Healthy habits, healthy minds? AI-based evidence on lifestyle effects on student success and stress

Damla KARAGOZLU, Kian JAZAYERI, Ahmet ADALIER

Cyprus International University, Department of Management Information Systems, Nicosia

dkaragozlu@ciu.edu.tr, kjazayeri@ciu.edu.tr, aadalier@ciu.edu.tr

Abstract: *Understanding how students' daily habits shape their academic outcomes and well-being has become increasingly important in digitally enhanced and virtual learning environments, where autonomy, self-regulation, and balanced routines are critical for success. In this study, machine learning and SHAP-based explainability were applied to explore how study time, sleep, extracurricular activities, social interaction, and physical exercise influence GPA and stress levels among university students. Results showed that while increased study hours improved performance, excessive workloads elevated stress, highlighting the importance of maintaining a balanced daily routine. These findings provide practical guidance for improving student support and designing healthier learning ecosystems in virtual and hybrid educational contexts. This work directly contributes to UN SDG 4 (Quality Education) by providing evidence-based insights to promote equitable and sustainable academic success in modern digital learning settings.*

Keywords: Higher education policy, Virtual learning, Student success, Stress prediction, Explainable AI, Student well-being, Quality education.

1. Introduction

Virtual and technology-driven learning environments have transformed higher education, offering flexibility and access while placing greater responsibility on students to manage their time, motivation, and well-being. As digital platforms become central to academic life, gaining insight into how daily behaviors influence academic success and stress has become crucial for both educators and policymakers. Understanding the connection between lifestyle patterns and performance can inform more supportive instructional designs, foster healthier academic cultures, and lead to targeted interventions that promote student well-being.

In this study, machine learning techniques were employed to predict Grade Point Average (GPA) and stress levels based on students' daily routines, and explainable AI, SHapley Additive exPlanations (SHAP), was applied to uncover how each habit shaped the outcomes. By identifying optimal ranges for study time, sleep, physical activity, social engagement, and extracurricular participation, the research highlights how balanced lifestyles can enhance academic success while preventing stress escalation. These insights are particularly relevant for virtual and hybrid learning environments, where student autonomy is high and structured

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support can be limited. Moreover, the study contributes to UN SDG 4 (Quality Education) by providing data-informed recommendations to foster equitable, supportive, and holistic learning environments in digitally mediated education settings.

2. Literature review

The link between students' habits, lifestyles, and academic outcomes has been widely explored, revealing that daily behaviors significantly influence both performance and stress. Research on study habits shows that the quality of learning strategies is more influential than the total amount of study time. Active methods such as self-testing and elaboration predict higher exam scores, whereas distraction hinders results (Walck-Shannon et al., 2021). Similarly, motivation, a preference for visual learning, and memory recall are correlated with better academic achievement among medical students (Aljaffer et al., 2024).

Studies on lifestyle behaviors support this view, emphasizing the importance of sleep, diet, and regular physical activity. Regular routines and hygiene are associated with stronger performance, while overly strict eating patterns show no clear advantage (Zhang et al., 2025). Balanced sleep and diet also enhance academic performance, as indicated by GPA (Shafie et al., 2022; Mahfouz et al., 2024).

Evidence linking lifestyle and stress highlights that academic strain undermines well-being and learning (Pascoe et al., 2019). Poor diet, insufficient sleep, and inactivity increase anxiety and depression risks (Rahimi et al., 2024; AlHamlan et al., 2025). Physical activity consistently reduces stress levels, though standardized protocols remain lacking (Guerriero et al., 2025).

The COVID-19 pandemic intensified these effects. Online learning has been linked to the development of unhealthy routines and increased stress (Salazar-Granizo et al., 2024a, 2024b), with students reporting greater well-being in face-to-face learning environments. Overload and time imbalance were key stressors, mitigated through planning and emotional support (Pérez-Jorge et al., 2025). International students also showed convergent behavioral adaptations (Kulykovets et al., 2025).

Recent data-driven research identifies psychological and physiological predictors, particularly anxiety and sleep quality, as the most critical stress factors (de Filippis & Foysal, 2024). Collectively, these findings suggest that regular habits and active study methods enhance performance, while maintaining healthy sleep, nutrition, and exercise helps protect against stress. However, few studies model these effects jointly. The present work addresses this gap through an Explainable AI-based analysis of the dual impact of daily habits on student success and stress.

