Moving Towards Health: Physical Activity as a Resource for Healthy Academic Engagement in University Students

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A. BACKGROUND, AIM, AND HYPOTHESES

Studying for an academic degree imposes a variety of cognitive, emotional, and social demands on university students. While academic engagement can foster personal growth and intellectual development, the pressures associated with higher education—such as performance expectations, workload, financial concerns, and future uncertainty—can pose significant risks to students' biopsychosocial health (Sheldon et al., 2021). Research frequently shows elevated levels of stress, depressive symptoms, and burnout among university students compared to non-student peers, highlighting their vulnerability to mental and physical health challenges (e.g., Auerbach et al., 2016; Garlow et al.; 2008; Ibrahim et al., 2013; Mortier et al., 2018). These strains can also manifest in maladaptive behavioral patterns and impaired academic performance (Metzger et al., 2017; Stock, 2017; Topham & Moller, 2011). A recent survey conducted on a representative sample of approximately 188,000 students in Germany found that 63.7% of respondents reported feeling stressed on a regular basis (Kroher et al., 2023), exceeding stress levels reported in student samples prior to the COVID-19 pandemic (Grützmacher et al., 2018; Herbst et al., 2016). In the same survey, 48.3% of respondents stated that they often feel overworked during the semester (Kroher et al., 2023). The cost of these implications can be particularly concerning in students, as experiencing health issues during their academic education may impede the development of resilience and coping mechanisms needed to successfully navigate demands

associated with their later profession. As future professionals and potential leaders, students represent a society's potential—struggles at this formative stage can therefore have long-term consequences for both the individuals and the communities they are meant to serve. Understanding the health risks associated with studying and identifying protective factors that can be integrated into the life on campus is crucial for developing effective support strategies and promoting durable health within student populations.

One protective factor against stress-related health impairments that has been identified in past studies is physical activity (PA), as attaining sufficient levels of PA has shown to buffer negative effects of stress on health (Gerber & Pühse, 2009). In general, there is an abundance of evidence demonstrating that meeting sufficient levels of PA levels is associated with several physiological and psychological health parameters, such as, improved mental well-being, reduced stress, and lower risk of mortality (Buecker et al., 2021; Ekelund et al., 2016; Mücke et al., 2018). In student populations, PA has been shown to act as a buffer against academic stress and is positively associated with academic performance (Wunsch et al., 2021). In contrast, an increase in sedentary time has been associated with an increase stress, anxiety and depressive symptoms in students (Lee & Kim, 2018; Nguyen-Michel et al., 2006). This is of importance since students spend considerable periods of time throughout their academic life in a seated position (Rouse & Biddle, 2010), as the format in which most university courses are offered poses a barrier to maintaining adequate levels of activity (e.g., lectures, seminars). Furthermore, previous research indicated that sedentary time in students increases from the first to the final year (Johnston et al., 2010). Given the growing recognition of the links between PA, sedentary behavior, and health, investigating their influence on academic behavior and experience patterns is of considerable relevance. Beyond advancing the understanding of the health-related outcomes of PA, such research can also serve as a foundation for evidence-based interventions within university health management,

aimed at proactively preventing health impairments and, in doing so, supporting students' academic performance in the long term.

The present study

The present study aims at better understanding the impact of both PA and sedentary time on health-related academic behavior and experience patterns in a sample of German university students. As previous studies in this field have predominantly employed measures of specific health outcomes (e.g., well-being, stress, burnout), this study uses an alternative approach by assessing students' behavioral and experiential patterns instead. This enables conclusions to be drawn about patterns in coping with the demands of academic life and whether they are conducive to or detrimental to health, rather than focusing on a specific aspect of health.

Furthermore, the present study aims at exploring whether the association between both PA and sedentary time and academic behavior and experience patterns differs as a function of time (i.e., within the first two years of study) and whether progressing from the freshmen year to the second year of study is associated with a change in academic behavior and experience patterns.

Hypotheses and Research Questions

Based on previous research, we developed the following hypothesis and research questions to explore the relationship between PA, sedentary time, and academic behavior and experience patterns.

1. We expect PA to be associated with an increase in the transition probability to healthy (G and S) academic behavior and experience patterns and with a decrease in the transition probability to risk patterns (A and B) of academic behavior and experience.
2. We expect sedentary time to be associated with a decrease in the transition probability to healthy (G and S) academic behavior and experience patterns and with an increase in the transition probability to risk patterns (A and B) of academic behavior and experience.

