27.06.2022

Exploring the relationship between mentally active and passive sedentary time and stress in a student population: introducing neuroticism as a moderator.
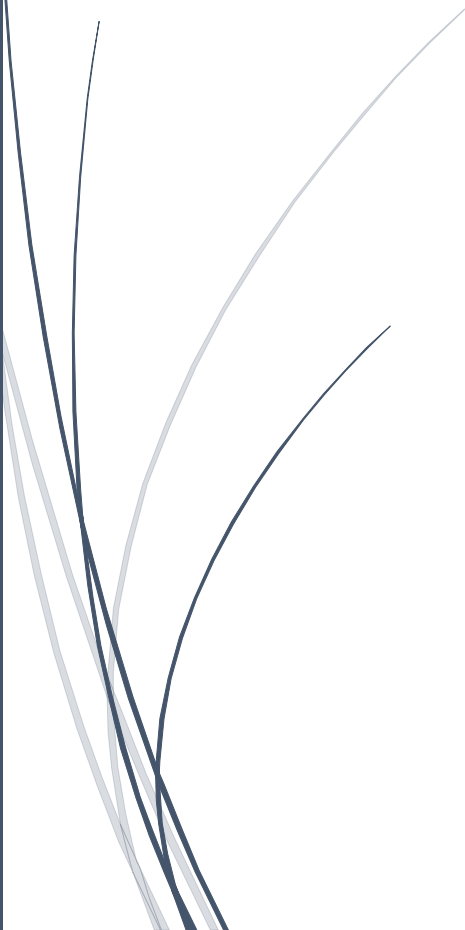
Bachelor Thesis

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Abstract

Sedentary time is a significant factor in physical and mental health. The connection between sedentary time and stress is not clear in existing literature. In this paper the relationship between mentally active or passive sedentary time and stress is investigated with the addition of neuroticism as a moderator in a student population. To do this, 3 questionnaires have been administered to participants: a modification of the PAST-U to measure sedentary time, the PSS-10 to measure stress and the neuroticism scale of the BFI-44. The sample consists of 100 participants (66% female, 34% male; 78% aged 18-25). The data was analysed using Pearson correlation and moderation analyses. This study was not able to find any significant relationship between sedentary time and stress in a student population, nor a moderation effect of neuroticism. However, some valuable insights are still generated based by administering the PSS-10 to the target population. Students report a higher level of stress on the PSS-10 compared to the general population as well as a significantly higher sedentary time than the general Dutch population. Further research is required specifically in the domain of division of sedentary time into mentally active and mentally passive sedentary time. Additionally, investigating stress and alternate relationships with stress in a student population is advised to explain the elevated stress levels.

Keywords: Sedentary Time, Stress, Neuroticism, Moderation

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Introduction

Whether it be leisure activities like sitting with family and having a chat, reading a book, watching TV, or working an office job, they all share a common characteristic: They are most often done while sitting or lying down. This type of behaviour is known as sedentary behaviour and in this paper the relationship between sedentary behaviour, stress and neuroticism will be explored within a university student population. Sedentary behaviours have been associated with poorer mental and physical health and a student population seems particularly vulnerable to engage in a high sedentary time.

What is sedentary behaviour?

As with any concept, definitions and terminologies are often argued about. Sedentary behaviour is no exception and can have varying definitions. Those definitions range from very simple and vague definitions as ""non-upright" activities" (Chastin & Granat, 2010, p. 83) to very elaborate definitions that resort to an objective physiological measurement like the definition of Pate et. al. (2008): "Sedentary behavior refers to activities that do not increase energy expenditure substantially above the resting level and includes activities such as sleeping, sitting, lying down, and watching television, and other forms of screen-based entertainment. Operationally, sedentary behavior includes activities that involve energy expenditure at the level of 1.0-1.5 metabolic equivalent units (METs)." (Pate, O'Neill, & Lobelo, 2008, p. 174). These are just some examples of the definitions that have been used by researchers. In 2012 however, the Sedentary Behaviour Research Network (SBRN) published a paper in which they proposed to define sedentary behaviour "any waking behaviour characterized by an energy expenditure ≤1.5 METs while in a sitting or reclining posture." (SBRN, 2012, p. 540). This was in direct contrast to some definitions employed by researchers so far, for example to Chastin & Granat (2010), by having a physiological measurement instrument rather than just describing the activity. It also differed significantly from the definition proposed by Pate and his colleagues as it specifically excludes sleep. The definition proposed by the SBRN seems to generally have been adopted by the majority of the researchers (Tremblay, et al., 2017), and therefore for the purposes of this study, the definition proposed by the SBRN will be used moving forward. With this definition, sedentary behaviours are activities like (all while seated or laying down): watching TV, using the computer, driving a car, playing board games, eating, etc.

