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Cluster Analysis of Sleep Time and Adolescent Health Risk Behaviors

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Abstract

Adolescents are prone to multiple health risk behaviors. These might lead to insufficient sleep, which is inconducive to adolescent growth. Therefore, this study explored the impact of a cluster of adolescent health risk behaviors on sleep time, providing a reference for designing relevant intervention measures. From November to December 2019, a stratified cluster sampling method was used to sample middle and high schools in 4 functional districts of Chongqing, China. A total of 8546 participants were selected for a questionnaire survey. Two-step clustering helped identify the health risk behavior clusters. Multivariate logistic regression models helped examine the association between the different clusters and sleep time. The rate of insufficient sleep was 65.8%. Three types of clusters were identified, namely (1) high-risk (poor) cluster (17.3%), (2) low physical activity (medium) cluster (55.1%), and (3) low-risk (good) cluster (27.6%). The high-risk and low physical activity clusters showed that the adjusted OR values of 1.471 (1.266-1.710) and 1.174 (1.052-1.310) were significantly associated with insufficient sleep ($P < .001$). Adolescent health risk behaviors were clustered, and different clusters had different sleep time. Schools authorities and healthcare practitioners should formulate effective intervention measures according to the characteristics of different clusters to promote healthy growth among adolescents.

Keywords

health promotion, risk behavior, sleep, cluster analysis, student

What do we already know about this topic?
Adolescents are more prone to health risk behaviors, which affect their growth.

How does this research contribute to the field?
This study is the first to explore the impact of clusters of risk behaviors on sleep time, breaking the norm of exploring the effect of a single risk behavior on sleep time.

What are the research's implications toward theory, practice, or policy?
This study suggests that different clusters have different sleep time, and school authorities and healthcare practitioners should design cluster-specific interventions.

Introduction

Sleep time has a far-reaching impact on healthy adolescent growth. Sufficient sleep is related to adolescents achieving ideal academic performance, enhancing immunity, and promoting growth and development, thus increasing their happiness.[1-3] Adolescence is a key transition phase from childhood to adulthood. During this phase, biological changes in sleep time (physiological phase delay) and adapting to heavy learning pressures as well as complicated social interactions make them susceptible to sleep and physiological disorders.[4] Lack of sleep among adolescents has been linked to lower academic performance, poorer lifestyle, and increased cardiometabolic disease.[5] About 70% of children and adolescents aged 6 to 17 years in China get insufficient sleep, and with age, the sleep time becomes shorter.[6] Research showed that adolescents in Asia sleep time less than those in Europe and North America.[7]

Sleep time is not only related to the family environment and students' academic burdens, but also to health risk behaviors (HRBs), such as smoking, drinking, physical activity (PA), screen time, and Internet addiction.[5,8-11] For example, on the one hand, low PA leads to lack of sleep.[12,13] On the other hand, some studies showed that the longer the extracurricular activities, the shorter the sleep time.[14] Smoking and drinking also reduce sleep time.[15-17] A recent

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cohort study showed a 2-way relationship between smoking, drinking, and sleep.[10] The relationship between smoking and sleep time may be partly caused by nicotine stimulating neurotransmitters that regulate sleep.[18] Although moderate drinking is good for sleep, alcohol is also a cause of anxiety in men, thus affecting sleep.[19] Kawabe et al's research showed that the total sleep time of the study's Internet addiction group was significantly less than that of the possible addiction group.[11] A meta-analysis also showed that the sleep time of an Internet addiction group was 0.24 h less than that of the non-Internet addiction group.[20]