3. Methodology

3.1 Dataset and preprocessing

This study used a dataset consisting of 2,000 university students, each providing daily lifestyle information covering five key habits: hours spent studying, participating in extracurricular activities, sleeping, socializing, and engaging in physical exercise (Rogg, 2024). GPA served as an indicator of academic success, while stress was categorized into three levels (low, moderate, high) based on daily routines and behaviors.

The dataset was already complete and clean, with no missing or inconsistent values. Therefore, only minimal preparation was necessary before analysis. The main preprocessing step involved converting the stress categories into numerical labels (Low = 0, Moderate = 1, High = 2) so that machine learning models could process them effectively.

3.2 Machine learning models

To investigate the relationship between lifestyle habits and academic success and stress, three established machine learning methods were applied: Random Forest, Support Vector Machine (SVM), and Naive Bayes. These models were selected because they are commonly used for analyzing structured data and are known to work well in predicting academic outcomes. The models were trained separately for two tasks: predicting GPA and predicting stress levels as continuous measures. In the case of stress prediction, the stress level was modeled as a continuous value ranging between 0 and 2, allowing for continuous SHAP explainability analysis similar to that applied for GPA prediction. Standard training and evaluation procedures were followed to ensure fair and reliable comparison among the models.

3.3 SHAP-based explainability

After training the models, explainable AI techniques were applied to gain a better understanding of how each lifestyle factor influenced the predictions. SHAP was used to interpret the most successful model. This method provided clear and intuitive visual insights, illustrating how habits such as study time, sleep duration, or physical activity shaped the predicted GPA and stress levels. By offering transparent explanations, SHAP helped translate machine learning outcomes into practical, human-understandable guidance for educators, students, and well-being support teams.

4. Results

4.1 Machine Learning Results

Three machine learning models, Random Forest, Support Vector Machine (SVM), and Naive Bayes, were trained to predict both GPA and stress levels based

on students' lifestyle habits. The performance of each model was measured using Mean Absolute Error (MAE) and Mean Absolute Percentage Error (MAPE), as shown in Table 1.

Table 1. Comparison of performance metrics of different machine learning models for GPA and Stress-level prediction

		MAE	MAPE
GPA Prediction	Random Forest	0.1762	5.70%
	SVM (RBF)	0.1767	5.74%
	Naïve Bayes	0.1804	5.85%
Stress Level Prediction	Random Forest	0.0158	7.12%
	SVM (RBF)	0.1141	37.53%
	Naïve Bayes	0.1945	62.68%

The Random Forest model achieved the best results, with MAPE of 5.7% for GPA prediction and 7.12% for Stress level prediction. Because Random Forest showed the highest prediction accuracy, it was selected for further analysis using explainable AI techniques.

4.2 SHAP explainability results

To interpret how lifestyle habits affected academic performance, SHAP explainability was applied to the best-performing model. The goal was not only to predict GPA but also to show how each daily habit contributed to the prediction.

Figure 1, a SHAP beeswarm plot, displays how all student records influenced GPA predictions. Each dot represents a student. Dots on the right indicate habits associated with a higher predicted GPA, while dots on the left indicate lower predicted GPA. The vertical axis lists features in order of importance, with the most influential at the top. Dot colors show whether a student had a high (pink/red) or low (blue) value for that habit. For instance, pink dots far to the right for study hours indicate that higher study time increases predictions, whereas blue dots on the left show that low study time decreases GPA predictions.

Overall, study hours exerted the strongest and most consistent positive effect on GPA. Physical activity also contributed positively, though to a smaller extent. Sleep, social time, and extracurricular hours showed subtler influences, with most points clustered near the center, indicating modest but still meaningful effects.