Inactivity, Sedentary Behaviour and Sedentary Lifestyle

Sedentary behaviours are not the same as being physically inactive. According to the SBRN in the same publication as they proposed a uniform definition for sedentary behaviour, they also proposed to use the term "inactive" for individuals who do not perform enough moderate to

vigorous physical activity (MVPA) according to national guidelines (SBRN, 2012). This generally means that too much time spent on sedentary behaviours (e.g., sitting) is not the same issue as too little time spent exercising (Owen, Bauman, & Brown, 2008; Owen, Healy, Matthews, & Dustan, 2010). A student who sits for eight hours a day and engages in exercise according to the national guidelines may still experience similar consequences of sedentary behaviour as a student who sits for eight hours a day and does not engage in any exercise. The benefit of the healthy exercise behaviour does not necessarily counteract the detrimental effect of sedentary time (Panahi & Tremblay, 2018). This implies that the consequences of being inactive are differing from the consequences of a high sedentary time. In this study, it will be focused on the sedentary time, not the lack of exercise by national guidelines.

Why is Sedentary Behaviour a problem?

The evidence for the effect of excessive sedentary behaviours on the health of an individual is overwhelming. It is generally well-known in the field that sedentary time (i.e., time spent on sedentary behaviours) is associated an increase in all-cause mortality (Loprinzi, Loenneke, Ahmed, & Blaha, 2016; Schmid, Ricci, & Leitzmann, 2015). A strong link between sedentary behaviour and BMI (Body Mass Index) has been established in numerous studies (Mortensen, Siegler, Barefoot, Grønbæk, & Sørensen, 2006; de Renzede, Rodrigues Lopes, Rey-López, Matsudo, & Luiz, 2014), however the causality between the two variables is still debated and researched upon, nonetheless, the connection between the two makes sedentary behaviour part of the problem. Furthermore, studies on sedentary behaviour show strong evidence to be connected to cardiovascular disease and type 2 diabetes (Grøntved & Hu, 2011; Wilmot, et al., 2012). This shows that there are clear detrimental health implications connected to sedentary behaviour.

Sedentary time is also starting to get associated with mental health problems, though that connection is less clear and more complex. A review indicated that some general mental health consequences are shown with a positive association with sedentary time, like perceived stress and self-reported mental health, however this review only used sedentary time spent as screentime (Hoare, Milton, Foster, & Allender, 2016). Another review indicates moderate evidence for an association between anxiety risk and sedentary behaviour (Teychenne, Costigan, & Parker, 2015). Hallgren et. al. (2020) recently proposed a framework under which they investigated major depressive disorder (MDD) (Figure 1). This framework divides sedentary behaviour further into mentally active and passive activities, where mentally active behaviours are for example playing computer games (while sitting or lying) and passive behaviours are for example watching television (Hallgren, Dunstan, & Owen 2020). They found

in their study, alongside other studies, that mentally active sedentary behaviours have a potentially protective function against MDD symptoms while passive sedentary behaviours have a detrimental effect on MDD symptoms (Hallgren, Dunstan, & Owen, 2020; Hallgren, et al., 2019; Hallgren, et al., 2018). This clearly has indications that not all sedentary behaviours are equal, and it may matter greatly how this sedentary time is spent. For this reason, mentally active and mentally passive sedentary time will be investigated separately from each other for the majority of this study.

Figure 1. Division of Mentally Active and Mentally Passive Sedentary Behaviours From Hallgren et. al. (2020).
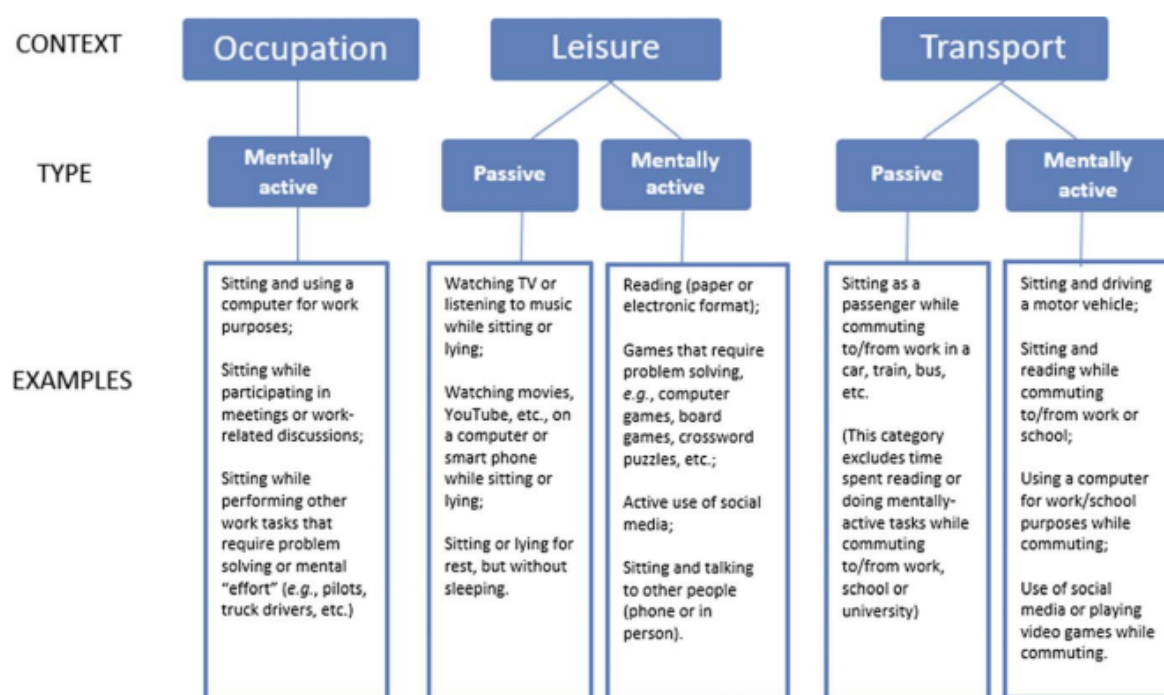
Stress

