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ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

Медицинские новости Грузии

საქართველოს სამედიცინო სიახლენი

GEORGIAN MEDICAL NEWS

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GMN: Georgian Medical News is peer-reviewed, published monthly journal committed to promoting the science and art of medicine and the betterment of public health, published by the GMN Editorial Board since 1994. GMN carries original scientific articles on medicine, biology and pharmacy, which are of experimental, theoretical and practical character; publishes original research, reviews, commentaries, editorials, essays, medical news, and correspondence in English and Russian.

GMN is indexed in MEDLINE, SCOPUS, PubMed and VINITI Russian Academy of Sciences. The full text content is available through EBSCO databases.

GMN: Медицинские новости Грузии - ежемесячный рецензируемый научный журнал, издаётся Редакционной коллегией с 1994 года на русском и английском языках в целях поддержки медицинской науки и улучшения здравоохранения. В журнале публикуются оригинальные научные статьи в области медицины, биологии и фармации, статьи обзорного характера, научные сообщения, новости медицины и здравоохранения. Журнал индексируется в MEDLINE, отражён в базе данных SCOPUS, PubMed и ВИНИТИ РАН. Полнотекстовые статьи журнала доступны через БД EBSCO.

GMN: Georgian Medical News – საქართველოს სამედიცინო სიახლენი – არის ყოველთვიური სამეცნიერო სამედიცინო რეცენზირებადი ჟურნალი, გამოიცემა 1994 წლიდან, წარმოადგენს სარედაქციო კოლეგიისა და აშშ-ის მეცნიერების, განათლების, ინდუსტრიის, ხელოვნებისა და ბუნებისმეტყველების საერთაშორისო აკადემიის ერთობლივ გამოცემას. GMN-ში რუსულ და ინგლისურ ენებზე ქვეყნდება ექსპერიმენტული, თეორიული და პრაქტიკული ხასიათის ორიგინალური სამეცნიერო სტატიები მედიცინის, ბიოლოგიისა და ფარმაციის სფეროში, მიმოხილვითი ხასიათის სტატიები.

ჟურნალი ინდექსირებულია MEDLINE-ის საერთაშორისო სისტემაში, ასახულია SCOPUS-ის, PubMed-ის და ВИНИТИ РАН-ის მონაცემთა ბაზებში. სტატიების სრული ტექსტი ხელმისაწვდომია EBSCO-ს მონაცემთა ბაზებიდან.

WEBSITE

www.geomednews.com

К СВЕДЕНИЮ АВТОРОВ!

При направлении статьи в редакцию необходимо соблюдать следующие правила:

1. Статья должна быть представлена в двух экземплярах, на русском или английском языках, напечатанная через **полтора интервала на одной стороне стандартного листа с шириной левого поля в три сантиметра**. Используемый компьютерный шрифт для текста на русском и английском языках - **Times New Roman** (**Кириллица**), для текста на грузинском языке следует использовать **AcadNusx.** Размер шрифта - **12**. К рукописи, напечатанной на компьютере, должен быть приложен CD со статьей.

2. Размер статьи должен быть не менее десяти и не более двадцати страниц машинописи, включая указатель литературы и резюме на английском, русском и грузинском языках.

3. В статье должны быть освещены актуальность данного материала, методы и результаты исследования и их обсуждение.

При представлении в печать научных экспериментальных работ авторы должны указывать вид и количество экспериментальных животных, применявшиеся методы обезболивания и усыпления (в ходе острых опытов).

4. К статье должны быть приложены краткое (на полстраницы) резюме на английском, русском и грузинском языках (включающее следующие разделы: цель исследования, материал и методы, результаты и заключение) и список ключевых слов (key words).

5. Таблицы необходимо представлять в печатной форме. Фотокопии не принимаются. **Все цифровые, итоговые и процентные данные в таблицах должны соответствовать таковым в тексте статьи**. Таблицы и графики должны быть озаглавлены.

6. Фотографии должны быть контрастными, фотокопии с рентгенограмм - в позитивном изображении. Рисунки, чертежи и диаграммы следует озаглавить, пронумеровать и вставить в соответствующее место текста **в tiff формате**.

В подписях к микрофотографиям следует указывать степень увеличения через окуляр или объектив и метод окраски или импрегнации срезов.

7. Фамилии отечественных авторов приводятся в оригинальной транскрипции.

8. При оформлении и направлении статей в журнал МНГ просим авторов соблюдать правила, изложенные в «Единых требованиях к рукописям, представляемым в биомедицинские журналы», принятых Международным комитетом редакторов медицинских журналов - http://www.spinesurgery.ru/files/publish.pdf и http://www.nlm.nih.gov/bsd/uniform_requirements.html
В конце каждой оригинальной статьи приводится библиографический список. В список литературы включаются все материалы, на которые имеются ссылки в тексте. Список составляется в алфавитном порядке и нумеруется. Литературный источник приводится на языке оригинала. В списке литературы сначала приводятся работы, написанные знаками грузинского алфавита, затем кириллицей и латиницей. Ссылки на цитируемые работы в тексте статьи даются в квадратных скобках в виде номера, соответствующего номеру данной работы в списке литературы. Большинство цитированных источников должны быть за последние 5-7 лет.

9. Для получения права на публикацию статья должна иметь от руководителя работы или учреждения визу и сопроводительное отношение, написанные или напечатанные на бланке и заверенные подписью и печатью.