Jessor's problem behavior theory posits that involvement in one problem behavior increases the likelihood of involvement in other forms of problem behavior.[21] However, most studies only discussed the relationship between one or a cluster of HRBs and sleep, ignoring the synergy of HRBs. In recent years, research has reported that adolescent HRBs tend to cluster or coexist with age.[22] Cluster or latent analysis has been applied to the analysis of adolescent HRBs. This method is individual-centered, and groups with common characteristics are placed under the same cluster.[23] A study in China identified 4 clusters, namely (1) active cluster, (2) high sleep duration cluster, (3) high screen time cluster, and (4) low physical activity-low sleep duration cluster. It was concluded that the risk of depression in cluster 1 was lower than that in clusters 3 and 4.[24] Verónica identified 5 clusters, namely (1) active cluster, (2) off-screen sedentary time-high diet quality cluster, (3) inactive-high sleep time cluster, (4) off-screen sedentary time-low diet quality cluster, and (5) sedentary screen time-low sleep time cluster. It was concluded that the physical fitness of cluster 1 was the best.[25] A study identified 3 types of clusters in Brazil: (1) phubbers, (2) gamers, and (3) healthier. It was concluded that cluster 3 has better self-rated health.[26] Another study identified 4 types of clusters: (1) high alcohol-sedentary cluster, (2) high sedentary cluster, (3) high smoking cluster, and (4) low risk cluster, where cluster 4 had better mental health.[27] Clustering of HRBs has been used to explain the etiology of important outcomes, so cluster analysis also contributes to a comprehensive understanding of the interdependence of behaviors associated with sleep timing. Additionally, existing studies have shown that multiple risk behavior approaches are usually not reflected in the formulation of policies and interventions to reduce adolescent HRBs.[28] Therefore, more comprehensive and workable HRBs assessments, such as clustering of adolescent HRBs, are needed. These are essential for the effective planning of adolescent health promotion interventions. This study is the first to explore the impact of the clustering of HRBs on adolescent sleep time. This is to assess whether interventions should address these HRBs sequentially or simultaneously.

Sufficient sleep is essential for adults and even more so, for adolescents. Teenagers are usually quite curiosity about the outside world, which makes them more vulnerable to HRBs. Therefore, for an improved promotion of adolescents' healthy growth, this study explored the relationship between sleep time and PA, smoking, drinking, and Internet addiction. It learned the characteristics of adolescent HRBs to suggest effective interventions that enable adolescents to get sufficient sleep.

Objectives and Methods

Research Objectives

This cross-sectional study was based on the formula $n = Z^2_{a/2}P(1\text{-}P)/\varepsilon^2$, $a = 0.05$, and $\varepsilon = 0.01$. According to existing literature, the incidence of insufficient sleep among adolescents is 70%.[6] Thus, the calculated sample size was 8068. Adding 10% to non-response rate, the final sample size was 8875.

From November to December 2019, the stratified cluster sampling method was adopted to select one district (county) from each of the 4 functional districts, namely the urban functional core district, the urban functional expansion district, the urban development new district, and the ecological conservation and development district in northeast Chongqing, as the survey district (county) according to the function of Chongqing and the geographical location. Finally, the Jiulongpo, Banan, Qijiang districts, and Yunyang County were chosen. Thereafter, 2 complete middle schools (including middle school and high school) were selected from each district (county), with 8 schools in total, 4 in urban areas and 4 in rural areas. Four classes were selected from each grade (grade 1 of middle school to grade 3 of high school), and a questionnaire survey was conducted involving all students in school on the day it was administered. A total of 9338 questionnaires were distributed. The Ethics Committee of Chongqing Medical University approved this study. All the participants and their guardians provided written informed consent.

Measures

Data on the 4 kinds of risk behaviors, namely PA, smoking, drinking, and Internet addiction, were collected using the Questionnaire on Health Related Behaviors of Chinese Adolescents related questions.[29]

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Physical activity. Participants were asked, in the past week, how many days did you engage in moderate-to-vigorous sports (60 min or more, making you gasp, or having your heart race. For example, running, playing basketball, playing football, swimming, etc.)? Eight options were available ranging from 0 to 7 days. Those who answered <3 days were considered to have engaged in low PA.[30]

Smoking. There were 5 options to the following question: "In the past 30 days, how many days have you smoked?" These were "Never smoked," "1-9," "10-19," "20-29," and "30" days. Those who answered ≥1 day were considered smoking.[31]

Drinking. There were 5 options to the following question: "In the past 30 days, how many days have you had at least 1 glass of wine?" These were "Never drank or tasted only a few mouthful," "1-9," "10-19," "20-29," and "30" days. Those who answered ≥1 day were considered drinking.[31]

Internet addiction. There were 10 items related to Internet addiction: ① "In the past 7 days, the average time of surfing the Internet was more than 4 hours," ② "When I am not surfing the Internet, I still think about the online content"; ③ "I feel uncomfortable when I don't surf the Internet, while surfing the Internet would ease me"; ④ "Increased online time to derive satisfaction," ⑤ "Lost interest in other activities because of surfing the Internet," ⑥ "I don't want to surf the Internet, but I can't control it"; ⑦ "Unable to finish homework or play truant because of surfing the Internet," ⑧ "Concealing the fact of surfing the Internet from parents, classmates, and teachers"; ⑨ "Continuing to surf the Internet knowing the negative consequences," ⑩ "Using the Internet to cope with difficulties, depression, helplessness, or anxiety." When the research object must exist ① and at least 4 items of ②-⑩ appear, Internet addiction is considered.[32,33]