Stress is a broad concept with different nuances and facets to it. The most relevant form of stress in the context of sedentary time seems to be *perceived psychological stress* as it mostly describes a general tendency rather than a reaction to a specific event (Cohen, Kamarck, & Mermelstein, 1983). *Perceived psychological stress* is characterised by unpredictability of the individual's life, it being overwhelming and out of control (Cohen, Kamarck, & Mermelstein, 1983; Kuiper, Olinger, & Lyons, 1986). Moving forward, this definition of perceived psychological stress will be adopted and mentionings of stress will refer to perceived psychological stress.

Stress is significant risk for the health of adults. During the COVID-19 pandemic, the prevalance of stress is reported to be 29,6%. That means that close to 1 in 3 individuals were stressed. This stress comes with a wide range of problems as it has been associated with decreased physical health. Physical health in this case is endangered by an increased risk of diseases such as cardiovascular disease, cancer, bowel disease and it can additionally cause immune system impairments (Cohen, Janicki-Deverts, & Miller, 2007; Morrison & Bennett, 2016). It also is inversely correlated with health behaviours which in turn have a positive effect on physical health again (Homan & Sirois, 2017). Health behaviours are, for example, regular exercise, a healthy diet and other behaviours aimed to maintain or promote one's health.

Adding onto the somatic health consequences, there is a number of mental health consequences as well. A study investigating medical students in Brazil has shown that 37.2% of the students showed symptoms of anxiety, 34,6% showed depressive symptomatology and 47.1% reported stress symptoms (Moutinho, et al., 2017). It has been shown that stress is associated with depression especially in a student population (Sawatzky, et al., 2012). However, the study of Moutinho et. al. suggests that students experience significantly more stress than the general population. Instead of 1 in 3 individuals that experience stress, 1 in 2 students experience stress.

Sedentary Behaviour and Stress

Another example of a health behaviour is reducing the sedentary time spent. Sedentary behaviour and stress are shown to be positively linked, however not all studies are consistent with their findings. With increasing sedentary time the stress experienced increases as well (Dėdelė, Miškinytė, Andrušaitytė, & Bartkutė, 2019). Another study found that sedentary time is also associated with stress and suicidal thoughts (An, Jang, & Kim, 2015). However, a recent review indicated that the connection between sdentary time and stress are inconsistent or non-existant (Teychenne, et al., 2019). The discrepancies found across studies may be explained by varying target groups and other factors that influence stress, such as neuroticism.

Neuroticism

Neuroticism is part of 'The Big Five' personality traits alongside openness, extraversion, agreeableness, and conscientiousness. There does not seem to be a uniform definition on neuroticism, however, the concepts it entails are very similar across all literature. Roccas et. al. define neuroticism in the context of The Big Five as the tendency "to be anxious, depressed, angry, and insecure." (Roccas, Sagiv, Schwartz, & Knafo, 2002, p. 793) and they later add that individuals low on neuroticism are emotionally stable. Others see it as a tendency to respond

negatively to various kinds of stresses, inefficiently coping with stress, impulsivity and to perceive stress more quickly (Barlow, Ellard, Sauer-Zavala, Bullis, & Carl, 2014; John, Robins, & Pervin, 2008). In either case, it is reasonable to state that stress and neuroticism are linked to one another, whereas higher neuroticism can lead to higher experienced stress. Moving forward, the definition of Roccas et. al. will be used with the addition of Barlow et. al. of susceptibility to stress. Furthermore, neuroticism has been linked to sedentary time already. A systematic review showed that higher sedentary time is associated with higher levels in neuroticism and lower levels in conscientiousness (Allen, Walter, & McDermott, 2017). Therefore, neuroticism is linked with both sedentary time and stress.