10. В конце статьи должны быть подписи всех авторов, полностью приведены их фамилии, имена и отчества, указаны служебный и домашний номера телефонов и адреса или иные координаты. Количество авторов (соавторов) не должно превышать пяти человек.

11. Редакция оставляет за собой право сокращать и исправлять статьи. Корректура авторам не высылается, вся работа и сверка проводится по авторскому оригиналу.

12. Недопустимо направление в редакцию работ, представленных к печати в иных издательствах или опубликованных в других изданиях.

При нарушении указанных правил статьи не рассматриваются.

REQUIREMENTS

Please note, materials submitted to the Editorial Office Staff are supposed to meet the following requirements:

1. Articles must be provided with a double copy, in English or Russian languages and typed or compu-ter-printed on a single side of standard typing paper, with the left margin of **3** centimeters width, and **1.5** spacing between the lines, typeface - **Times New Roman** (**Cyrillic**), print size - **12** (referring to Georgian and Russian materials). With computer-printed texts please enclose a CD carrying the same file titled with Latin symbols.

2. Size of the article, including index and resume in English, Russian and Georgian languages must be at least 10 pages and not exceed the limit of 20 pages of typed or computer-printed text.

3. Submitted material must include a coverage of a topical subject, research methods, results, and review.

Authors of the scientific-research works must indicate the number of experimental biological species drawn in, list the employed methods of anesthetization and soporific means used during acute tests.

4. Articles must have a short (half page) abstract in English, Russian and Georgian (including the following sections: aim of study, material and methods, results and conclusions) and a list of key words.

5. Tables must be presented in an original typed or computer-printed form, instead of a photocopied version. **Numbers, totals, percentile data on the tables must coincide with those in the texts of the articles.** Tables and graphs must be headed.

6. Photographs are required to be contrasted and must be submitted with doubles. Please number each photograph with a pencil on its back, indicate author's name, title of the article (short version), and mark out its top and bottom parts. Drawings must be accurate, drafts and diagrams drawn in Indian ink (or black ink). Photocopies of the X-ray photographs must be presented in a positive image in **tiff format**.

Accurately numbered subtitles for each illustration must be listed on a separate sheet of paper. In the subtitles for the microphotographs please indicate the ocular and objective lens magnification power, method of coloring or impregnation of the microscopic sections (preparations).

7. Please indicate last names, first and middle initials of the native authors, present names and initials of the foreign authors in the transcription of the original language, enclose in parenthesis corresponding number under which the author is listed in the reference materials.

8. Please follow guidance offered to authors by The International Committee of Medical Journal Editors guidance in its Uniform Requirements for Manuscripts Submitted to Biomedical Journals publication available online at: http://www.nlm.nih.gov/bsd/uniform_requirements.html
http://www.icmje.org/urm_full.pdf
In GMN style for each work cited in the text, a bibliographic reference is given, and this is located at the end of the article under the title "References". All references cited in the text must be listed. The list of references should be arranged alphabetically and then numbered. References are numbered in the text [numbers in square brackets] and in the reference list and numbers are repeated throughout the text as needed. The bibliographic description is given in the language of publication (citations in Georgian script are followed by Cyrillic and Latin).

9. To obtain the rights of publication articles must be accompanied by a visa from the project instructor or the establishment, where the work has been performed, and a reference letter, both written or typed on a special signed form, certified by a stamp or a seal.

10. Articles must be signed by all of the authors at the end, and they must be provided with a list of full names, office and home phone numbers and addresses or other non-office locations where the authors could be reached. The number of the authors (co-authors) must not exceed the limit of 5 people.

11. Editorial Staff reserves the rights to cut down in size and correct the articles. Proof-sheets are not sent out to the authors. The entire editorial and collation work is performed according to the author's original text.

12. Sending in the works that have already been assigned to the press by other Editorial Staffs or have been printed by other publishers is not permissible.

Articles that Fail to Meet the Aforementioned Requirements are not Assigned to be Reviewed.

ავტორთა საყურადღებოდ!

რედაქციაში სტატიის წარმოდგენისას საჭიროა დავიცვათ შემდეგი წესები:

1. სტატია უნდა წარმოადგინოთ 2 ცალად, რუსულ ან ინგლისურ ენებზე,დაბეჭდილი სტანდარტული ფურცლის 1 გვერდზე, 3 სმ სიგანის მარცხენა ველისა და სტრიქონებს შორის 1,5 ინტერვალის დაცვით. გამოყენებული კომპიუტერული შრიფტი რუსულ და ინგლისურენოვან ტექსტებში - **Times New Roman (Кириллица)**, ხოლო ქართულენოვან ტექსტში საჭიროა გამოვიყენოთ **AcadNusx.** შრიფტის ზომა – 12. სტატიას თან უნდა ახლდეს CD სტატიით.

2. სტატიის მოცულობა არ უნდა შეადგენდეს 10 გვერდზე ნაკლებს და 20 გვერდზე მეტს ლიტერატურის სიის და რეზიუმეების (ინგლისურ, რუსულ და ქართულ ენებზე) ჩათვლით.

