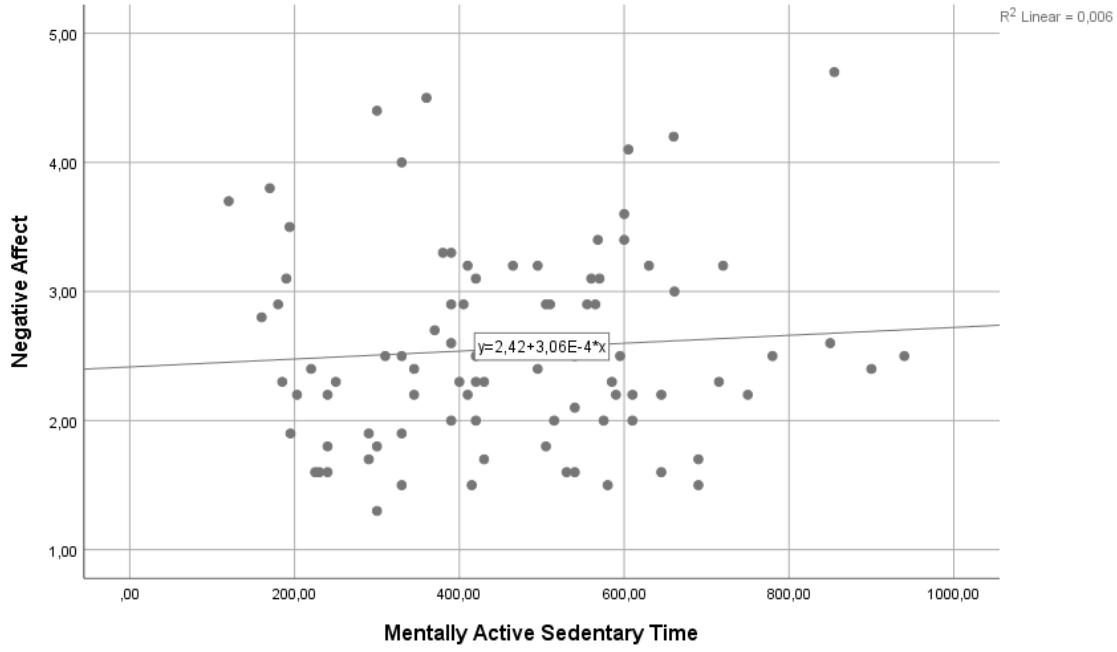


Figure H3

Assumption of Linearity Check for Positive Affect and Mentally Passive Sedentary Time