Sleep time. The question on sleep time was "How much sleep do you usually get during school days?" Those who answered less than 8 h were considered to get insufficient sleep.[34]

Statistical Analysis

Epi Data 3.1 software was used to establish the database, and IBM SPSS software (version 25.0) was used for data processing and statistical analysis. Sample numbers and percentages were used to describe the basic sample characteristics. After weighing the sample, a chi-squared test was used to compare the differences in the different demography characteristics of sleep time. The 2-step clustering method was used for clustering the HRBs, which is an ideal method for processing big data and can automatically determine the optimal clustering number.[35] The logarithmic likelihood method was used for clustering distance, and the Schwartz Bayes criterion (BIC) was used as the clustering criterion. According to the best combination of low BIC, high BIC change ratio, and high distance measurement ratio, the 3 clusters were automatically determined by the system. The closer the contour coefficient is to 1, the better the clustering quality. The average contour coefficient in this study was 0.9, and the clustering quality was good. The importance of each variable ranges from 0 to 1, with a value close to 1 indicating a relatively greater importance. In this study, the importance of the 3 variables was 1, and that of 1 variable was 0.87. Finally, multivariate logistic regression was used to analyze the influence of different clusters on sleep time, and the model was tested using the Hosmer-Lemeshow goodness of fit test. $P < .05$ was considered statistically significant.

Results

Basic Information

A total of 9338 questionnaires were distributed, and the effective rate was 91.5%. The sample consisted of 4083 (47.8%) middle school students and 4463 (52.2%) high school students; boys accounted for 47.1% (n = 4025) of the sample, while girls comprised 52.9% (n = 4521). The rates of low PA, smoking, drinking, and Internet addiction were found to be 66.1% (n = 5649), 2.9% (n = 251), 12.9% (n = 1102), and 4.9% (n = 421), respectively.

Demographic Differences in Sleep Time

Based on all valid responses, 34.2% (n = 2926) of the adolescents had sufficient sleep time, while 65.8% (n = 5620) had insufficient sleep time. Additionally, sleep time varied observably according to adolescents' grade, gender, accommodation type, homestyle, economic status, and academic performance. However, there was no difference in a singleton ($P > .05$). High school students got more insufficient sleep than middle school students (79.8% vs 50.4%, $P < .001$); girls got more insufficient sleep than boys (69.7% vs 61.4%, $P < .001$); the boarding students got more insufficient sleep than commuting students (72.8% vs 59.7%, $P < .001$); students from single parent families got more insufficient sleep than those from big, nuclear, or other kinds of families (71.5% vs 64.9% vs 66.0% vs 64.2%, $P = .007$); those who had a bad economic status got more insufficient sleep than those who had medium and good economic status (74.7% vs 66.0% vs 55.8%, $P < .001$); those with bad academic performance got more insufficient sleep than those with medium and good academic performance (67.5% vs 66.8% vs 61.8%, $P < .001$) (Table 1).

Cluster Analysis of Health Risk Behaviors

SPSS 25.0 was used for 2-step clustering, and the better models were finally determined as 3 clusters. Table 2 presents the 3 clusters. Cluster 1 was labeled as "high-risk

Table 1. Demography Characteristics in Sleep Time.