B. Method

Design and procedure

The data analyzed in this study was collected as a part of the the Lübeck University Student Trial study (LUST; Kötter et al., 2014) between 2022 and 2025. The LUST study is a longitudinal cohort survey study concerned with monitoring developments in students' health status and identifying risk factors and protective factors common to health issues in the academic setting. Since 2011, each student of the University of Lübeck is invited annually to participate. Each cohort is first invited to participate in a baseline survey during the period of pre-course week and the first two weeks of study at the start of the winter semester. This is followed by survey invitations during the summer semester on an annual basis. The LUST study comprises fixed components (i.e., questionnaires that are administered since the start of the study in 2011) and variable, cohort-specific components that address recent trends and developments with respect to student's health. In the present study, data from cohorts starting in 2022 until 2024 will be considered. The rationale behind this was that the questionnaire measuring PA and sedentary time was first introduced to the LUST study in the freshmen cohort 2022. The survey was administered using LimeSurvey (LimeSurvey GmbH, 2025). We state that data collection for the period under discussion had already taken place at the time of preregistration. However, the analysis of the data in relation to the aforementioned research questions and hypotheses has not yet been conducted, nor has the data been inspected to this effect.

Sample

The sample consisted of 785 students (M_{age} = 20.81 ± 3.33, 80.3 % female) from various area of study at the University of Lübeck. Only participants with more than two observations were considered in this study. Of these 785 students, 474 participated at two time points, 227 at three time points, and 84 at 4 time points, resulting in 1,965 observations in total.

Recruitment took place via announcements in lectures, the institute homepage, notices, flyers, and email lists. Individuals obtained a gift voucher (5€) in exchange for participation. Psychology students could also receive research participation credit. Each German-speaking student of the University of Lübeck was eligible to participate in the study.

Measures

Dependent variable

Academic behavior and experience patterns. Academic behavior and experience patterns were measured using a German version the Work-related Behaviour and Experience Patterns ("Arbeitsbezogene Verhaltens- und Erlebensmuster" [AVEM]; Schaarschmidt & Fischer, 1997). The AVEM was originally developed to collect self-reported data about personal experiences with work-related stress and typical coping strategies. We administered the 44-item short version adapted for students. The AVEM comprises 11 dimensions measured 4 items each. Responses are given on a 5-point Likert scale (1: "Does not apply at all"; 5: Applies completely"). Based on their characteristics in the 11 dimensions, the respondents can be classified into health-endangering risk patterns (A, B) and health-promoting (G, S) AVEM patterns using the scoring procedure outlined by Schaarschmidt and Fischer, 2008. The resulting score reflects the probability (0-1) that a person belongs to one of these patterns. The probabilities for all four patterns of one individual sum up to 1. Schaarschmidt & Fischer (2008) report an acceptable to good reliability for the 44-item version, with Cronbach 's α for the AVEM subscales ranging from 0.76 to 0.84. The validity of the AVEM has been examined in different groups, and exploratory factor analysis has supported the factorial structure of the instrument (Beutel et al., 2004; Heitzmann et al., 2004; Schaarschmidt & Fischer, 2008).

Independent variables

Physical activity. Physical activity was measured using a modified version of the short form International Physical Activity Questionnaire (IPAQ, Craig et al., 2003). In the original IPAQ, participants are asked to report the number of days in a week when they do intense or moderate activities for more than 10 minutes and to estimate how long they spend doing these activities on one of these days. In the present study, the decision was taken to combine these items into a single question by asking participants to report the amount of time per week spent with moderate and intense physical activity during leisure time. The rationale behind this was twofold: firstly, to keep the LUST study questionnaire as short as possible, and secondly, to avoid jeopardising the response rate. The data will be processed according to the guidelines provided by the IPAQ research group (IPAQ Group, 2005). A total score reflecting metabolic equivalents of task (METs) per week will be calculated by multiplying weekly active time by intensity specific metabolic values as per IPAQ scoring instructions (Craig et al., 2003).
Sedentary time. Sedentary time was obtained by enquiring participants to report the amount of time they spent sitting on a typical day. Sedentary time was measured in hours and will be transformed to minutes.

Statistical analysis

Continuous-time multi-state Markov models were fitted using the *msm* package (Jackson, 2011) in R (R Core Team, 2024) to describe transitions between behavior and experience patterns across measurement waves. Each model estimated the transition intensity matrix Q, representing instantaneous transition rates between states, from which transition probabilities over time and mean sojourn times were derived. Sedentary time and physical activity were entered as covariates to examine their effects on specific transition intensities, with effects modeled through log-linear relationships on the corresponding q_{ij} parameters. Model fit was assessed using the Akaike Information Criterion (AIC) and likelihood ratio

tests to compare nested models with and without covariates. Transition probabilities were only estimated for transitions with at least 30 observed cases to ensure stable inference.
To test the robustness of the findings, sensitivity analyses were conducted including semester and sex as additional covariates. These analyses examined whether the inclusion of demographic or study-related factors altered the estimated effects of sedentary time and physical activity on the transition dynamics. All analyses were performed using R.

Preliminary results

Continuous-time Markov multi-state model analyses revealed that sedentary time was associated with an increased hazard of direct transition from pattern G (Good health) to B (Burnout, HR = 2.33, 95% CI: 1.14 - 4.74). The probability of B being the next pattern after G was 3% when sedentary time was low (-1 SD). This probability increased to 16% when sedentary time was high (+1 SD). Physical activity was not significantly associated with transition hazard ratios between coping patterns. Sojourn times did not significantly differ between high (+1 SD) and low (-1 SD) sedentary time or physical activity.

