

Original Paper

Research on the Correlativity of Daily Schedule Sequences and Academic Achievement among Senior High School Students Based on Dimensional Statistical Analysis

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Abstract

Based on the survey data of 54,102 eighth-grade students in Shanghai, this study adopts statistical methods such as multiple regression analysis, threshold model and Shapley value decomposition to explore the correlation between senior high school students' daily schedule sequences (including sleep duration, study time, homework burden, electronic device use and extracurricular activities) and academic achievement. The study finds that both sleep duration and study time have a significant inverted U-shaped relationship with academic achievement, with the optimal interval of sleep duration being 7-9 hours and that of study time being 2-4 hours. Homework burden is negatively correlated with academic achievement, especially for rural students, excessive homework burden will significantly inhibit their academic performance. There is an obvious "substitution effect" in the use of electronic devices: excessive recreational use crowds out study time, while moderate educational use has a positive impact on academic achievement. The results of Shapley value decomposition show that sleep duration contributes the most to the explanation of academic achievement, followed by study time, and homework burden has the most significant negative impact. The findings provide an empirical basis for optimizing senior high school students' schedules and improving their academic achievement.

Keywords

senior high school students' schedule, academic achievement, multiple regression analysis, threshold model, Shapley value decomposition, time management, learning efficiency

1. Introduction

With the increasing pressure of the college entrance examination, the academic burden and schedule arrangement of senior high school students have become the focus of social attention. The "Double

Reduction” policy implemented by the Ministry of Education of China in 2021 aims to reduce the homework burden and off-campus training burden of students in the compulsory education stage, but the applicability and impact of this policy on senior high school education still need further research. In the current educational environment, senior high school students generally face problems such as insufficient sleep, excessive study time, heavy homework burden, frequent use of electronic devices and low participation in extracurricular activities. Whether these problems affect their academic achievement and how they affect it are common concerns of educational researchers and practitioners.

In recent years, an increasing number of studies have focused on the relationship between adolescents’ sleep and academic achievement. A study conducted in a middle school in Shanghai found that there is an obvious inverted U-shaped relationship between sleep duration and academic achievement. Students who sleep less than 6 hours have the lowest average math score (458 points), while those who sleep 8-9 hours perform the best (average score 509 points), and the average score drops to 482 points when sleep duration exceeds 10 hours. This indicates that longer sleep duration is not always better, but there is an optimal interval. Meanwhile, the study also finds that the positive impact of sleep on academic achievement is more significant among students with lower academic performance, which may mean that good sleep habits have a more significant improvement effect on students with poor academic performance.

The relationship between study time and academic achievement is also complex. On the one hand, study time is positively correlated with academic achievement; on the other hand, there is a phenomenon of diminishing marginal benefits beyond a certain threshold. A 2023 study by the National Center for Education Statistics in the United States found that students who spend 2.5 hours on homework and independent learning on five weekdays on average perform better in standardized tests than those who study less than 1 hour or more than 5 hours per day. This indicates that the quality and quantity of study time are equally important, and excessive study time may be counterproductive.

Homework burden is another important factor affecting students’ schedules. Data show that more than 70% of senior high school students spend more than 2 hours on homework per day on average, and nearly 90% of senior three students spend more than 3 hours. After the implementation of the “Double Reduction” policy, although the amount of homework in primary schools has decreased, the homework burden in senior high schools is still at a high level, which may have a negative impact on students’ learning efficiency and mental health.

The use of electronic devices has become an indispensable part of senior high school students’ daily life. The American Academy of Pediatrics recommends that adolescents’ daily screen time should not exceed 2 hours, but actual data show that the average daily screen time of senior high school students generally exceeds this standard, and it is mainly used for recreational activities such as games and social media. Studies have shown that excessive recreational screen use interferes with learning and affects academic achievement. However, educational screen use (such as online courses and learning software) may have a positive impact on learning, and this phenomenon needs further research.