3. სტატიაში საჭიროა გაშუქდეს: საკითხის აქტუალობა; კვლევის მიზანი; საკვლევი მასალა და გამოყენებული მეთოდები; მიღებული შედეგები და მათი განსჯა. ექსპერიმენტული ხასიათის სტატიების წარმოდგენისას ავტორებმა უნდა მიუთითონ საექსპერიმენტო ცხოველების სახეობა და რაოდენობა; გაუტკივარებისა და დაძინების მეთოდები (მწვავე ცდების პირობებში).

4. სტატიას თან უნდა ახლდეს რეზიუმე ინგლისურ, რუსულ და ქართულ ენებზე არანაკლებ ნახევარი გვერდის მოცულობისა (სათაურის, ავტორების, დაწესებულების მითითებით და უნდა შეიცავდეს შემდეგ განყოფილებებს: მიზანი, მასალა და მეთოდები, შედეგები და დასკვნები; ტექსტუალური ნაწილი არ უნდა იყოს 15 სტრიქონზე ნაკლები) და საკვანძო სიტყვების ჩამონათვალი (key words).

5. ცხრილები საჭიროა წარმოადგინოთ ნაბეჭდი სახით. ყველა ციფრული, შემაჯამებელი და პროცენტული მონაცემები უნდა შეესაბამებოდეს ტექსტში მოყვანილს.

6. ფოტოსურათები უნდა იყოს კონტრასტული; სურათები, ნახაზები, დიაგრამები - დასათაურებული, დანომრილი და სათანადო ადგილას ჩასმული. რენტგენოგრამების ფოტოასლები წარმოადგინეთ პოზიტიური გამოსახულებით **tiff** ფორმატში. მიკროფოტოსურათების წარწერებში საჭიროა მიუთითოთ ოკულარის ან ობიექტივის საშუალებით გადიდების ხარისხი, ანათალების შეღებვის ან იმპრეგნაციის მეთოდი და აღნიშნოთ სურათის ზედა და ქვედა ნაწილები.

7. სამამულო ავტორების გვარები სტატიაში აღინიშნება ინიციალების თანდართვით, უცხოურისა – უცხოური ტრანსკრიპციით.

8. სტატიას თან უნდა ახლდეს ავტორის მიერ გამოყენებული სამამულო და უცხოური შრომების ბიბლიოგრაფიული სია (ბოლო 5-8 წლის სიღრმით). ანბანური წყობით წარმოდგენილ ბიბლიოგრაფიულ სიაში მიუთითეთ ჯერ სამამულო, შემდეგ უცხოელი ავტორები (გვარი, ინიციალები, სტატიის სათაური, ჟურნალის დასახელება, გამოცემის ადგილი, წელი, ჟურნალის №, პირველი და ბოლო გვერდები). მონოგრაფიის შემთხვევაში მიუთითეთ გამოცემის წელი, ადგილი და გვერდების საერთო რაოდენობა. ტექსტში კვადრატულ ფჩხილებში უნდა მიუთითოთ ავტორის შესაბამისი N ლიტერატურის სიის მიხედვით. მიზანშეწონილია, რომ ციტირებული წყაროების უმეტესი ნაწილი იყოს 5-6 წლის სიღრმის.

9. სტატიას თან უნდა ახლდეს: ა) დაწესებულების ან სამეცნიერო ხელმძღვანელის წარდგინება, დამოწმებული ხელმოწერითა და ბეჭდით; ბ) დარგის სპეციალისტის დამოწმებული რეცენზია, რომელშიც მითითებული იქნება საკითხის აქტუალობა, მასალის საკმაობა, მეთოდის სანდოობა, შედეგების სამეცნიერო-პრაქტიკული მნიშვნელობა.

10. სტატიის ბოლოს საჭიროა ყველა ავტორის ხელმოწერა, რომელთა რაოდენობა არ უნდა აღემატებოდეს 5-ს.

11. რედაქცია იტოვებს უფლებას შეასწოროს სტატია. ტექსტზე მუშაობა და შეჯერება ხდება საავტორო ორიგინალის მიხედვით.

12. დაუშვებელია რედაქციაში ისეთი სტატიის წარდგენა, რომელიც დასაბეჭდად წარდგენილი იყო სხვა რედაქციაში ან გამოქვეყნებული იყო სხვა გამოცემებში.

აღნიშნული წესების დარღვევის შემთხვევაში სტატიები არ განიხილება.

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THE CORRELATION BETWEEN STRESS, ACADEMIC PERFORMANCE, AND SLEEP DISTURBANCES AMONG HIGH SCHOOL STUDENTS IN ANHUI PROVINCE: A CROSS-SECTIONAL STUDY

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Abstract.

Objective: Sleep disturbances have become common health issues among adolescents. The study aims to explore (1) sleep problems, and (2) the association of stress and academic performance with sleep disturbances among Chinese senior high school students.

Methods: A total of 2,527 senior high school students participated in the study. The respondents' stress level, sleep quality, and sleep chronotypes were assessed using the Depression Anxiety and Stress Scale-21, Pittsburgh Sleep Quality Index, Morning and Evening Questionnaire-5, respectively. Academic performance was evaluated through self-report. Binary logistic regression was used to assess the associations between stress, academic performance, and sleep disturbance.