This study

As the literature is inconclusive and contradictory , this study investigated the relationship between sedentary time and stress. However, as Hallgren and colleagues (2020) proposed, it may matter how the sedentary time is spent in the effect it has on individuals. Therefore, the relationship between sedentary time and stress is also investigated under the light of mentally active and mentally passive sedentary time as they classified those behaviours (Figure 1). The resulting research question is as follows:

Research question 1: "To what extent is sedentary time correlated with perceived psychological stress in university students?"

➔ Hypothesis 1a: Total Sedentary Time is positively correlated with perceived psychological stress in students.

➔ Hypothesis 1b: Mentally Active Sedentary Time is negatively correlated with perceived psychological stress in students.

➔ Hypothesis 1c: Mentally Passive Sedentary Time is positively correlated with perceived psychological stress in students.

Hypothesis 1a was formulated with a positive correlation as previous studies have found a positive correlation. No study has been found that shows perceived stress decreasing with higher sedentary time. Hypothesis 1b and 1c result from the implications of Hallgren et. al. (2020). It is possible that mentally active sedentary time does decrease stress as there is mental engagement with a task in the process, while mentally passive sedentary time increases stress due to lack of engagement with any task.

As a second investigation, this paper tests for neuroticism as a moderator in the relationship between mentally active or mentally passive sedentary time as neuroticism increases the

suseptibility and intensity of the experienced stress of individuals. The second research question is formulated as follows:

Research question 2: "To what extent does neuroticism moderate the relationship between mentally active sedentary behaviour and perceived psychological stress, and passive sedentary behaviour and perceived psychological stress in a university student population?"

➔ Hypothesis 2a: Neuroticism is a moderator for the relationship between Mentally Active Sedentary Time and perceived psychological stress in students.

➔ Hypothesis 2b: Neuroticism is a moderator for the relationship between Mentally Passive Sedentary Time and perceived psychological stress in students.

Hypothesis 2a is follow-up on the hypothesis 1b. If mentally active sedentary time is negatively correlated with stress, then the stress experienced by an individual is lower. With less stress involved, neuroticism plays a smaller role in the link. Hypothesis 2b is the opposite of that. As it is hypothesised that mentally passive sedentary time is positively correlated with stress and stress is shown to be linked with neuroticism, it appears plasuible that neuroticism plays a strong moderation role in the relationship.

Methods

Design

The research questions and the hypotheses were investigated using a cross-sectional quantitative study design. This study is part of a joint data collection of five undergraduate students under supervision. All the papers based on the collective study are interested in sedentary behaviours with their own respective variables to investigate, which in this paper are "neuroticism" and "stress". The ethical approval for this study was given by the BMS ethical committee on the Domain Humanities & Social Sciences of the University of Twente with the request number 220299.

Participants

The study's inclusion criteria were: being 18 years or older, being proficient in English, and being a full time student at either an university of applied sciences or university. Convenicence sampling was used in this study. The link of the study was distributed to peer students as well as put on the SONA-system of the University of Twente. The participants were compensated by 0.25 Credits on the SONA-system. Furthermore, the study was also shared to peers outside of the University of Twente. They were otherwise not compensated. The study was conducted

in April 2022. The GPower calculations show that for the correlation analysis a sample size of 84 is required, while the moderation analysis needs a total sample size of 77.

Materials

There were three instruments used in this study, one to assess each variable (Sedentary time, Neuroticism, Stress). On top of that there were some demographic questions asked at the start of the study. All the questionnaires and items used in the study can be found in Appendix A.

Demographics

There were four questions about the demographics of the participants of the study. First, it was asked about the gender of the participant. Second, the age was assessed in different categories (e.g., 18-25 years). Third, it was asked about the nationality (Dutch or German, Other). Lastly the participant's study programme was asked for.

Sedentary time

The sedentary time was assessed with a modified PAST-U questionnaire. This questionnaire was modified to differentiate between mentally active and mentally passive sedentary time. The PAST-U questionnaire requires the participant to answer by giving the hours and minutes they spent on the specified behaviour. For example, one question that was part of the used instrument was: "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.).". The modified questionnaire contains 14 questions on various sedentary behaviours such as leisure activities, transport, and occupation, which fits the chosen framework of Hallgren et. al (2020) (Figure 1). Eight questions fall under the category of mentally active sedentary behaviour and four questions under mentally passive sedentary behaviour. The remaining two neither clearly defined as mentally active nor as mentally passive and are excluded in their respective analyses. The reliability and validity of the unmodified PAST-U questionnaire has been tested on a university population and was deemed acceptable (Clark, Pavey, Lim, Gomersall, & Brown, 2016).