Variable	Total sample n = 8546 (100%)	Sleep time: sufficient n = 2926 (34.2%)	Sleep time: insufficient n = 5620 (65.8%)	x^2	*P*
Grade				818.992	<.001
Middle school	4083 (47.8)	2025 (49.6)	2058 (50.4)		
High school	4463 (52.2)	901 (20.2)	3562 (79.8)		
Gender				65.281	<.001
Boy	4025 (47.1)	1555 (38.6)	2470 (61.4)		
Girl	4521 (52.9)	1371 (30.3)	3150 (69.7)		
Accommodation type				161.362	<.001
Boarding students	3966 (46.4)	1080 (27.2)	2886 (72.8)		
Commuting students	4580 (53.6)	1846 (40.3)	2734 (59.7)		
Singleton				0.086	.770
Yes	2763 (32.3)	940 (34.0)	1823 (66.0)		
No	5783 (67.7)	1986 (34.3)	3798 (65.7)		
Homestyle				12.007	.007
Big family	4279 (50.1)	1503 (35.1)	2776 (64.9)		
Nuclear family	3059 (35.8)	1040 (34.0)	2019 (66.0)		
Single parent family	677 (7.9)	193 (28.5)	484 (71.5)		
Other families	531 (6.2)	190 (35.8)	341 (64.2)		
Economic status				97.853	<.001
Bad	1208 (14.1)	306 (25.3)	902 (74.7)		
Medium	6079 (71.1)	2064 (34.0)	4015 (66.0)		
Good	1259 (14.7)	556 (44.2)	703 (55.8)		
Academic performance				21.386	<.001
Bad	3140 (36.7)	1019 (32.5)	2121 (67.5)		
Medium	3192 (37.4)	1061 (33.2)	2131 (66.8)		
Good	2214 (25.9)	846 (38.2)	1368 (61.8)		

Table 2. Cluster Analysis of Health Risk Behaviors.

Cluster	Sample n = 8546 (100%)	Low PA n = 5649 (66.1%)	Smoking n = 251 (2.9%)	Drinking n = 1102 (12.9%)	Internet addiction n = 421 (4.9%)
1 high-risk (poor) cluster	1476 (17.3)	937 (63.5)	251 (17.0)	1102 (74.7)	421 (28.5)
2 low PA (medium) cluster	4712 (55.1)	4712 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)
3 low-risk (good) cluster	2358 (27.6)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)

(poor)," accounting for 17.3% (n = 1476), and the incidence of most risk behaviors was at a high level in the 3 clusters. Cluster 2 was labeled as "low PA (medium)," accounting for 55.1% (n = 4712) of the total sample, in which 100.0% adolescents reported low PA. Cluster 3 was labeled as "low-risk (good)," accounting for 27.6% (n = 2358), and the incidence of each behavior was 0.

Multivariate Logistic Regression

The logistic regression model passed the Hosmer-Lemeshow goodness-of-fit test ($X^2 = 9.177$, $P = .240$). Table 3 shows the association between insufficient sleep and the clusters of HRBs. After adjusting for demographic characteristics (grade, gender, accommodation type, homestyle, economic status, academic performance), clusters 1 and 2 were 1.471 times (AOR = 1.471, 95% CI: 1.266-1.710; $P < .001$) and 1.174 times (AOR = 1.174, 95% CI: 1.052-1.310; $P < .01$) more likely to cause insufficient sleep compared to cluster 3.

Discussion

Our results showed that 65.8% of adolescents did not get sufficient sleep. Although it is lower than the average level in China,[6] it is still on the higher side, and this needs to be addressed. High school students slept less than middle school students, which was consistent with the results of a study based on 4 cities in China,[36] which attributed this phenomenon to more intense academic pressure and more complicated interpersonal relationships in high school.[37]

Table 3. Association of Insufficient Sleep With Different Cluster of Health Risk Behaviors.

		Insufficient sleep	
Variables	n (%)	OR (95% CI)	AOR (95% CI)
1 high-risk (poor) cluster	1076 (72.9)	2.044 (1.775-2.352)[a]	1.471 (1.266-1.710)[a]
2 low PA (medium) cluster	3204 (68.0)	1.614 (1.458-1.787)[a]	1.174 (1.052-1.310)[b]
3 low-risk (good) cluster	1340 (56.8)	1	1

Note. AOR, adjusted for grade, gender, accommodation type, homestyle, economic status, academic performance.
OR = odds ratio; AOR = adjusted odds ratio; 95% CI = 95% confidence interval.
[a]<.001. [b]<.01.

Consistent with previous studies,[38,39] there was a significant gender-based difference in sleep time. Adolescent girls are more sensitive, and tend to stress over trivial matters that increases pressure and affects sleep.[40] Insufficient sleep of boarding students was more than that of commuting students, which was inconsistent with the research results of Zhang et al,[40] and may be related to the differences in schools and regions. There was no difference in sleep time based on whether a student was a single child or had siblings, similar to the results of a study in South Korea.[41] However, Blair et al showed that adolescents with siblings got lesser sleep time due to delays.[42] Students from single-parent families got more insufficient sleep than students from other family types, which was consistent with previous research results.[43] Perhaps children from single-parent families receive less attention, which affects their sleep. Students belonging to a poor economic background got more insufficient sleep, consistent with another studies.[44] Students from poor families have a higher sense of inferiority, which affects their sleep.[40] Students with bad academic performance got more insufficient sleep, which was consistent with the results of a study in China.[45] Perhaps such students do not have much self-control and stay up late but have to wake up early, leading to lesser sleep time.