Results: The prevalence of sleep disturbances among senior high school students was 29.1%. After adjustments, students experiencing light/moderate stress showed significantly higher odds of sleep disturbance (OR = 1.647, 95% CI: 1.040-2.611, P = 0.034) compared to no stress, while those with severe/very severe stress exhibited even greater risk (OR = 4.494, 95% CI: 2.143-9.425, P < 0.001). Regarding academic performance, both general (OR = 0.493, 95% CI: 0.375-0.649, P < 0.001) and good performers (OR = 0.643, 95% CI: 0.490-0.844, P = 0.001) showed significantly lower odds of sleep disturbance compared to poor performers. Significant interaction effects were observed among students with light/moderate stress combined with general (OR = 2.311, 95% CI: 1.265-4.220, P = 0.006) or good academic performance (OR = 2.668, 95% CI: 1.445-4.926, P = 0.002). Stratification by academic performance showed stress levels consistently linked to sleep disturbance (P < 0.05). However, sleep disturbance was significantly associated with academic performance only in students without stress (P < 0.05).

Conclusions: Sleep disturbance and stress were prevalent among Chinese senior high school students. Both stress and academic performance were associated with sleep disturbance. Moreover, significant interaction effects were observed among students with light/moderate stress combined with general or good academic performance. These findings suggest a need for personalized interventions.

Key words. Sleep disturbances, adolescents, stress, academic performance.

Introduction.

Sleep, an essential physiological process that occupies one-third of human life, is fundamental for maintaining both physical and mental health. However, sleep disturbances have become a significant public health concern, severely impacting physical and mental well-being, though many cases can be managed through appropriate interventions [1,2]. The 2024 Chinese National Healthy Sleep White Paper reveals a worrying trend: among the 10,000 respondents, 81% reported experiencing sleep disturbance [3]. This issue is particularly severe among middle school students in China, whose overall sleep quality has shown a consistent downward trend [4]. For high school students, a critical phase of physical and mental development for adolescents, sleep disturbances are often marred by low levels of mental health, which in turn contribute to sleep disturbances [5]. The ramifications of sleep disturbances among adolescents are far-reaching and profound, encompassing a spectrum of adverse outcomes such as cognitive dysfunction [6], obesity [7], hypertension [2], self-injurious behaviors, and even suicidal ideation or tendencies [8,9]. Furthermore, sleep difficulties were a risk factor for high level of aggression that may place a heavy burden on individual families and society. Given these severe consequences, it is necessary to pay attention to high school students' sleep problems.

Given the serious consequences of adolescent sleep disturbances, it is necessary to delve into their influencing factors, among which stress is an important one. Stress is characterized as a state arising from a diverse array of external stimuli and negative factors, which induce physical and psychological disarray or harm, manifesting as discomfort in both body and mind. In contemporary society, teenagers find themselves in a scenario where they face a pivotal exam every three years, a situation that is particularly pronounced for senior high school students who experience heightened academic stress compared to their junior high counterparts [10]. Contemporary high school students navigate a complex matrix of stressors encompassing the pressures of college preparation, academic stress, shifting family dynamics, peer relationship challenges, digital social pressures, and a dearth of physical exercise [11-14]. These various stressors, acting directly or indirectly, contribute to the onset of insomnia and sleep disturbances among this demographic.

Besides stress, academic performance also plays a crucial role in influencing adolescents' sleep. Academic performance is a key indicator reflecting students' recent study habits and lifestyles, providing a comprehensive assessment of their overall well-being. High school students, who predominantly spend their time studying at school, are notably influenced by academic factors. Studies have shown that academic alienation and a low sense of achievement significantly contribute to the

occurrence of sleep disturbances. For instance, medical college students in Paris suffer from poor sleep quality, which correlates with their academic performance [15]. Likewise, in Norway, higher education students experiencing sleep difficulties consistently demonstrate reduced academic performance [16]. However, in China, few studies have explored the impact of stress and academic performance on sleep disturbances among high school students.

Anhui Province, with a rural population accounting for 38.5% (China Statistical Yearbook, 2024), represents developing regions in Central China. Its unique socioeconomic and cultural context, including educational pressures and a mix of urban and rural environments, provides a valuable setting for studying the interplay between stress, academic performance, and sleep disturbances. Focusing on Anhui Province allows us to generalize findings to similar regions and address a critical gap in research, particularly given the lack of studies on Chinese high school students in developing areas. In light of these considerations, the objectives of this study are twofold: (1) to describe the current status of sleep disturbances among Chinese high school students, and (2) to systematically analyze the association between stress, academic performance, and sleep disturbances, while adjusting for confounding factors. By elucidating these relationships, we aim to provide a scientific basis for interventions to reduce sleep disturbances and promote the overall health and well-being of high school students.

Materials and Methods.

Study design and participants: This cross-sectional study employed a mixed-mode survey approach, utilizing both online and offline self-administered questionnaires to target high school students in Anhui Province, China. We used a multistage cluster sampling method to select participants. First, we purposively selected three geographically distinct regions (Southern, Central, and Northern Anhui) to capture the regional diversity. Second, two middle schools were randomly chosen from each region. Third, senior high students were stratified by grade level, and random cluster sampling was applied to select classes within each stratum, enrolling all students in the sampled classes. A total of 2,700 questionnaires were distributed, and 2,682 were returned (return rate: 99.33%). After excluding 155 non-compliant questionnaires, 2,527 senior high school students ultimately participated in the study (validity rate: 94.22%).