Neuroticism

To assess the neuroticism of a participant, the "Big Five Inventory" was used, only including the questions that are relevant for the neuroticism dimension. In the questionnaire, the participant was asked to rate how much they agree to a statement followed up on "I see myself as someone who…" on a 5-point Likert scale from. An example statement would be: "I see myself as someone who is relaxed, handles stress well.". Neuroticism is a personality trait that is a stable construct over time and the Big Five Inventory was chosen as it is a well-

established tool in personality testing. The Big Five Inventory has good psychometric properties (John, Donahue, & Kentle, 1991).

Stress

To assess the stress of a participant, the 10 item "Perceived Stress Scale" was used. The PSS-10 has acceptable reliability and validity and scores, slightly better than the PSS-14 and PSS-4 (Eun-Hyun Lee, 2012). The PSS-10 consists of 10 questions about the thoughts and feelings that the participant felt over the last month. The answer scale ranges from 0 = "never" to 4 = "very often". An example item of the questionnaire is "In the last month, how often have you felt that you were unable to control the important things in your life?". This questionnaire was chosen as it measures the construct that was defined as stress for this paper and reflects the general stress level rather than acute stress in relation to a specific event.

Procedure

One the participants decided they want to participate in the study, they get directed to the Qualtrics questionnaire. The first page they got shown, was the information about the study and the researchers involved in the study including contact information. The second page contained the informed consent which the participants had to agree to participate in the study. Afterwards, the study started and the order of the questionnaires for each variable was as follows: Demographics, Sedentary Time, Stress, Neuroticism, Extraversion, Social Anxiety, Creativity, Mood and Sleep Quality. At the end of the study, there was a text box where a participant could write any thoughts, feelings or feedback they had if any. Aside from that there was a message of appreciation for having participated in the study and the study was over for the participant at that point.

Data analysis

To analyse the collected data, SPSS version 27 was used. To prepare the data set for the analysis a couple of exclusion criteria were applied. First, the sum of the total daily sedentary time had to be below 24 hours to be included and second, the questionnaires of neuroticism and stress were not allowed to have any missing values. Total, mentally active, and mentally passive sedentary times were computed in minutes and hours by adding up the relevant item scores. Second, the raw score for the PSS-10, by inverting the reverse item scores and then summing them up. Third, the score for neuroticism of the BFI was computed in the same way as the PSS-10 raw score. These five variables (neuroticism, stress, sedentary time, mentally active sedentary time, mentally passive sedentary time) were then subject of a normality test of both the Kolmogorov-Smirnov test and the Shapiro-Wilk test. Furthermore, the PSS-10 and the BFI

neuroticism scale are tested for their internal reliability with Cronbach's alpha. After that, the descriptive analysis was conducted for the variables which included their means, standard deviation, minimum, maximum as well as the total number of cases included in the analysis.

For Hypothesis 1a ("Total Sedentary Time is positively correlated with perceived stress in students."), 1b ("Mentally Active Sedentary Time is negatively correlated with perceived stress in students."), and 1c ("Mentally Passive Sedentary Time is positively correlated with perceived stress in students.") a bivariate Pearson correlation test was used to test the correlation between the two variables. The five assumptions are all met for the Pearson correlation, except for the second assumption, linear relationship. The scatterplots show no clear pattern of a linear relationship between the variables, however a Pearson correlation will still be conducted. In total three separate correlation tests will be performed. Using the computed scores of the PSS-10 in each and total sedentary time, total mentally active sedentary time and total mentally passive sedentary time as the counterpart to the correlation test.

For Hypothesis 2a ("Neuroticism is a weak moderator for the relationship between Mentally Active Sedentary Time and perceived stress in students.") and Hypothesis 2b ("Neuroticism is a strong moderator for the relationship between Mentally Passive Sedentary Time and perceived stress in students.") two separate, simple moderation analyses have been performed using the PROCESS macro version 4.1 for SPSS created by Hayes (Hayes, 2012). The variables created at the start were utilised in this moderation analysis, i.e., mentally passive sedentary time and mentally active sedentary time as an independent variable each, neuroticism as the moderator in both cases and stress as the dependent variable in both cases. No variable was controlled for. The significance threshold required to accept the hypotheses is $p < .05$.

Results

142 responses were recorded, one of which declined the informed consent. After the exclusion criteria specified above, 100 participants remained subject to this study meaning that 42 participants had been excluded. Table 1 shows an overview of all demographic data. The majority of the participants is female (66%) and most of the participants are German (73%). The most represented age range in this study is 18-25 years (79%).

Table 1

Frequency table of the demographics of all analysed participants (N=100).

Characteristic		Frequency	Percentage
Gender	**Male**	34	34%
	Female	66	66%
Age	**18-25 years**	79	79%
	26-30 years	19	19%
	31-40 years	2	2%
Nationality	**German**	73	73%
	Dutch	12	12%
	Other	15	15%

Note. Other reported nationalities were: Israeli, Bulgarian, Vietnamese, Ukrainian, Polish, Lithuanian, British, Iranian, French, Croatian, United States, Belgian, Swedish.