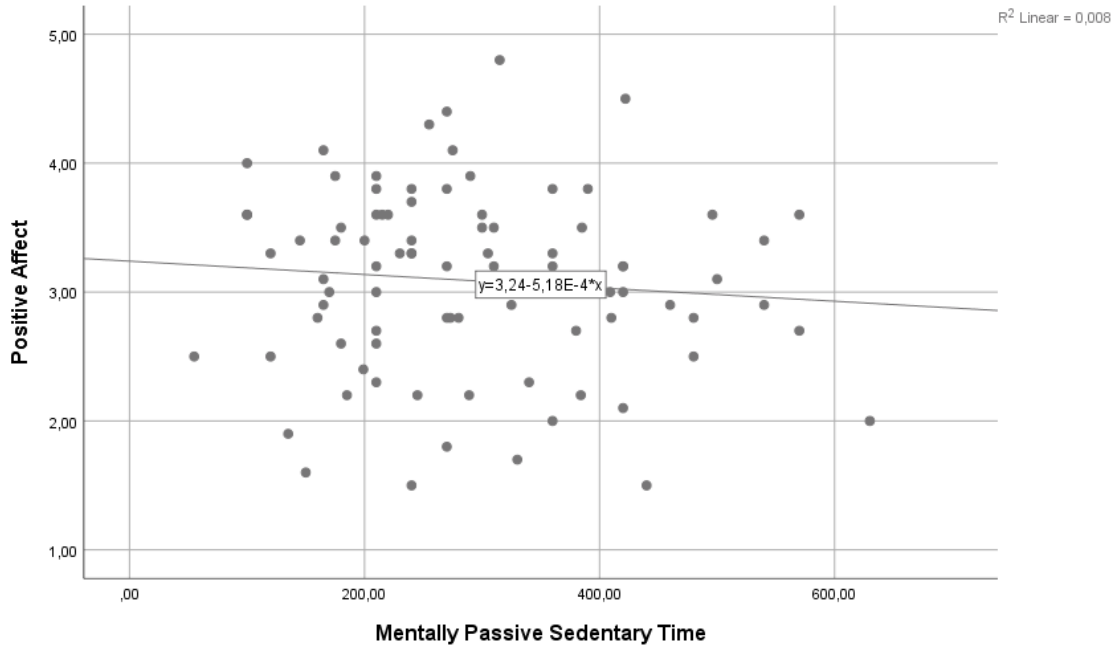
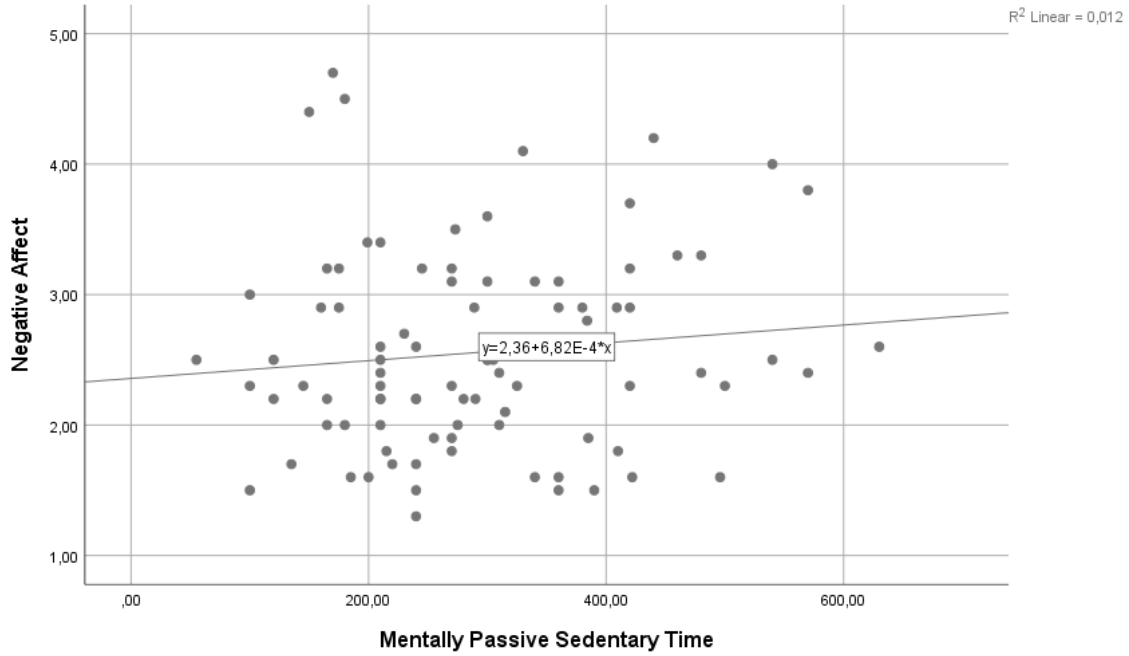


Figure H4

Assumption of Linearity Check for Negative Affect and Mentally Passive Sedentary Time



Appendix I

Assumption of Independence

Figure I1

Assumption of Independence Check for Positive Affect and Mentally Active Sedentary Time