As an important part of students' all-round development, the relationship between extracurricular activities and academic achievement has also attracted much attention. Studies show that moderate participation in extracurricular activities (1-5 hours per week) is positively correlated with academic achievement, but participation beyond a certain duration (such as more than 30 hours per week) may have a negative impact on academic achievement. There are significant urban-rural differences: the participation rate of urban students in extracurricular activities is about 2.5 times that of rural students. Urban students are more inclined to participate in high-benefit extracurricular activities such as academic and service activities, while rural students mostly participate in low-benefit activities such as sports and social activities.

To sum up, senior high school students' schedule arrangement is a multi-dimensional complex system, including sleep duration, study time, homework burden, electronic device use, extracurricular activities and other aspects. These factors interact and jointly affect students' academic achievement. However, most current studies focus on a single factor, lacking a systematic study on the comprehensive impact of multiple dimensions of schedule sequences. Therefore, this study aims to explore the correlation between senior high school students' daily schedule sequences and academic achievement through statistical methods such as multiple regression analysis, threshold model and Shapley value decomposition, so as to provide a scientific basis for optimizing senior high school students' schedules and improving their academic achievement.

2. Research Methods and Data Sources

2.1 Research Subjects

The data of this study comes from a large-scale basic education quality survey conducted in Shanghai in 2024. The research subjects are eighth-grade students, with a final valid sample of 54,102 students who provided sleep and achievement data. The sample covers 717 middle schools in Shanghai, including urban and rural areas, as well as different school types (such as key middle schools and ordinary middle schools). About 25% (13,549 students) of the sample reported sleeping no more than 7 hours per night during school, 61% (33,098 students) slept 8 hours or less, and about 9% (5,144 students) reported sleeping more than 9 hours.

2.2 Variable Measurement

Dependent variable: academic achievement. This study adopts standardized subject tests (including Chinese, mathematics, English, science and art) for evaluation. Raw scores are converted into standard scores with a mean of 500 and a standard deviation of 100.

Core independent variables:

- Sleep duration: the average nightly sleep duration of students during school reported by themselves, divided into six categories: <6 hours, 6-7 hours, 7-8 hours, 8-9 hours, 9-10 hours and >10 hours.
- Study time: the daily study time reported by students, divided into four categories: <2 hours, 2-3

hours, 3-4 hours and >4 hours.

- Homework burden: the daily homework time reported by students, divided into three categories: <2 hours, 2-3 hours and >3 hours.
- Electronic device use: including use time for study and recreation. Study use is divided into <1 hour, 1-2 hours, >2 hours; recreational use is divided into <2 hours, 2-4 hours, >4 hours.
- Extracurricular activities: including academic, sports, art, social and service activities, divided into five levels by weekly participation duration: 0 hours, 1-10 hours, 11-20 hours, 21-30 hours and >30 hours.

Control variables: including gender, urban-rural classification, local residence status, school type and family socio-economic and cultural status (ESCS), etc.

2.3 Statistical Methods

This study adopts a variety of statistical methods, including:

- Multiple linear regression (OLS): used to analyze the linear relationship between each schedule dimension and academic achievement.
- Threshold regression model: used to capture the non-linear relationship between schedule dimensions and academic achievement, especially the inverted U-shaped relationship.
- Shapley value decomposition: used to quantify the comprehensive contribution rate of each schedule dimension to academic achievement, considering the interaction effect between variables.
- Quantile regression: used to analyze the differential impact of schedule dimensions on students with different academic levels.

3. Research Results

3.1 Descriptive Statistical Analysis

Table 1. Descriptive Statistics of the Sample

Variable	Category	Percentage	Mean (Standard Deviation)
Sleep duration	<6 hours	11.4%	-
	6-7 hours	13.6%	-
	7-8 hours	25.8%	-
	8-9 hours	29.2%	-
	9-10 hours	10.0%	-
	>10 hours	10.0%	-
Study time	<2 hours	15.0%	-