Descriptive Results

Table 2

Descriptive statistics of the variables used in the analyses, Total Sedentary Time, Mentally Active Sedentary Time, Mentally Passive Sedentary Time, Stress Score and Neuroticism Score (N=100).

	M	*SD*	*Minimum*	*Maximum*
Total Sedentary Time (in minutes)	815.5	248.6	0.0	1400.0
Mentally Active Sedentary Time (in minutes)	496.5	223.2	0.0	1130.0
Mentally Passive Sedentary Time (in minutes)	292.8	129.9	0.0	630.0
Stress Score	20.0	6.8	4.00	35.0
Neuroticism Score	25.4	5.8	12.0	39.0

Table 2 shows all five computed variables, their means, standard deviation, minimum and maximum. The mean of the total sedentary time is 815 minutes which is equivalent to roughly 13.5 hours. The mean of mentally active sedentary time is 496 minutes, which is equivalent to a little more than 8 hours. The mean for mentally passive sedentary time is 292 minutes, which is equivalent to just short of 5 hours. This data also shows that this student population has in more mentally active sedentary time than mentally passive sedentary time. The mean of the PSS-10 stress score is 20 in a range of 0-40. The included norm group of the PSS-10 in the age range of 18-29 has a mean of 14.2 and therefore our population is scoring roughly 40% higher on the PSS-10 (Cohen, Kamarck, & Mermelstein, 1983). There is no clear norm group for the neuroticism score of the BFI-44, however its mean in this study is at 25.4 in a range of 8 to 40.

The internal reliability of the 10 items of the PSS-10 show a good internal reliability (α = .86). The internal reliability of the BFI-44 neuroticism scale is acceptable (α = .80). These Cronbach's alpha values indicate that the questions in each questionnaire measures the same construct. All variables are normal distributed (see Appendix B for details).

Sedentary Time and Stress

Hypothesis 1a: Total Sedentary Time is positively correlated with perceived psychological stress in students

Stress and sedentary time have been found to be weakly positively correlated $r(99)$ = .14. However, the findings are statistically insignificant p = .178. Based on this the hypothesis is rejected.

Hypothesis 1b: Mentally Active Sedentary Time is negatively correlated with perceived psychological stress in students

Stress and mentally active sedentary time have been found to be weakly positively correlated $r(99)$ = .07. However, the findings are statisically insignificant p = .512. Based on this the hypothesis is rejected.

Hypothesis 1c: Mentally Passive Sedentary Time is positively correlated with perceived psychological stress in students

Stress and mentally passive sedentary time have been found to be weakly positively correlated $r(99)$ = .15. However, the findings are statisically insignificant p = .141. Based on this the hypothesis is rejected.

Mediation analysis of Neuroticism

Hypothesis 2a: Neuroticism is a moderator for the relationship between Mentally Active Sedentary Time and perceived psychological stress in students

The overall model of the moderation was significant (R^2 = .46; F = 27,08; p <.001). Table 3 shows the output of the model which shows that the interaction effect is insignificant. Based on this the hypothesis that neuroticism is a moderator for the relationship between mentally active sedentary time and stress is rejected.

Table 3

Neuroticism as a moderator on the relationship of mentally active and mentally passive sedentary time as an independent variable and stress as a dependent variable. 95% confidence interval.

	b	se	t	p	LLCI	ULCI
constant	-2.7724	5.2209	-.5310	.5966	-13.1359	7.5910
Mentally Active Sedentary Time	.0054	.0093	.5808	.5627	-.0131	.0239
Neuroticism	.8255	.1980	4.1695	.0001	.4325	1.2185
Mentally Active Sedentary Time * Neuroticism	-.0001	.0004	-.2070	.8365	-.0008	.0006
constant	7.7768	5.3391	1.4566	.1485	-2.8212	18.3748
Mentally Passive Sedentary Time	-.0265	.0174	-1.5192	.1320	-.0610	.0081
Neuroticism	.4520	.2095	2.1581	.0334	.0363	.8678
Mentally Passive Sedentary Time * Neuroticism	.0011	.0007	1.6811	.0960	-.0002	.0024

Hypothesis 2b: Neuroticism is a moderator for the relationship between Mentally Passive Sedentary Time and perceived psychological stress in students

The overall model of the moderation was significant (R^2 = .46; F = 27,47; p <.001). Table 3 shows the output of the model which shows that the interaction effect is insignificant. Based on this, the hypothesis that neuroticism is a moderator for the relationship between mentally passive sedentary time and stress is rejected. Worth of note is that neuroticism has a significant interaction with stress in both moderation analyses (Table 3).