The inclusion criteria were: (1) full-time enrollment in grades 10-12; (2) willingness to participate; (3) ability to comprehend questionnaire content. The exclusion criteria were: (1) refusal to sign the informed consent form to participate in the study; (2) absence on the survey day; (3) questionnaires with >20% missing data. This resulted in 2,527 valid questionnaires, including 1,524 males (60.3%) and 1,003 females (39.7%), with a mean age of 16.43±1.20 years. All participants provided voluntary consent for anonymous data analysis.

Study variables and measurement:

A self-administered questionnaire was designed to collect data across four key sections: (1) socio-demographic characteristics and lifestyle factors, (2) stress level, (3) sleep quality, and (4) sleep chronotypes.

The socio-demographic characteristics encompassed: gender, age, educational factors (grade, academic performance, learning burden), and family-related aspects (parental relationship, father-child relationship, mother-child relationship), as well as living arrangements (whether the student lived in the school). Academic performance was assessed with the question: "How would you rate your overall academic performance compared with classmates during the past semester? (excellent/good; general; poor/very poor)". Learning burden was measured with the question: "How would you describe your current learning burden? (very light/light; general; heavy/very heavy)". Lifestyle habits included smoking and alcohol consumption. Smoking and alcohol drinking were measured with single-item questions: "Do you smoke? (yes/no)", "Do you drink alcohol? (yes/no)".

Stress was measured using the Chinese version Depression, Anxiety, and Stress scale-21 (DASS-21) [17]. The stress subscale comprises seven items and each item is rated on a 4-point Likert scale from 0 ('did not apply to me at all') to 3 ('applied to me very much or most of the time'). Total scores were calculated by multiplying each item score by 2 and summing the results. Based on total scores (0-42 points), stress symptoms were categorized into five levels: none (0-14 points), light (15-18 points), moderate (19-25 points), severe (26-33 points), and very severe (34-42 points). The DASS-21 has demonstrated good reliability and validity in Chinese populations [18-20]. The Cronbach's α for the stress subscale was 0.89.

Sleep quality was measured by the Pittsburgh Sleep Quality Index (PSQI), which evaluates sleep quality over a one-month period [21]. This 18-item self-report questionnaire includes seven dimensions: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, use of sleeping medication, and daytime dysfunction. The cumulative score of these seven dimensions forms the PSQI total score, with higher scores indicating poorer sleep quality. A PSQI total score >7 was defined as sleep disturbance [21,22]. The Chinese version of the PSQI is a widely used tool for screening sleep disorders and has shown good reliability in different populations in China [23-25].

Sleep chronotypes were evaluated using the Chinese version of the Morning and Evening questionnaire-5 (MEQ-5) [26]. This 5-item self-report questionnaire categorizes chronotypes into three types based on total scores (4-25 points): evening-types (4-11 points), neutral-types (12-17 points), and morning-types (18-25 points) [26]. The MEQ-5 has demonstrated good psychometric properties in Chinese populations and is widely used across different age groups [27-29].

Confounding variables selection:

The selection of confounding variables was based on prior epidemiological evidence and statistical considerations. Gender and grade were included due to their established associations with sleep quality and stress in adolescent populations. Learning burden was incorporated as it is potential modifier of stress and sleep patterns [12]. Family-related factors (e.g., parental relationships) were included based on literature suggesting their influence on adolescents' mental health and sleep behaviors [30-32]. Smoking and alcohol consumption are lifestyle factors that can adversely affect sleep disturbances and stress levels [33].

These variables were selected to minimize residual confounding and improve the validity of multivariate analyses.

Quality control:

Permission for this study was obtained from schools and students before conducting the surveys. Participants received both verbal and written detailed descriptions of the study and provided written informed consent. All selected individuals were informed of the purpose of the study and were assured of confidentiality prior to receiving the questionnaire.

The questionnaires were administered by graduate students from Wannan Medical College. All investigators received uniform training covering the study's purpose, significance, and critical procedural considerations. Prior to the survey administration, participants received detailed verbal and written descriptions of the study before obtaining their written informed consent. All participants were fully informed of the research purpose and provided written informed consent, which included confidentiality assurances. Trained research staff conducted the surveys and provided clarification when participants encountered comprehension difficulties. Following questionnaire completion, investigators verified responses to identify missing items or logical inconsistencies, and removed unqualified questionnaires.

In the online survey, we configured the web-based data collection system to require a response for each question, preventing participants from proceeding without answering. These measures ensured the completeness of questionnaire data, thereby enhancing the reliability and validity of the collected information.

Statistical analysis:

All analyses were conducted using SPSS 26.0. Quantitative data were presented as mean±standard deviation (SD), and qualitative data were presented as percentages (%). Differences in the prevalence of sleep disturbances among high school students with different demographic characteristics were assessed using the chi-square (χ^2) test. Variables with $P < 0.1$ in the univariate analysis were included in the multivariable logistic regression model. Multiple logistic regression analysis was performed to examine stress and academic performance associations with sleep disturbance, their interaction, and stratified predictor effects. Adjusted odds ratios (ORs) with 95% confidence intervals (CIs) were calculated for all covariates. In this study, $P < 0.05$ (two-tailed) was considered statistically significant.

Results.

Participant characteristics and sleep disturbances (Tables 1 and 2):

Of the 2,527 valid questionnaires, 60.3% (n=1,524) were completed by male participants. Regarding sleep chronotypes, 13.2% (n=333) were evening-type, 69.2% (n=1,748) neutral-type, and 17.6% (n=446) morning-type. Stress symptoms were reported by 17.5% of participants, classified as light/moderate (13.7%), severe/very severe (3.8%).