	2-3 hours	40.0%	-
	3-4 hours	30.0%	-
	>4 hours	15.0%	-
Homework burden	<2 hours	30.0%	-
	2-3 hours	40.0%	-
	>3 hours	30.0%	-
Electronic device use for study	<1 hour	50.0%	-
	1-2 hours	30.0%	-
	>2 hours	20.00%	-
Electronic device use for recreation	<2 hours	40.0%	-
	2-4 hours	30.0%	-
	>4 hours	30.0%	-
Extracurricular activities	0 hours	20.0%	-
	1-10 hours	30.0%	-
	11-20 hours	25.0%	-
	21-30 hours	15.0%	-
	>30 hours	10.0%	-
Academic achievement	-	-	500 (100)

Data source: Author's own calculation.

It can be seen from Table 1 that about 25% of the students in the sample sleep less than 7 hours, 61% sleep 8 hours or less, and the proportion of students sleeping 8-9 hours is the highest (29.2%). Study time is mainly concentrated in the 2-4 hours interval, with the highest proportion of students studying 2-3 hours (40.0%). Homework burden is mainly concentrated in the 2-3 hours interval (40.0%). Most students use electronic devices for study less than 1 hour (50.0%), while recreational use is mainly 2-4 hours (30.0%). The participation in extracurricular activities is uneven: 20% of students do not participate in any extracurricular activities, and 10% spend more than 30 hours per week on extracurricular activities.

3.2 Relationship Between Sleep Duration and Academic Achievement

There is a significant inverted U-shaped relationship between sleep duration and academic achievement. As shown in Figure 1, with the increase of sleep duration, students' academic achievement first gradually improves and then declines after reaching a peak. Specifically, students who sleep less than 6 hours have the lowest average math score (458 points), while those in the 8-9 hours sleep interval perform the best (average score 509 points), and the average score drops to 482 points when sleep duration exceeds 10 hours.

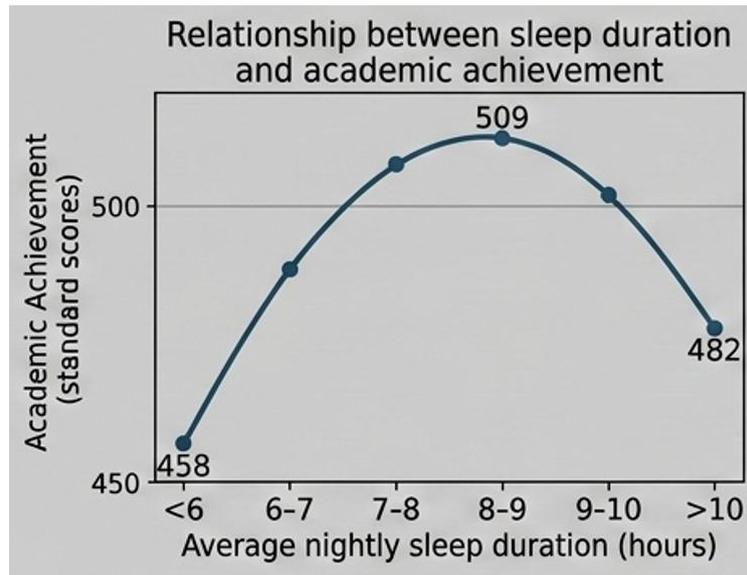


Figure 1. Relationship between Sleep Duration and Academic Achievement

Quadratic regression analysis is used to further verify this finding. The results show that the linear coefficient of sleep duration and academic achievement is positive, the quadratic coefficient is negative, and both are statistically significant ($p < 0.01$), indicating that the inverted U-shaped relationship does exist. The threshold regression model further clarifies this relationship. Taking mathematics, Chinese and science as examples, when sleep duration is less than 7-8 hours, increasing sleep will significantly improve grades; the positive effect reaches the strongest in the 7-9 hours interval; and when sleep exceeds 8-9 hours, the correlation with grades becomes significantly negative. This indicates that about 8 hours is the overall optimal point for multiple subjects.