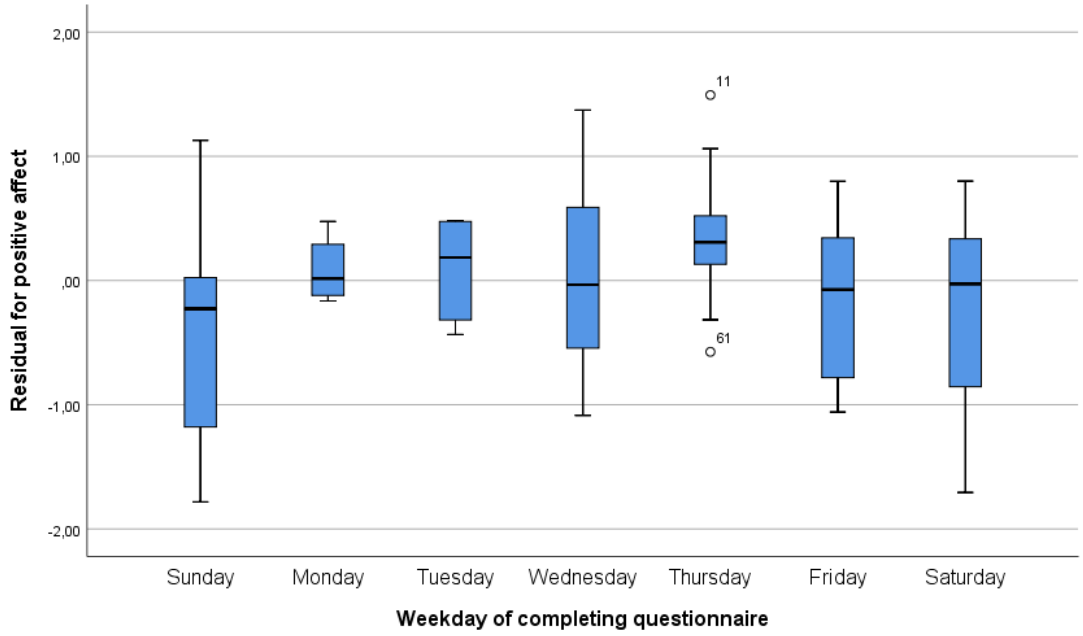
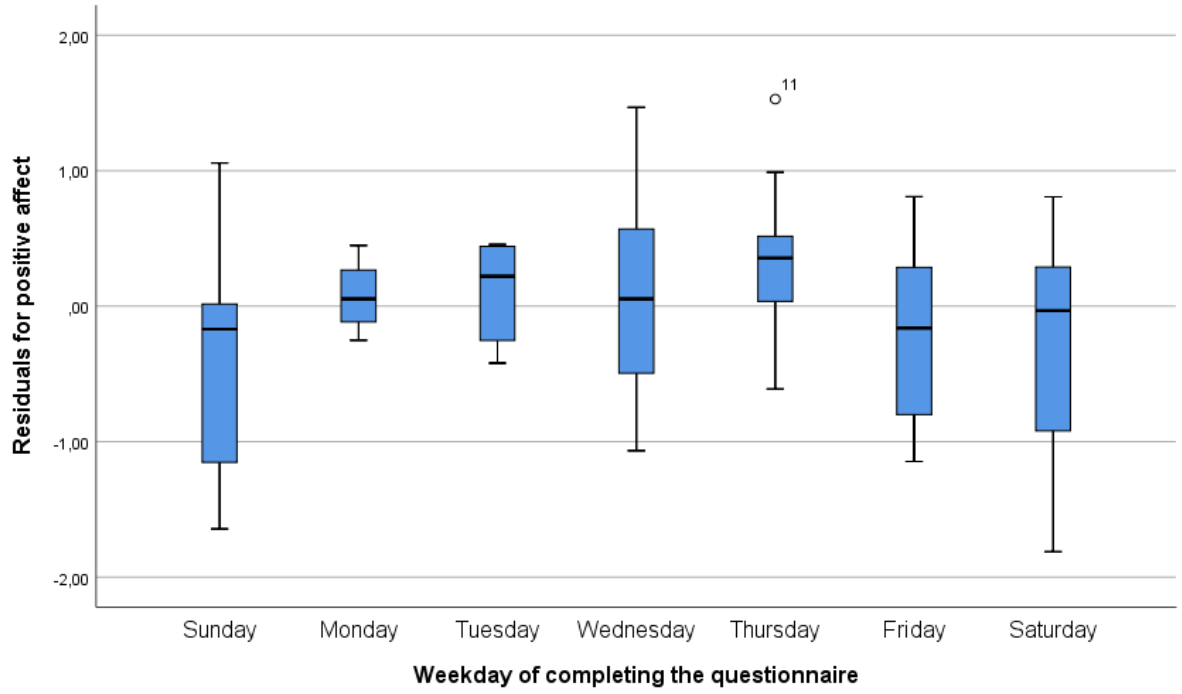


Figure I2

Assumption of Independence Check for Positive Affect and Mentally Passive Sedentary Time



Appendix J

Distribution of Mentally Active and Mentally Passive Sedentary Time

Figure J1

Distribution of the Mentally Active and Mentally Passive Sedentary Time