Discussion

The purpose of this study was to investigate the possible relationship of sedentary time and stress in students. Furthermore, the sedentary time was broken up into two separate sedentary times, mentally active and mentally passive sedentary time. To answer the first research question ("To what extent is sedentary time correlated with perceived psychological stress in university students?"), three hypotheses were investigated. Each deals with total, mentally active and mentally passive sedentary time and their correlation with stress respectively. None of the hypotheses could be accepted, leading to the conclusion that sedentary time is not correlated with perceived psychological stress in university students. This is in line with the conclusion of the systematic review of Teychenne et. al. (2019) as there was no connection found between sedentary time and stress either. The investigation was still necessary however, as other papers found a connection between sedentary time and stress, such as the findings of Dėdelė et. al. (2019). They conclude an association between sedentary time and stress, however they used different questionnaires to assess each of those variables. For stress, they still measured perceived stress, but instead of the PSS-10 they used the Reeder Stress Scale. When assessing the sedentary time, they do not seem to use any specific questionnaire for that, but rather ask the participants how many hours they sit outside of work. An important remark to that is that they did not include the occupational sedentary time, which was included in this study. Additionally, they have not asked for the time an individual spent laying down which can be further reason for differing results.

To answer the second research question "To what extent does neuroticism moderate the relationship between mentally active sedentary behaviour and perceived psychological stress, and passive sedentary behaviour and perceived psychological stress in a university student population?", two hypotheses were formulated. None of the hypotheses could be accepted, leading to the conclusion that neuroticism is not a moderator in the relationship between mentally active, mentally passive sedentary time and stress. After the initial pre-requisite of a correlation between the independent variable and dependent variable was not found, this was to be expected, however the moderation analysis still yielded an interesting result. In both moderation models (mentally active and mentally passive sedentary time), neuroticism showed a significant connection to stress. This is already a well-known connection (e.g., Schneider, 2004), but it demonstrates that the instruments used in this study work properly in this context as they do show this well-known established connection, but do not show a moderation effect.

Another interesting finding in this study is that the student population sample in this study has a 40% higher score on the PSS-10 than the norm group of that questionnaire. The

norm group refers to respondents in the United States of all age ranges, though like in this study, the majority are female. The literature is clear on the link between stress and physical as well as mental health outcomes. This data suggests that this student sample is more prone to be negatively effected by stress as they score 40% higher on the stress scale. While this is a young population, the physical health outcomes may not be as severe, though that may not be true for the mental health outcomes. This is in line with the findings of Moutinho et. al. (2017) who found that the Brazilian medical students experience more stress, anxiety and depression symptoms. There a numerous possible explanations for this, though most would be speculative as there is not enough research done on student populations in this context. The most simple explanation is that the student population is more stressed compared to the general population, however, the evidence for that is not convincing enough yet and there are other indicators that could underlie this relationship.

One last finding that is worth discussion is the total sedentary time found in this sample. It is with 13.5 hours very high when compared to the general Dutch population in the age range of 18-34, who spend about 7.5 hours per day sedentary (Loyen, Chau, Jelsma, van Nassau, & van der Ploeg, 2019). This sample is almost double as sedentary as the general Dutch population. It is worth of note however that the average mentally active sedentary time of this sample is a little over 8 hours per day. This is reasonable as a full-time student is expected to work on their studies about 8 hours per day and this work mostly consists of mentally active sedentary behaviours such as writing reports, studying, reading, attending lectures, etc. Despite that, the mentally passive sedentary time is still at about 5 hours which is very high compared to the total sedentary time of the general Dutch population. Even though the sedentary time is alarmingly high in this sample, there is no connection to perceived psychological stress.

Strengths

One strength of the study is the measurement of neuroticism and perceived stress. They show a good internal validity in this study. Neuroticism is seen as a constant personality trait throughout the lifespan whereas the PSS-10 measures trait stress which is also a measurement that remains relatively constant. This gives an excellent ground of analysis of the two variables. Another strength is that this paper contributes to the ongoing debate whether sedentary time is linked mental health in general and specifically stress, while also pioneering into research including the division of mentally active and mentally passive sedentary time.

Limitations

There are a number of limitations with this study. To start, the study offered a text box at the end of it where the participants could enter comments and remarks about the study. One comment that was made is that the study was too extensive and took too long to complete. This is the result of multiple theses combined into one questionnaire with many different measurement instruments. While this is common practise, it may cause a distorted data set due to loss of attention or participants cancelling the study altogether.

Another limitation is the fact that all of the measurements are based on self-reports. This is generally known to be able to cause some problems in the data collect. There is a tendency in participants to express the more socially desired behaviour or to make a misjudgement on the situation that they should report on. In this study this reflects very well in the modified PAST-U as there are participants that exceed the 24 hours in their sedentary time. The PAST-U questions about the day prior to the assessment and any sum of hours that is above 24 hours can logically not be true. While there are alternatives that take a physiological approach to measure the sedentary time of participants with the use of wearables for example, it was beyond the scope of this study and was not practical as those instruments cannot yet distinguish between mentally active and mentally passive sedentary time.