3.3 Relationship Between Study Time and Academic Achievement

There is also a significant inverted U-shaped relationship between study time and academic achievement. As shown in Figure 2, students who study less than 2 hours have low academic achievement, and their grades gradually improve as study time increases to 2-4 hours; however, when study time exceeds 4 hours, grades tend to stabilize or even decline. Specifically, students with study time in the 2-4 hours interval have significantly higher academic achievement than those who study less than 2 hours or more than 4 hours ($p < 0.01$).

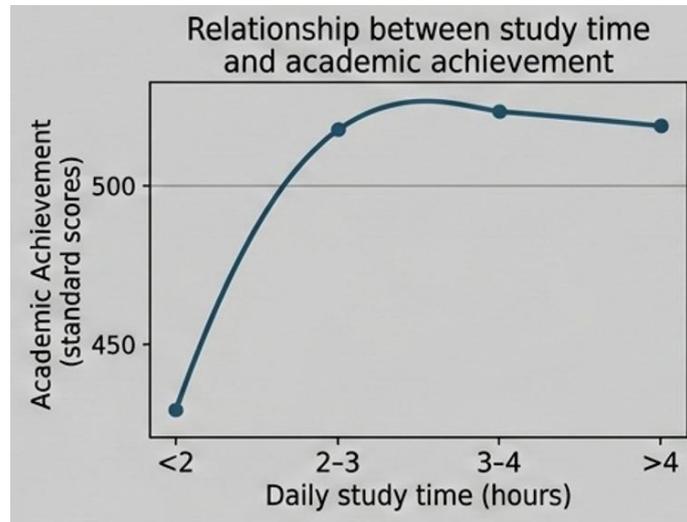


Figure 2. Relationship between Study Time and Academic Achievement

Regression analysis results show that study time can significantly predict academic achievement ($\beta=0.5$, $p<0.01$), but this positive predictive effect gradually weakens or even disappears when study time exceeds 4 hours. This indicates that for senior high school students, the quality and quantity of study time are equally important, and excessive study time may be counterproductive, because long-term study may lead to fatigue, inattention and decreased learning efficiency.

3.4 Relationship Between Homework Burden and Academic Achievement

There is a significant negative correlation between homework burden and academic achievement. As shown in Figure 3, with the increase of homework burden, students' academic achievement gradually declines. Specifically, students with homework time <2 hours have the highest academic achievement, and their grades drop slightly as homework time increases to 2-3 hours; when homework time exceeds 3 hours, grades drop significantly ($p<0.01$).

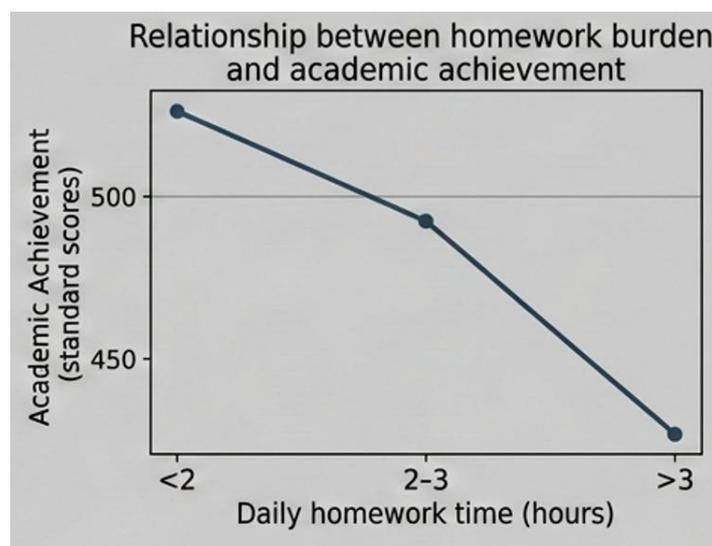


Figure 3 Relationship between Homework Burden and Academic Achievement

Regression analysis results show that the impact of homework burden on academic achievement is significantly negative ($\beta=-0.3$, $p<0.01$), and this negative impact is more obvious in rural students ($\beta=-0.5$, $p<0.01$). This may be because rural students often lack sufficient rest time after completing homework, leading to insufficient sleep and decreased learning efficiency. At the same time, rural students have a heavier homework burden, with more repetitive and mechanical content, which further exacerbates the negative impact on academic achievement.