This study used cluster analysis to cluster the HRBs of adolescents into high-risk (poor), low PA (medium), and low-risk (good) clusters. The number of clusters was inconsistent with relevant research, which may be related to the behavioral factors or analysis methods of clustering.[25,26] The high-risk cluster accounted for 17.3% of the sample, among which 63.5% adolescents had low PA, 17.0% adolescents were smokers, 74.7% adolescents were drinkers, and 28.5% adolescents were addicted to the Internet. The incidence of various risk behaviors was higher than that of the other clusters. This was consistent with the results of an African study.[46] Previous studies showed that smoking and drinking often occur simultaneously,[47] and this study further showed that Internet addiction may also appear along with these 2 habits. This can be explained by the fact that teenagers who indulge in intense smoking and substance abuse tend to have longer screen time, which leads to Internet addiction.[48] Previous studies only showed that Internet addiction affects sleep time.[11] This study included Internet addiction in cluster analysis, which may provide new perspective for related research. In today's age of the Internet, teenagers' Internet addiction should be understood. The low PA cluster accounted for 55.1% of the sample, and the incidence of low PA behavior was 100%, which was similar to another study in China.[27] The potential explanation for the existence of this model is the heavy academic burden. Studies showed that physical activity is related in a U-shaped manner to a variety of health outcomes, and there may be a potential threshold, that is, spending enough time engaging in PA can compensate for the negative effects of adolescence.[24] It is suggested that PA should be emphasized in the intervention of adolescent-related risk behaviors; only a small number of low-risk clusters were included in this study, which was consistent with the results of other studies.[26,44] The incidence of the 4 kinds of HRBs was 0 in the low-risk cluster, which was inconsistent with the cluster results of other HRBs.[24,25,49] These studies showed that although there were fewer HRBs in the low-risk cluster, they were present nonetheless, and this may be related to the lower incidence of smoking, drinking, and Internet addiction or evaluation criteria.[49-53] However, monitoring and health promotion of this cluster is also important, as the proportion of adolescents transitioning from the healthy behavior to the sedentary and low PA clusters is quite high.[54]

This study showed that the sleep time of the different HRBs clusters differed. The incidence of insufficient sleep in the high-risk cluster was higher than that in the other clusters, which is consistent with the results of other related studies. For example, according to study, clusters with higher risk behaviors are at a higher risk of psychological issues, obesity, and low quality of life.[24,27,55,56] Unfortunately, we could not find an analysis of behavior clustering and sleep time. Although the incidence of low PA was 100% in the low PA cluster and 63.5% in the high-risk cluster, the high incidence of other behaviors in high-risk cluster resulted in more students with insufficient sleep. This suggests that the cluster with multiple risk behaviors had a higher risk of insufficient sleep than the cluster with a single behavior. However, teenagers with low PA clusters deserve attention.

The large sample size was an obvious strength of this study. It provided new understanding of the clustering of adolescent HRBs and a new and unique perspective on the relationship

between HRBs and sleep. Additionally, previous studies only discussed the influence of one or one kind of risk behavior on sleep, ignoring the clustering phenomenon of adolescent HRBs. Our study has broken this norm. Despite these strengths, this study has some limitations. First, the survey was cross-sectional, and no causal relationships could be obtained. Second, the study adopted a self-report method, which may have resulted in a recall bias. Finally, we only investigated students who were in school, and students who were not in school were perhaps more likely to engage in risk behaviors.

Conclusions

In general, this study showed the presence of a clustering phenomenon of adolescent HRBs, and that the incidence of insufficient sleep differs among adolescents across different clusters. Therefore, targeted intervention measures should be formulated according to the characteristics of the different clusters. Additionally, this study noted that clusters with higher rates of multiple risk behaviors had a higher risk of insufficient sleep. Schools and healthcare practitioners should focus on monitoring and designing interventions for this cluster. Future research should focus on the mechanisms related to different risk behaviors and how they interact with each other to influence sleep.

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Ethics Approval

The investigation was approved by the Ethics Committee of Chongqing Medical University. Participants and their guardians were given written informed consent.

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