Additionally, by using an online questionnaire, we had no control over the environment or the day at which the participants filled out the questionnaire. As the PAST-U asks for the past day, the resulting sedentary behaviour may heavily vary. For example, if a student fills out the questionnaire on a Monday, the sedentary behaviours are measured of the Sunday, a day where they presumably had a more slow and relaxing day compared to when they would fill it out on a Thursday and report their sedentary behaviours of the Wednesday. This was something this study did not take into account, but should have and future research is encouraged to control for this.

Future research

Future research should focus on the factors in elevated stress levels in students. This is not the first study to have found a high prevalance in stress in students (Moutinho, et al., 2017). If the factors in the increased stress can be identified, interventions can be utilised by universities that attempt to decrease the stress students experience and therefore lower the health risks that are associated with an elevated stress level.

Another important detail that future research should keep in mind when investigating the relationship between sedentary time and stress is what stress is measured. In this study

perceived psychological stress was measured and there may be a significant difference between the different stresses and their connection to sedentary time (e.g., physiological stress, acute stress, etc.). Furthermore, the instrument to measure sedentary time (PAST-U) was modified in this study to assess both screen-time vs. non screen-time and mentally active vs. mentally passive sedentary time. A superior measurement tool to distinguish between mentally active and mentally passive sedentary time is recommended, especially one that does not only rely on self-report to have more confidence in the accuracy of the sedentary time data.

Conclusion

This paper has outlined the risks of high sedentary time as well as high levels of stress with their health implications. The goal was to investigate whether sedentary time and stress are correlated in a student sample. No evidence for that connection was found in this study. However, the stress reported by the students in this study was significantly higher than the stress of the general population which suggests that students may be a high risk population for stress and its detrimental health effects. Furthermore, the total sedentary time of this sample population is close to double of that of the general population. Again, this means that this sample is exposed to the risks of the health drawbacks of high amounts of sedentary time and this needs to be addressed in future studies and interventions.

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Appendix A

PAST-U:

Yesterday's date: _____

Yesterday's day: Monday Tuesday Wednesday Thursday Friday Saturday Sunday

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

I am 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, <u>only count the time this was your main activity</u>. For example, if you watched TV and ate dinner at the same time, this might be TV or mealtime, 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.)

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 paperwork, tutoring, etc.)

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.

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.

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. It does not include other activities than watching videos, movies etc. performed on the computer.

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.).

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.).

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).

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.

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

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.

Sitting for eating

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

Sitting for socializing

ST8. Please estimate the total time yesterday that you spent sitting down to socialize with friends or family, regardless of location (at university, at home or in a public place). Include time on the telephone.

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 **<u>NOT</u>** including time that you have told us about in the previous answers.

PSS-10:

	0 = Never	1 = Almost Never	2 = Sometimes	3 = Fairly Often	4 = Very Often

1. In the last month, how often have you been upset
   because of something that happened unexpectedly?................................. 0 1 2 3 4

2. In the last month, how often have you felt that you were unable
   to control the important things in your life? 0 1 2 3 4

3. In the last month, how often have you felt nervous and "stressed"? 0 1 2 3 4

4. In the last month, how often have you felt confident about your ability
   to handle your personal problems? 0 1 2 3 4

5. In the last month, how often have you felt that things
   were going your way?... 0 1 2 3 4

6. In the last month, how often have you found that you could not cope
   with all the things that you had to do? 0 1 2 3 4

7. In the last month, how often have you been able
   to control irritations in your life?.. 0 1 2 3 4

8. In the last month, how often have you felt that you were on top of things?.. 0 1 2 3 4

9. In the last month, how often have you been angered
   because of things that were outside of your control?.................................. 0 1 2 3 4

10. In the last month, how often have you felt difficulties
    were piling up so high that you could not overcome them? 0 1 2 3 4

BFI-44 Neuroticism scale:

1 = Disagree strongly; 2 = Disagree a little; 3 = Neither agree nor disagree; 4 = Agree a little; 5 = Agree strongly

<u>I see Myself as Someone Who…</u>

__ 1. Is depressed, blue

__ 2. Is relaxed, handles stress well   (Reverse item)

__ 3. Can be tense

__ 4. Worries a lot

__ 5. Is emotionally stable, not easily upset   (Reverse item)

__ 6. Can be moody

__ 7. Remains calm in tense situations   (Reverse item)

__ 8. Gets nervous easily

Appendix B

Kolmogorov-Smirnov and Shapiro-Wilk significance values for the test of normality.

	Kolmogorov-Smirnov (p-value)	Shapiro-Wilk (p-value)
Total Sedentary Time (in minutes)	.200*	.213
Mentally Active Sedentary Time (in minutes)	.200*	.538
Mentally Passive Sedentary Time (in minutes)	.200*	.743
Stress Score	.150	.166
Neuroticism Score	.056	.058

*.This is a lower bound of the true significance