3.5 Relationship Between Electronic Device Use and Academic Achievement

The impact of electronic device use on academic achievement varies by purpose. The use of electronic devices for study (such as online courses and learning software) is positively correlated with academic achievement, but this positive impact gradually weakens after the use time exceeds 2 hours. The recreational use of electronic devices (such as games and social media) is negatively correlated with academic achievement, and this negative impact is significantly enhanced when the use time exceeds 4 hours.

As shown in Figure 4, the use time of electronic devices for study is positively correlated with academic achievement, but the slope gradually flattens; while the recreational use time is negatively correlated with academic achievement, and the slope increases significantly after exceeding 4 hours.

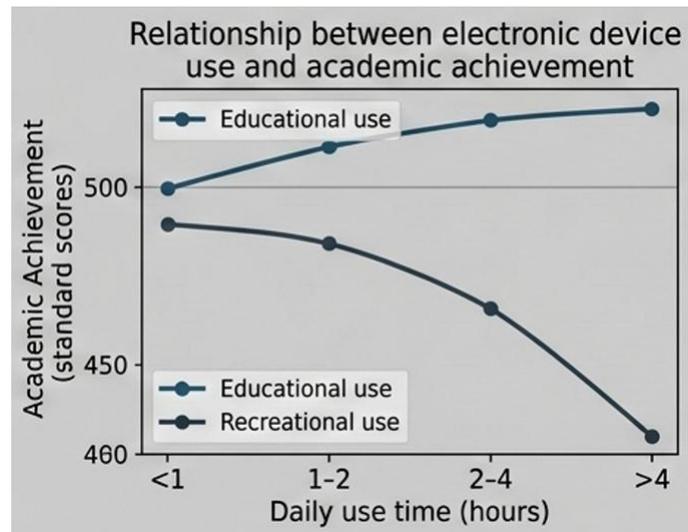


Figure 4. Relationship between Electronic Device Use and Academic Achievement

Regression analysis results show that the positive impact of electronic device use for study on academic achievement is significant ($\beta=0.2$, $p<0.01$), but it is most obvious when the use time is <2 hours; while the negative impact of recreational use on academic achievement is significant ($\beta=-0.4$, $p<0.01$), and it is the most serious when the use time is >4 hours. This indicates that there is an obvious “substitution effect” in the use of electronic devices: excessive recreational use crowds out study and rest time, thus having a negative impact on academic achievement.

3.6 Relationship Between Extracurricular Activities and Academic Achievement

The impact of extracurricular activities on academic achievement presents a non-linear relationship of first increasing and then decreasing. As shown in Figure 5, when extracurricular activity time increases to 1-10 hours, academic achievement improves significantly; but when extracurricular activity time exceeds 20 hours, academic achievement begins to decline. Specifically, students who participate in 1-10 hours of extracurricular activities per week have significantly higher academic achievement than those who do not participate or participate for too long ($p < 0.01$).

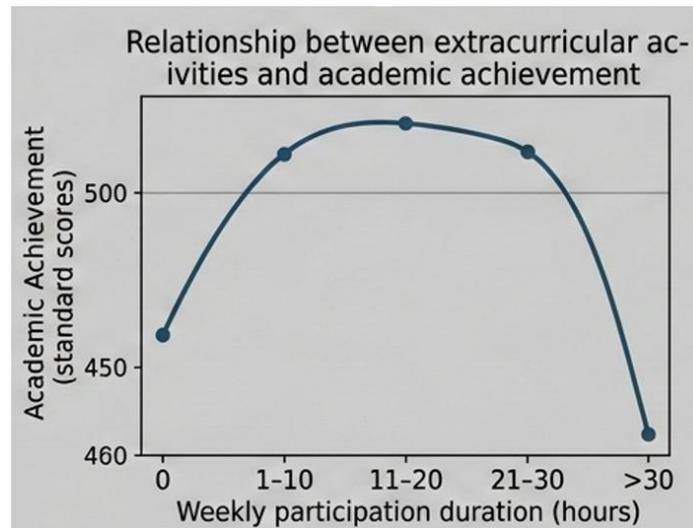


Figure 5. Relationship between Extracurricular Activities and Academic Achievement