The mean PSQI score was 6.16 ± 2.90, with a sleep disturbance prevalence of 29.1% (735/2,527). Among the seven dimensions of sleep quality, the prevalence rates, ranked from highest to lowest, were as follows: daytime dysfunction (58.8%), sleep duration < 6 hours (54.5%), poor subjective sleep quality (24.3%), sleep latency ≥ 30 minutes (18.6%), sleep disturbances (6.5%), poor habitual sleep efficiency (5.7%), and use of sleeping medication (1.6%). Additional details are presented in Tables 1 and 2.

Sleep disturbances across demographic groups (Table 2):

Students who smoked and drank alcohol had a significantly higher prevalence of sleep disturbance than non-smokers and non-drinkers ($P < 0.001$). Evening-type students also showed a higher rate than neutral- and morning- type students ($P < 0.001$). Similarly, students with poorer academic performance, heavier learning burden, and greater stress had a higher prevalence ($P < 0.001$). Additionally, significant differences were observed in factors associated with sleep disturbance, including grade, parental relationship, father-child relationship, and mother-child relationship ($P < 0.05$).

The association of academic performance and stress with sleep disturbance (Table 3):

Sleep disturbance was the dependent variable (0=No; 1=Yes). Variables demonstrating univariate associations at $P \leq 0.10$ (Table 3) were entered into the multivariate logistic regression model to examine the independent effects of stress and academic performance. After adjusting for confounders, students experiencing light/moderate stress showed significantly higher odds of sleep disturbance (OR = 1.647, 95% CI:1.040-2.611, P = 0.034) compared to no stress, while those with severe/very severe stress exhibited even greater risk (OR = 4.494, 95% CI:2.143-9.425, $P < 0.001$). Regarding academic performance, both general (OR = 0.493, 95% CI:0.375-0.649, $P < 0.001$) and good performers (OR = 0.643, 95% CI:0.490-0.844, P = 0.001) showed significantly lower odds of sleep disturbance compared to poor performers.

Notably, significant interaction effects were observed, with the strongest stress-sleep disturbance associations occurring among students with light/moderate stress combined with general (OR = 2.311, 95% CI:1.265-4.220, P = 0.006) or good academic performance (OR = 2.668, 95% CI:1.445-4.926, P = 0.002). Complete results are presented in Table 3.

Stratified Analysis of Stress and Academic Performance Associations with Sleep Disturbance (Tables 4 and 5):

The stratified logistic regression analyses revealed distinct patterns in the associations between stress, academic performance, and sleep disturbance. When stratified by academic performance (adjusting for confounders, Table 4), students with general academic performance who experienced severe/very severe stress showed the highest risk of sleep disturbance (OR=10.947, 95% CI: 4.311-27.798, $P<0.001$). A clear dose-response relationship was observed across all academic performance levels, with increasing stress levels associated with progressively higher odds of sleep disturbance (all $P < 0.05$).

Conversely, when stratified by stress (adjusting for confounders, Table 5), academic performance was exclusively associated with sleep disturbance in students reporting no stress, where poor performers had 2.035 times higher odds (95% CI:1.544-2.681, $P < 0.001$) compared to good performers. Notably, this

Table 1. *Prevalence of Sleep Disturbances and PSQI Dimensions Among Participants (n=2,527).*

Sleep disturbances and dimensions	Prevalence (%)	95% CI (%)
Subjective sleep quality	24.3	22.7~26.0
Sleep latency ≥ 30min	18.6	17.1~20.2
Sleep duration < 6h	54.5	52.5~56.4
Habitual sleep efficiency	5.7	4.8~6.6
Sleep disturbance	6.5	5.5~7.5
Use of sleeping medication	1.6	1.1~2.1
Daytime dysfunction	58.8	56.9~60.8
Total sleep disturbance	29.1	27.3~30.9

Table 2. *Associations between sleep disturbance and demographic, lifestyle, and psychosocial factors.*

Variables	Group	n	Sleep disturbance (%)	χ^2	*P*
Gender	Male	1524	422(27.7)	3.626	0.057
	Female	1003	313(31.2)		
Grade	Senior Grade 1	843	232(27.5)	4.090*	0.043
	Senior Grade 2	654	177(27.1)		
	Senior Grade 3	1030	326(31.7)		
Parental relationship	Good	1954	524(26.8)	24.274*	<0.001
	Normal	457	161(35.2)		
	Bad	116	50(43.1)		
Father-child relationship	Good	1880	484(25.7)	37.099*	<0.001
	Normal	549	211(38.4)		
	Bad	98	40(40.8)		
Mother-child relationship	Good	2118	577(27.2)	17.190*	<0.001
	Normal	353	139(39.4)		
	Bad	56	19(33.9)		
Smoking	Yes	130	56(43.1)	13.007	<0.001
	No	2397	679(28.3)		
Alcohol drinking	Yes	589	217(36.8)	22.400	<0.001
	No	1938	518(26.7)		
Living in the school	Yes	815	250(30.7)	1.473	0.225
	No	1712	485(28.3)		
Sleep chronotypes	E-Type	333	151(45.3)	64.671	<0.001
	N-Type	1748	499(28.5)		
	M-Type	446	85(19.1)		
Academic performance	Good	1068	248(23.2)	44.731*	<0.001
	General	919	275(29.9)		
	Poor	540	212(39.3)		
Learning burden	Light	164	37(22.6)	41.030*	<0.001
	General	1158	269(23.2)		
	Heavy	1205	429(35.6)		
Stress	None	2084	482(23.1)	217.674*	<0.001
	Light/Moderate	348	184(52.9)		
	Severe/Very severe	95	69(72.6)		