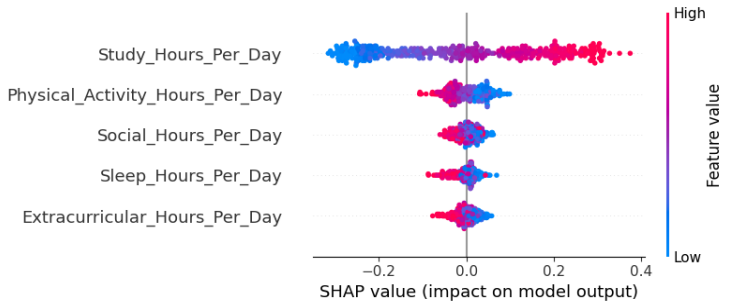

Figure 1. The SHAP Beeswarm plot explaining the factors contributing to student success (GPA)

For the stress prediction task, the SHAP results (Figure 2) show how daily habits influenced students' stress levels. As in the GPA model, each point in the beeswarm plot represents a student, illustrating whether their habits pushed stress predictions higher or lower. Higher SHAP values indicate factors contributing to increased stress, while lower values reflect stress-reducing effects.

Study hours were the most influential feature; however, unlike the GPA results, increased study time shifted SHAP values positively, indicating higher predicted stress. Students studying fewer hours showed lower stress predictions. Sleep was also a key determinant: longer sleep durations were associated with lower stress, whereas insufficient sleep clustered on the positive axis, indicating a heightened risk of stress, consistent with evidence linking sleep to emotional regulation.

Physical activity, social time, and extracurricular activities had smaller but noticeable effects. Engaging in more physical activity and spending more time socialising generally reduces stress. Extracurricular involvement displayed the weakest influence, indicating its impact is minor relative to study load and sleep.

Overall, the results show that intensive study and inadequate sleep most strongly increased predicted stress, while sufficient rest and regular physical activity support lower stress levels. These findings highlight a common trade-off: academic effort is vital, yet maintaining balanced routines and sleep is essential for managing stress effectively.

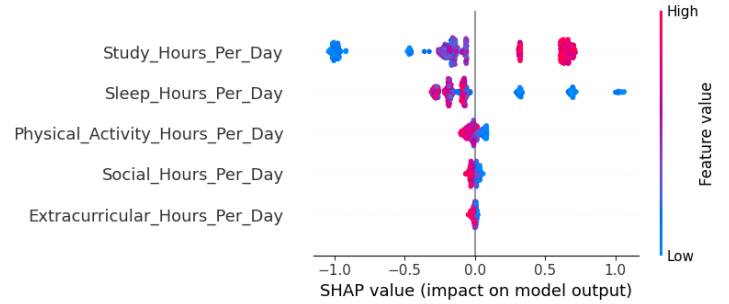

Figure 2. The SHAP Beeswarm plot explaining the factors contributing to stress levels

Before examining the SHAP dependence plots, it is important to recognize that even very small SHAP values matter. GPA and stress are not driven by a single habit; they result from the combined influence of many daily behaviors. Small positive or negative effects from each feature accumulate, ultimately shaping academic performance and well-being. The following plots highlight how each habit contributes when considered within the student's broader lifestyle.

Figure 3 illustrates the relationship between study hours per day and predictions for GPA (left) and stress (right). Each dot represents a student. The horizontal axis shows study hours, and the vertical axis shows the SHAP value (how much study time pushes the prediction up or down relative to the average). Higher dots indicate increased predictions (higher GPA on the left, higher stress on the right), while lower dots indicate decreased predictions. Vertical spread at the same study duration reflects differences in students' other habits, such as sleep or exercise.

For GPA, SHAP values increase steadily as study hours rise, indicating that more study time improves the predicted GPA. For stress, a threshold pattern emerges: up to about 6 hours/day, stress remains low or neutral, but beyond ~6 hours, values begin to increase, and beyond ~8 hours/day, they rise sharply, signaling high stress. In summary, more studying supports a higher GPA, but workloads exceeding 6–8 hours/day start to increase stress. Recognizing these patterns reflects the combined effect of all daily habits.