Regression analysis results show that the positive impact of extracurricular activity participation on academic achievement is significant ($\beta = 0.3$, $p < 0.01$), but it is most obvious when the participation time is 1-10 hours. The results of Shapley value decomposition show that the explanatory contribution rate of extracurricular activities to academic achievement is 4.36%, among which academic (such as debate, subject competition) and service (such as community service) activities have the highest contribution rates, reaching 5.2% and 4.8% respectively; while sports and social activities have lower contribution rates, 3.5% and 2.8% respectively.

3.7 Comprehensive Impact of Different Schedule Dimensions on Academic Achievement

To explore the comprehensive impact of different schedule dimensions on academic achievement, this study adopts the Shapley value decomposition method to quantify the explanatory contribution rate of each factor to academic achievement. As shown in Table 2, sleep duration (including linear and quadratic terms) contributes the most to the explanation of academic achievement, reaching 6.94%; followed by study time (5.11%); and homework burden has the most significant negative impact, with an explanatory contribution rate of -2.95%.

Table 2. Results of Shapley Value Decomposition

Variable	Explanatory contribution rate	95% confidence interval
Sleep duration	6.94%	6.52%-7.36%
Study time	5.11%	4.78%-5.44%
Homework burden	-2.95%	-3.21% - -2.69%
Electronic device use for study	2.15%	1.98%-2.32%
Electronic device use for recreation	-1.89%	-2.05% - -1.73%
Extracurricular activities	4.36%	4.01%-4.71%
Urban-rural classification	1.23%	1.05%-1.41%
Control variables	-	-

Data source: Author's own calculation.

Further analysis finds that different schedule dimensions have significant differences in the impact on academic achievement of different subjects. Subjects requiring high logical reasoning, problem-solving and abstract thinking abilities, such as mathematics, science and Chinese, are more sensitive to schedule changes, and sleep duration has the highest explanatory contribution rate (mathematics 6.24%, science 6.94%, Chinese 5.11%). In contrast, foreign language and art subjects are less sensitive to schedule changes, and the negative impact of homework burden is more significant (foreign language -2.95%, art -4.36%).

3.8 Impact of Urban-Rural Differences on Schedule Arrangement

Urban-rural differences significantly affect the impact of schedule arrangement on academic achievement. As shown in Table 3, urban students have significantly longer sleep duration than rural students (8.2 hours vs 7.5 hours), and slightly longer study time (3.5 hours vs 3.0 hours). At the same time, urban students have significantly higher participation in extracurricular activities than rural students (15.0 hours per week vs 8.5 hours). Urban students are more inclined to participate in academic and service activities, while rural students mostly participate in sports and social activities.

Table 3. Comparison of Schedule Arrangements between Urban and rural Students

Variable	Urban students	Rural students	Difference (p-value)
Sleep duration	8.2 hours	7.5 hours	0.7 hours (p<0.01)
Study time	3.5 hours	3.0 hours	0.5 hours (p<0.01)
Homework burden	2.8 hours	3.2 hours	-0.4 hours (p<0.01)

Electronic device use for study	1.5 hours	0.8 hours	0.7 hours ($p < 0.01$)
Electronic device use for recreation	3.0 hours	4.5 hours	-1.5 hours ($p < 0.01$)
Extracurricular activities	15.0 hours	8.5 hours	6.5 hours ($p < 0.01$)
Academic achievement	515 points	485 points	30 points ($p < 0.01$)

Data source: Author's own calculation.