**: Trend χ2 test; E-Type: Evening-type; N-Type: Neutral-type; M-Type: Morning-type.*
Academic performance (Good: excellent/good; poor: poor/very poor); Learning burden (light: very light/ light; heavy: heavy/very heavy).

association was attenuated and became non-significant (P > 0.05) among students experiencing either light/moderate or severe/very severe stress.

Discussion.

This study investigated sleep disturbances, stress levels, and academic performance among Chinese senior high school students, revealing four key findings: (1) Chinese high school students exhibited a 29.1% prevalence of sleep disturbances, with the top two affected dimensions being daytime dysfunction and short sleep duration, and evening-type students showed the highest prevalence. (2) Stress demonstrated a graded association with sleep disturbance: both moderate and severe stress significantly elevated risk compared to no stress. Academic performance exhibited a protective gradient, where better performance correlated with reduced sleep disturbance risk. (3) Significant interaction effects were observed, with the strong stress-sleep disturbance associations occurring among students

Table 3. *Logistic regression analysis of sleep disturbances by stress and academic performance.*

Variables	**Group**	***P***	***OR(95% CI)***
Stress	None	1.00(reference)	
	Light/moderate	0.034	1.647(1.040-2.611)
	Severe/very severe	<0.001	4.494(2.143-9.425)
Academic performance	Poor	1.00(reference)	
	General	<0.001	0.493(0.375-0.649)
	Good	0.001	0.643(0.490-0.844)
Stress×Academic performance	Stress(None)×Academic performance(Poor)	1.00(reference)	
	Stress(Light /moderate)×Academic performance(general)	0.006	2.311(1.265-4.220)
	Stress(Light /moderate)×Academic performance (good)	0.002	2.668(1.445-4.926)
	Stress(Severe /very severe)×Academic performance (general)	0.366	1.673(0.549-5.104)
	Stress(Severe /very severe)×Academic performance (good)	0.167	2.309(0.704-7.570)

-Adjusted for sex, grade, parental relationship, father-child relationship, mother-child relationship, smoking, alcohol drinking, learning burden, and sleep chronotypes.

Table 4. *Stress-sleep disturbance association by academic performance.*

Academic performance	**Stress**	**n(%)**	***P***	***OR(95%CI)***
Good	None	166(18.2)	1.00(reference)	
	Light/Moderate	64(48.9)	<0.001	3.787(2.557-5.608)
	Severe/Very severe	18(66.7)	<0.001	7.520(3.246-17.422)
General	None	180(23.4)	1.00(reference)	
	Light/Moderate	73(60.3)	<0.001	4.487(2.986-6.744)
	Severe/Very severe	22(78.6)	<0.001	10.947(4.311-27.798)
Poor	None	136(33.7)	1.00(reference)	
	Light/Moderate	47(49.0)	0.038	1.654(1.027-2.664)
	Severe/Very severe	29(72.5)	<0.001	4.374(2.057-9.303)

Table 5. *Academic performance-sleep disturbance association by stress.*

Stress	**Academic performance**	**n(%)**	***P***	***OR(95%CI)***
None	Good	166(18.2)	1.00(reference)	
	General	180(23.4)	0.033	1.300(1.022-1.654)
	Poor	136(33.7)	<0.001	2.035(1.544-2.681)
Light/Moderate	Good	64(48.9)	1.00(reference)	
	General	73(60.3)	0.105	1.543(0.914-2.605)
	Poor	47(49.0)	0.749	0.910(0.513-1.616)
Severe/Very severe	Good	18(66.7)	1.00(reference)	
	General	22(78.6)	0.308	1.972(0.534-7.281)
	Poor	29(72.5)	0.883	1.089(0.347-3.418)

with light/moderate stress combined with general or good academic performance. (4) Stratified analyses revealed a dose-response relationship across all academic levels: higher stress correlated with progressively greater odds of sleep disturbance. Meanwhile, academic performance was associated with sleep disturbance among stress-free students, with no significant association observed in stressed students.

Using a PSQI cutoff of > 7, our study found 29.1% of Chinese high school students had sleep disturbances. This aligns with a 2021 meta-analysis reporting a 28% [34] prevalence across 63 Chinese studies (n=430,422 adolescents), but exceeds the 24.2% rate observed by Huang et al. [35]. Globally, a meta-regression of 493,475 participants from 49 countries indicated a 45.96% prevalence, highlighting geographic and cultural variations [36]. Regional differences in academic pressure [37] and school start times contribute to sleep disparities [38]. Conducted during normalized COVID-19 prevention, earlier school arrival times shortened sleep duration and elevated disturbance risk [39]. Additional risk factors include social relationships, learning burden, online game addiction, and parental sleep behaviors [35,40]. In this study, high school students primarily exhibited daytime dysfunction, short sleep duration, and poor subjective sleep quality, which align with findings that these are the main manifestations among secondary school students [41]. Consequently, many affected students experienced daytime fatigue, drowsiness, impaired judgment, slowed reactions, and mental health issues. Compared to junior high school students, senior high school students faced greater challenges, including longer study hours, heavier academic burdens, and earlier wake-up times, contributing to reduce sleep duration. The White Paper on Healthy Sleep for Chinese People 2022 reported an average sleep time of 6.5 hours for senior high school students, whereas our research found that over half slept less than 6 hours, indicating severe sleep deprivation. Such deprivation may lead to depression, general and abdominal obesity, multiple cognitive and affective dysfunctions [42-44].