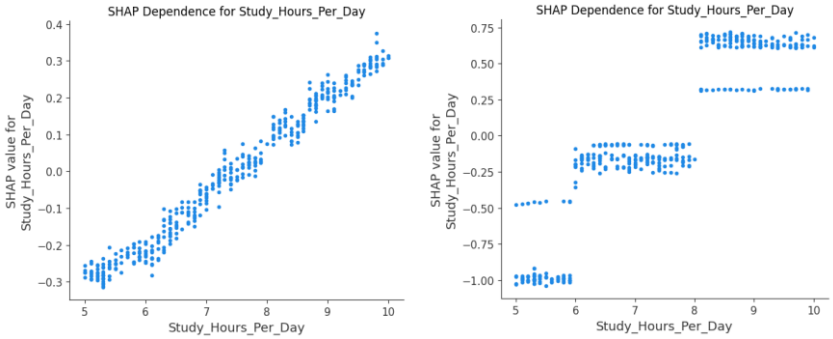

Figure 3. SHAP dependence plot explaining the effect of 'study hours per day' on GPA (left) and stress level (right)

Figure 4 illustrates how Extracurricular Hours per Day affect GPA (left) and stress (right). For GPA, the pattern is curved: increasing extracurricular time up to roughly 1.5 hours/day is associated with positive SHAP values, suggesting improved academic outcomes, likely due to structure, engagement, or skill-building. Beyond ~1.5 hours/day, SHAP values trend downward, indicating that heavier extracurricular loads may begin to reduce GPA, likely due to time trade-offs affecting study or rest.

For stress, the pattern shifts. Light involvement shows mixed effects, but after approximately 2 hours/day, SHAP values generally decrease, suggesting a stress-reducing effect (possibly due to physical activity, social interaction, or meaningful engagement) even though such levels may not support GPA.

In summary, moderate extracurricular participation (~1–1.5 hours/day) is associated with a higher predicted GPA, while broader involvement exceeding ~2 hours/day tends to reduce predicted stress.

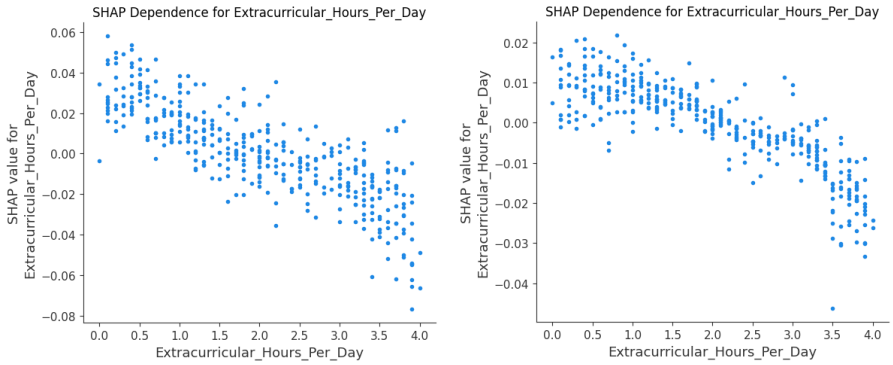

Figure 4. SHAP dependence plot explaining the effect of 'extracurricular hours per day' on GPA (left) and stress level (right)

Figure 5 shows how Sleep Hours per Day affect GPA (left) and stress (right). For GPA, a tipping pattern appears. As sleep increases from low levels to adequate rest, SHAP values rise, indicating a positive effect on GPA. Beyond approximately 8 hours/day, SHAP values decline, indicating that very long sleep predicts lower GPA, likely due to reduced study time or daytime engagement.

For stress, a clear lower-bound threshold exists. Sleeping for less than 6 hours/day produces high positive SHAP values, indicating sharply elevated stress. As sleep duration reaches 6–7 hours and beyond, SHAP values drop toward zero or become negative, indicating that adequate sleep reduces predicted stress.

In summary, adequate sleep supports learning and lowers stress, while very short sleep (<6 hours) strongly increases stress, and very long sleep (>8 hours) is associated with lower predicted GPA, recognizing that outcomes also depend on other daily habits.