Regression analysis results show that urban-rural differences have a significant impact on the relationship between schedule arrangement and academic achievement. For urban students, the positive impacts of sleep duration and study time on academic achievement are more significant, and the positive impact of extracurricular activities is also more obvious. For rural students, the negative impact of homework burden is more significant, and the negative impact of recreational use of electronic devices is also more serious. This indicates that rural students' academic achievement may be more negatively affected when facing the same schedule arrangement, which may be related to the differences in educational resources and learning environment between urban and rural areas.

4. Discussion and Conclusion

4.1 Theoretical Significance of Research Findings

The findings of this study have important theoretical significance for educational psychology and time management theory. Firstly, the inverted U-shaped relationship between sleep duration and academic achievement confirms the importance of sleep for cognitive function. Too much or too little sleep will affect students' attention, memory and learning efficiency. Secondly, the inverted U-shaped relationship between study time and academic achievement indicates that learning efficiency does not increase linearly, but there is an optimal interval, which is consistent with the cognitive load theory. That is, when study time is too long, students' cognitive load exceeds their processing capacity, leading to decreased learning efficiency.

Thirdly, the negative correlation between homework burden and academic achievement supports the "overtraining" theory, that is, too much repetitive practice can not only not improve learning effect, but also lead to fatigue and weariness of learning. Fourthly, the "substitution effect" of electronic device use confirms the dual impact of technology use on learning. Moderate educational use can improve learning efficiency, but excessive recreational use will interfere with learning.

Finally, the non-linear impact of extracurricular activities confirms the "all-round development" theory,

that is, moderate extracurricular activities can promote students' social ability, emotional regulation and self-concept, thereby indirectly improving academic achievement; but excessive extracurricular activities may lead to uneven time allocation and affect learning and rest.

4.2 Policy and Practical Implications

The findings of this study have important implications for educational policy formulation and school management practice. Firstly, schools and parents should pay attention to students' sleep quality and ensure that students get 7-9 hours of sufficient sleep every night. For students with insufficient sleep, measures should be taken to improve their sleep environment and habits, such as reducing the use of electronic devices and adjusting schedules.

Secondly, the management of study time should focus on the balance between quality and quantity, and avoid excessive extension of study time leading to decreased efficiency. Teachers should design high-quality homework and learning tasks to improve learning efficiency; students should learn to reasonably plan study time and avoid ineffective learning.

Thirdly, reducing homework burden should be an important direction of senior high school education reform. Schools should strictly control the total amount and difficulty of homework and avoid mechanical and repetitive homework; teachers should design layered homework according to students' ability differences to meet the learning needs of different students.

Fourthly, the use of electronic devices should be reasonably guided. Schools should formulate electronic device use policies, distinguish between study and recreational use, encourage educational use and limit recreational use; parents should cooperate with schools to supervise students' electronic device use and help students establish healthy digital habits.

Finally, the participation in extracurricular activities should encourage moderate and diversified participation. Schools should provide a variety of extracurricular activity options, especially academic and service activities, to promote students' all-round development; at the same time, avoid forcing students to participate in too many extracurricular activities that affect their normal study and rest.

5. Suggestions and Prospects

5.1 Suggestions for Educational Management

1) Optimize curriculum arrangement and schedule: Schools should reasonably arrange class time and extracurricular activities to ensure that students have sufficient rest and sleep time. It is recommended to advance the afternoon dismissal time to 4:30-5:00, so that students have more time for extracurricular activities and rest.

2) Implement layered homework and personalized tutoring: Schools should strictly control the total amount of homework and avoid the "one-size-fits-all" homework assignment method. It is recommended to design layered homework according to students' ability differences and provide personalized tutoring for students with academic difficulties to improve learning efficiency.

3) Strengthen the management of electronic device use: Schools should formulate electronic device use

policies, distinguish between study and recreational use, encourage educational use and limit recreational use. It is recommended to restrict the use of electronic devices in class and provide appropriate guidance on electronic device use during after-school study periods.