Table 1. Transition hazard ratios corresponding to physical activity effects for transitions between State 1 (G), State 2 (S), State 3 (A), and State 4 (B).

Transition	HR	LCI	UCI
State 1 - State 2	1.14	0.87	1.50
State 1 - State 3	1.29	0.94	1.76
State 1 - State 4	1.14	0.42	3.09
State 2 - State 1	0.97	0.65	1.46
State 2 - State 4	0.88	0.57	1.33
State 3 - State 1	1.18	0.89	1.57
State 3 - State 4	0.77	0.56	1.06
State 4 - State 2	1.00	0.71	1.41
State 4 - State 3	1.01	0.69	1.48

Table 2. Transition hazard ratios corresponding to sedentary time effects for transitions between State 1 (G), State 2 (S), State 3 (A), and State 4 (B).

Transition	HR	LCI	UCI
State 1 - State 2	0.97	0.73	1.29
State 1 - State 3	1.03	0.74	1.44
State 1 - State 4	2.33	1.14	4.74
State 2 - State 1	0.89	0.59	1.37
State 2 - State 4	1.12	0.78	1.60
State 3 - State 1	1.14	0.82	1.58
State 3 - State 4	1.20	0.93	1.55
State 4 - State 2	0.93	0.69	1.25
State 4 - State 3	1.17	0.85	1.61

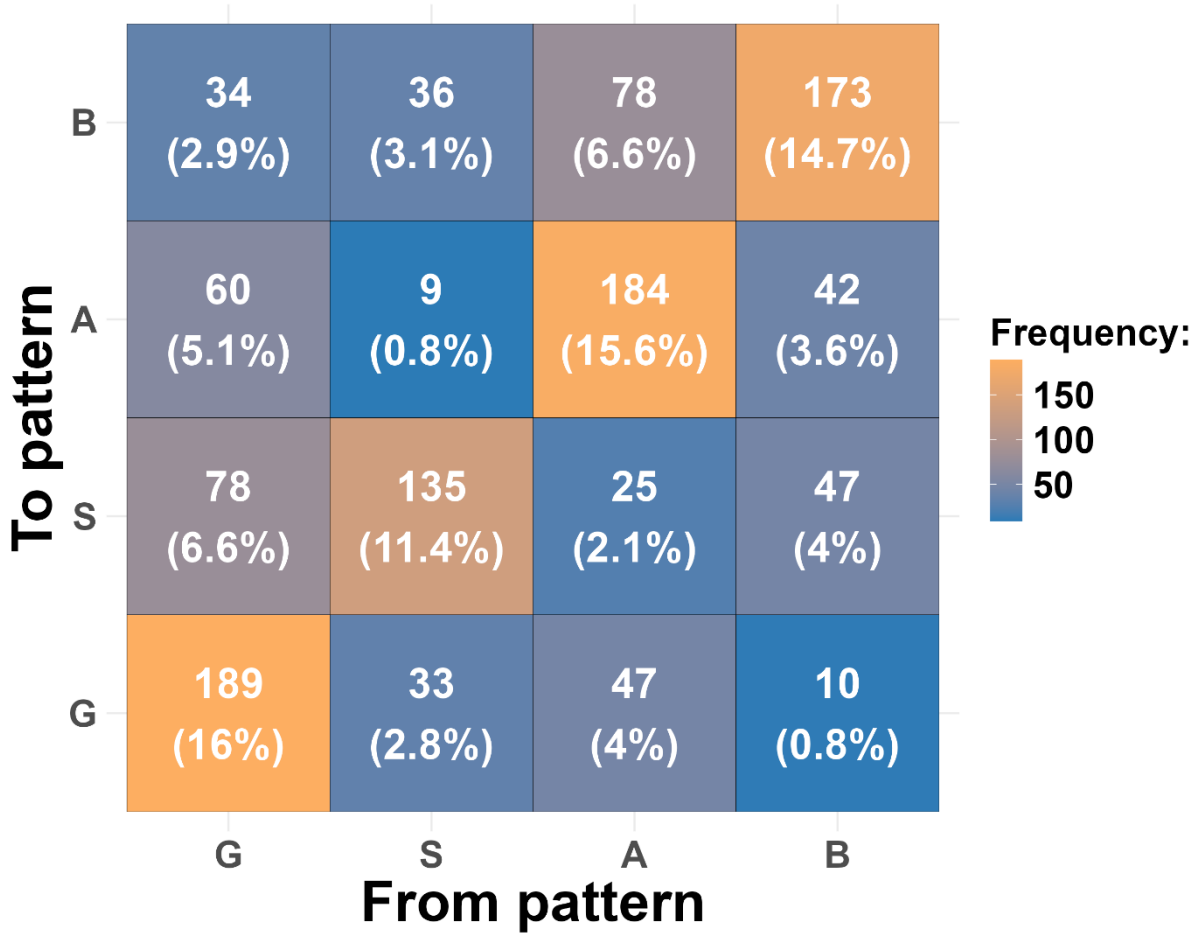

Figure 1. Transition frequency between each pattern.

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