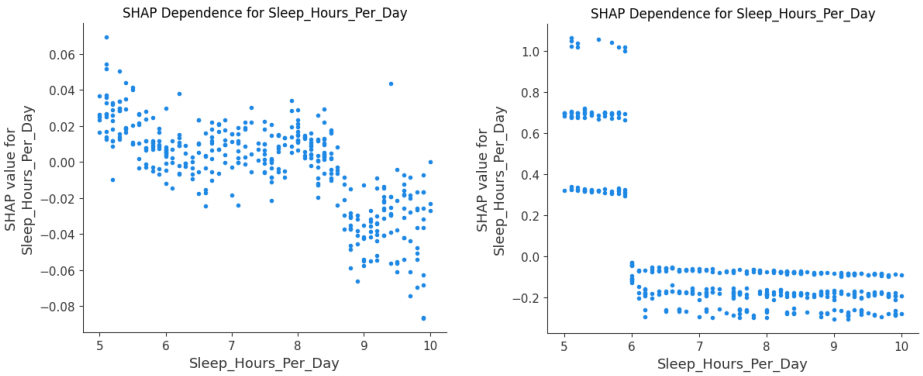

Figure 5. SHAP dependence plot explaining the effect of 'sleep hours per day' on GPA (left) and stress level (right)

Figure 6 illustrates how Social Hours per Day affect GPA (left) and stress (right). For GPA, a balanced pattern appears. Socializing up to about 1.5 hours/day generally corresponds to rising SHAP values, indicating a positive influence, likely due to emotional support, mental breaks, or improved time management. Beyond roughly 3.5 hours/day, SHAP values trend negatively, suggesting that excessive social time may reduce study or rest, thereby lowering the predicted GPA.

For stress, the pattern reflects the benefits of healthy social connections. Below ~2.5 hours/day, SHAP values trend upward, indicating higher predicted stress, which may be linked to isolation or academic pressure. Above ~2.5 hours/day, values decrease, indicating stress reduction through social support and relaxation.

Overall, moderate social engagement supports academic performance and well-being, while too much socializing may hinder GPA, and too little may increase stress.

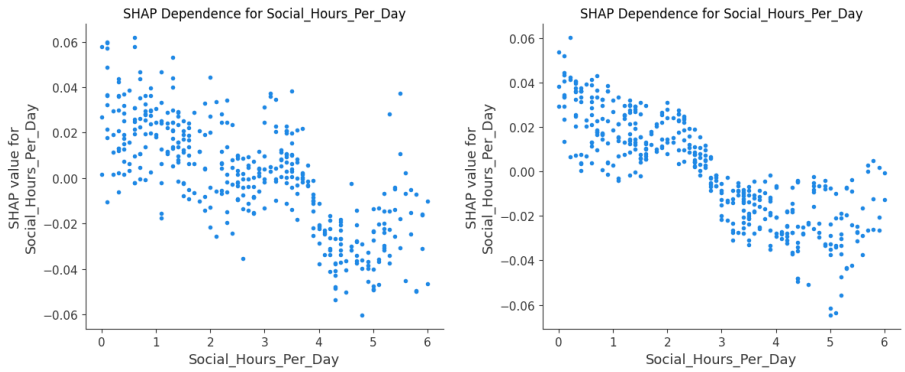

Figure 6. SHAP dependence plot explaining the effect of 'social hours per day' on GPA (left) and stress level (right)

Figure 7 shows how Physical Activity Hours per Day affect GPA (left) and stress (right). For GPA, physical activity appears beneficial up to about 2.5 hours/day. As exercise increases to this level, SHAP values rise, suggesting better predicted academic performance, likely due to improved focus, energy, and stress regulation. Beyond ~2.5 hours/day, SHAP values decline, indicating that excessive exercise may begin to compete with study time or recovery, reducing predicted GPA.

For stress, the effect is more pronounced. Students exercising more than roughly 2.5 hours/day generally show negative SHAP values, meaning lower predicted stress, consistent with established findings that sustained physical activity reduces stress through mood regulation, endorphin release, and improved sleep.

In summary, moderate daily exercise supports GPA and strongly reduces stress, while very high exercise levels may detract from academic performance.