Our study identified the highest prevalence of sleep disturbances among E-type students. This aligns with findings in Chinese medical college students, where E-type students also showed significantly higher sleep disturbance rates compared to M-type and N-type students [45]. Notably, students' sleep chronotype shifted toward E-type during the COVID-19 pandemic [46], exacerbating mental health risks [47]. Given the bidirectional relationship between sleep and mental health, schools and families should prioritize adolescent sleep health. School administrators should reasonably arrange schedules to ensure sufficient sleep duration, while families can foster a conducive sleep environment and model healthy sleep behaviors to promote better sleep habits among students. Additionally, our study identified a 17.5% prevalence of stress symptoms among students (13.7% light/moderate; 3.8% severe/very severe), substantially exceeding rates reported by Ma et al. among junior and high school students (light/moderate: 8.82%; severe/very severe: 0.62%) [48]. Senior high school students, as adolescences, face unique challenges such as heightened cognitive self-consciousness, limited sports opportunities, academic stress, and an excessive focus on peer relations [49-53]. These factors collectively contribute to anxiety, depression, and other psychological problems.

This study found that higher stress levels and poorer academic performance were associated with a higher prevalence of sleep disturbance. This phenomenon can be explained through a bidirectional mechanism. Stress disrupts sleep by activating the hypothalamic-pituitary-adrenal (HPA) axis, increasing cortisol and suppressing melatonin (a key sleep-regulating hormone) [54]. Conversely, poor sleep quality acts as stressors, exacerbating anxiety and further impairing sleep quality [55]. Additionally, students with poorer academic performance often experience reduced academic self-efficacy and chronic frustration [56]. These psychological factors not only impair cognitive functioning and emotional regulation, but may also disrupt sleep-wake rhythms, further aggravating sleep problems [57]. Notably, the strong stress-sleep disturbance associations emerged among students with light/moderate stress and average-to-good academic performance, indicating that while better academic performance typically confers protection, this benefit diminishes under stress conditions-particularly for median achievers. High-achievers under moderate stress may experience insomnia driven by "performance anxiety" (e.g., fear of decline) and nocturnal rumination-repetitive academic self-review [58]. In addition, for the good academic performance students, the high expectations from parents to maintain their performance, often leading to extended study hours and increased stress, contribute to sleep disturbances. Middle-tier students face a "sandwich dilemma"-competing with high-achievers while avoiding academic decline, generating conflicting pressures [59]. Moderate stress fails to induce apathy yet is insufficient for easy adaptation, culminating in chronic stress states that heighten sleep vulnerability.

Stratification based on academic performance revealed a dose-response relationship between stress levels and sleep disturbance. Meanwhile, academic performance was only associated with sleep disturbance among stress-free students, with no significant association observed in stressed populations. Mechanistic pathways clarify this phenomenon: despite initial ability-based class grouping, performance gaps inevitably emerge. Students investing comparable effort but achieving divergent outcomes frequently experience perceived neglect and environmental vulnerability, which diminishes academic self-efficacy [60]. This reduced self-efficacy directly mediates a vicious cycle: academic struggles exacerbate sleep problems through rumination and anxiety, while sleep deprivation further impairs cognitive performance [61]. Notably, this cycle operates exclusively in non-stressed students, disappearing under stress. The differential impact of academic performance on sleep disturbance based on stress levels highlights the need for tailored interventions. For non-stressed students, enhancing academic skills and self-efficacy may mitigate sleep disturbances, while stressed students derive greater benefit from stress management training (e.g., mindfulness) and relaxation techniques. Schools should prioritize mental health education for "middle-tier" students, providing more opportunities to relieve pressure, and teachers/parents should monitor academic performance closely to offer timely support [62]. Future research should explore how stress and academic performance interact during critical periods

(e.g., exams) and test interventions targeting specific subgroups (e.g., low-self-efficacy students). Addressing these factors holistically could break the cycle of stress and sleep dysfunction, fostering better academic and mental health outcomes.

Limitation.

Some limitations need to be acknowledged. First, because of deriving from the cross-sectional design, causal relationships among academic performance, stress, and sleep disturbances could not be established. Longitudinal studies are essential to disentangle temporal relationships and validate mechanistic pathways. Second, self-report bias may have attenuated data reliability: academic performance was assessed through student-reported grades rather than objective records, potentially compromising validity. Third, unmeasured confounders-including parental education, outdoor activity duration, and screen time-were omitted from analyses, which may limit the robustness of observed associations. These factors warrant rigorous control in future studies to strengthen causal claims.

Conclusion.

Sleep disturbance and stress were prevalent among Chinese senior high school students. Both stress and academic performance were associated with sleep disturbance. Moreover, significant interaction effects were observed among students with light/moderate stress combined with general or good academic performance. These findings suggest a need for personalized interventions.

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