4) Promote the diversification and quality improvement of extracurricular activities: Schools should provide a variety of extracurricular activity options, especially academic and service activities, to promote students' all-round development. At the same time, ensure the quality of extracurricular activities and avoid formalism and inefficient activities.

5.2 Suggestions for Families

1) Pay attention to children's sleep quality: Parents should create a good sleep environment, such as keeping the bedroom quiet, dark and at a suitable temperature, limiting the use of electronic devices before bedtime, and helping children establish a regular schedule.

2) Improve learning efficiency rather than extending study time: Parents should help children improve learning efficiency, such as adopting learning methods such as active recall and spaced repetition, and avoid simply extending study time. Studies show that active learning methods (such as recalling knowledge points without notes) are more effective than passive learning (such as repeated reading or doing exercises).

3) Reduce homework burden: Parents should communicate with schools to understand the specific content of the "Double Reduction" policy, supervise the school's homework assignment, and avoid excessively increasing students' homework burden. At the same time, parents should pay attention to their children's homework completion and help solve learning difficulties instead of blindly increasing the amount of homework.

4) Reasonably guide the use of electronic devices: Parents should supervise their children's use of electronic devices, distinguish between study and recreational use, encourage educational use and limit recreational use. It is recommended to formulate an electronic device use plan with children to cultivate their digital literacy and self-control ability.

5.3 Future Research Directions

1) Longitudinal tracking study: This study adopts cross-sectional data, which is difficult to determine causality. Future studies can adopt a longitudinal tracking design to observe the long-term impact of schedule arrangement on academic achievement and determine causality more accurately.

2) Regional difference study: The data of this study mainly comes from Shanghai. Future studies can be extended to different regions to compare the relationship between schedule arrangement and academic achievement of students in urban and rural areas, eastern and western regions, so as to provide a more comprehensive basis for policy formulation.

3) In-depth study of learning methods and efficiency: This study focuses on study time, but the research on learning methods and efficiency is relatively limited. Future studies can further explore the impact of different learning methods on students' academic achievement and how to improve learning efficiency by optimizing learning methods.

4) Research on the integration of digital technology and education: With the rapid development of digital technology, the application of electronic devices in education is increasingly widespread. Future studies can further explore how to effectively integrate digital technology into the educational process to improve learning efficiency while avoiding its negative impact.

6. Conclusion

Through statistical methods such as multiple regression analysis, threshold model and Shapley value decomposition, this study systematically explores the correlation between senior high school students' daily schedule sequences (including sleep duration, study time, homework burden, electronic device use and extracurricular activities) and academic achievement. The main findings are as follows:

- 1) Both sleep duration and study time have an inverted U-shaped relationship with academic achievement, with the optimal interval of sleep duration being 7-9 hours and that of study time being 2-4 hours.
- 2) Homework burden is negatively correlated with academic achievement, especially for rural students, excessive homework burden will significantly inhibit their academic performance.
- 3) There is an obvious "substitution effect" in the use of electronic devices: moderate use for study has a positive impact on academic achievement, while excessive recreational use has a negative impact on academic achievement.
- 4) The impact of extracurricular activities on academic achievement presents a non-linear relationship of first increasing and then decreasing. Moderate participation (1-10 hours per week) has a positive impact on academic achievement, while excessive participation (>30 hours per week) may have a negative impact.
- 5) Urban-rural differences significantly affect the impact of schedule arrangement on academic achievement. Under the same schedule arrangement, urban students usually have better academic achievement than rural students, which may be related to the differences in educational resources and learning environment between urban and rural areas.
- 6) Sleep duration contributes the most to the explanation of academic achievement, reaching 6.94%, followed by study time (5.11%), and homework burden has the most significant negative impact, with an explanatory contribution rate of -2.95%.

To sum up, optimizing senior high school students' daily schedule sequences is of great significance to improving their academic achievement. Schools, parents and students themselves should pay attention to the rationality of schedule arrangement, ensure sufficient sleep, moderate study time, reasonable homework burden, appropriate use of electronic devices and moderate participation in extracurricular activities, so as to create good conditions for students' academic success and all-round development.

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