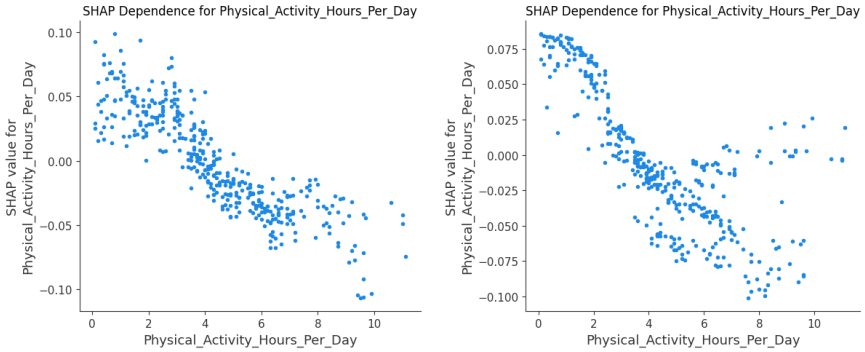

Figure 7. SHAP dependence plot explaining the effect of 'physical activity hours per day' on GPA (left) and stress level (right)

Altogether, the pattern suggests that moderate physical activity enhances academic performance, while higher amounts serve as a strong buffer against stress, though possibly at the expense of GPA if taken to an extreme. Maintaining a healthy balance of activities appears to support both academic and emotional well-being.

5. Discussion and implications

The results indicate that student success and stress are closely linked to everyday behavioral patterns. Study hours showed the strongest positive association with GPA, yet excessive study time beyond clear thresholds (particularly beyond six to eight hours) was tied to increased stress. Balanced levels of sleep, physical activity, social engagement, and extracurricular participation supported both performance and well-being, whereas extremes in any of these areas reduced the benefits. In particular, sleeping less than six hours was significantly associated with elevated stress, while prolonged sleep and very high exercise levels were associated with lower predicted academic outcomes. Overall, academic success appeared most sustainable when effort was complemented by rest, movement, and social connection, rather than being driven solely by intensity.

These insights are especially relevant in virtual learning environments, where independent study and self-regulated learning are prominent. Institutions can help students maintain healthy routines by designing balanced academic workloads, distributing assessments throughout the semester, and incorporating time-management and digital well-being guidance into online platforms. Virtual learning systems can integrate gentle nudges (such as reminders to take short breaks, maintain sleep routines, or log physical activity). At the same time, instructors can model balanced expectations by pacing content, offering structured social interaction opportunities, and encouraging brief movement breaks during long online sessions. Promoting virtual peer-learning groups and time-bounded online study circles may further support both success and mental health.

Taken together, the findings emphasize that maximizing academic effort alone does not guarantee optimal outcomes; instead, students thrive when learning

demands are balanced with restorative habits. Virtual and hybrid learning ecosystems that normalize healthy routines, provide structured engagement, and promote self-regulation are likely to enhance both academic performance and student well-being.

6. Conclusion

This study examined how everyday lifestyle habits influence students' academic performance and stress, emphasizing that achievement in higher education is shaped not by a single behavior but by the balanced interaction of study effort, rest, physical activity, and social connection. While increased study hours supported higher GPA outcomes, excessive workloads were associated with elevated stress, particularly when restorative behaviors such as adequate sleep or physical activity were limited. Moderate levels of sleep, movement, social engagement, and extracurricular participation contributed to better academic and emotional well-being, underscoring that sustainable success emerges from consistent balance rather than intensity alone.

These insights hold particular importance in virtual and digitally driven learning environments, where self-regulated learning, independent time management, and personal well-being practices play a central role. As students navigate remote coursework, online assessments, and flexible learning schedules, institutions should encourage healthy routines, integrate well-being guidance into digital platforms, and design virtual learning structures that promote both academic productivity and psychological resilience. For higher education policy-makers, this calls for embedding wellness and stress management modules into curricula, adopting workload policies that balance rigor with mental health, and supporting data-driven systems to monitor and assist students at risk. Collaboration between academic and student support units should be strengthened to ensure sustained academic success and well-being across digital and traditional settings.

By demonstrating the connection between lifestyle patterns and learning outcomes, this study offers actionable evidence for nurturing student-centred and supportive virtual learning ecosystems. Importantly, the work contributes to United Nations Sustainable Development Goal 4 (Quality Education) by advancing data-informed strategies that enhance learning experiences, promote equitable student success, and strengthen well-being, ensuring that digital and hybrid education environments support not only academic excellence but also healthy, resilient learners equipped for future challenges.

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