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Association of macronutrient intake, physical activity, anxiety, and depression with sleep quality among Iranian male adolescents

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Abstract

Background Adolescence is a unique stage of life accompanied by physiological and psychological modifications, along with stress, confusion, and depression.

Materials and methods The present descriptive-analytical cross-sectional research was done on 267 male adolescents who studied at high schools in Zanjan, Iran. Demographic characteristics questionnaires, a 48-item food frequency questionnaire, a short version of the International Physical Activity Questionnaire (IPAQ), the Depression Anxiety Stress Scale (DASS-21), and the Pittsburgh Sleep Quality Index (PSQI) were used to collect data.

Results The mean ± standard deviation (SD) of age, weight, height, and sitting time was 15.94 ± 0.91 years, 68.53 ± 15.28 kg, 1.75 ± 0.06 m, and 449.25 ± 322.06 min, respectively. The study results showed that students with poor sleep quality showed a higher rate of depression than those with good sleep quality in the high and low physical activity groups ($p < 0.05$). The stress, depression, and anxiety scores significantly correlated with sleep quality in the physical activity groups ($p < 0.05$). The structural equation model analysis results showed that mental health directly affected sleep quality; this association was significant in the low physical activity group.

Conclusion We found that sleep quality was independently related to mental health in young Iranian men. However, dietary intake was not a significant predictor of mental health or sleep quality. More studies are required to evaluate the association between dietary intake and sleep quality in adults.

Keywords Sleep quality, Physical activity, Mental health, Macronutrient intake, Depression, Anxiety

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Introduction

Adolescence can be defined as a period of rapid growth that begins with puberty. Transition from childhood to adulthood and changes in social, physical, and psychological aspects can cause stress, confusion, and depression [1]. Common traits during adolescence include irritability, depression, anxiety, and aggression. About 20% of the world's population are adolescents [2]. According to previous studies, approximately 29% of Iranian boys have severe depression [3]. During puberty, the feeling of excitement increases and contributes to hypersensitivity and intense excitement [4]. Depression is a psychological disturbance associated with at least two weeks of low mood [5]. These include symptoms of low self-esteem, fatigue, slowing movements, and disturbed sleep [6, 7]. Emotional disorders, such as anxiety and depression, are involved in adolescence period stress. Stress, which results in mental health problems among adolescents, is caused by excessive pressure or any other force imposed on individuals [8, 9].

Anxiety is one of the most prevalent psychiatric diseases in the general population [10]. Anxiety is interpreted as an emotional response to sudden feelings of fear and intimidation. Some of the anxiety symptoms can be attributed to excessive fear and anxiety, and a tendency to be overly cautious and alert [11]. In global health, anxiety and stress are essential in adolescence. Every teenager experiences stress as a negative emotion that reacts to an enormous force. Stress and anxiety can cause sleep problems in anxious teens. However, common issues, including anxiety, sleep disorders, and depression, have been observed in adolescents due to the unique characteristics of this period of life. Sleep is essential for physical and mental development and plays a crucial role in supporting adolescent health. Some evidence suggests that health issues, such as overweight, obesity, and non-communicable diseases (e.g., diabetes), are associated with sleep disorders [12]. Recent research has indicated that the association between sleep disturbance, anxiety, and depression is bidirectional [13].

As reported by some studies, sleep disorders can enhance the risk of obesity and overweight in adolescents [14, 15]. Despite the decline in malnutrition, overweight and obesity have risen among teenagers in developing countries [16]. The rate of obesity and overweight among Iranian adolescents (12–18 years) has been reported as 6.5% [17]. Moreover, some cardiometabolic disorders in teenagers and children are caused by anxiety, depression, and sleep disturbance as emotional disorders [18]. During adolescence, most eating behaviors evolve and play a role in predicting future health status [19].

Adolescence is a unique stage of life accompanied by physiological and psychological modifications. Children's refusal to eat nutritious foods, such as fruits or vegetables, can lead to food imbalances and growth failure [20]. Moreover, there is evidence that fruits and vegetables have protective effects against depression and anxiety [20, 21]. A healthy diet that includes low-fat dairy products, non-refined grains, and meat is correlated with lower depression [22]. In addition, the consumption of macronutrients and calories can affect sleep quality [15]. We hypothesize that people with low sleep quality, low physical activity, and insufficient dietary intake have more depression, anxiety, and stress.

Due to the high prevalence of obesity and overweight among Iranian adolescents, the current study was conducted to determine the relationship of the diet of Iranian adolescents with anxiety, depression, and sleep quality. Dietary intake as a modifiable risk factor may have a role in preventing and treating depression and anxiety in adolescence.

Materials and methods

The present descriptive-analytical cross-sectional research was done during 2019–2020. The research population included 265 male adolescents aged 15–18 years in the high schools of Zanjan City, Iran, who were selected by the randomized multistage cluster sampling technique. Selection of schools and classes (9th to 10th grades) was performed through cluster sampling from a complete list of schools. Furthermore, the students were selected using systematic sampling from the students studying in the considered classes who met the inclusion criteria (students whose parents had signed the consent form, agreed to participate, and aged 15–18 years).

Based on the study design, students who took psychiatric medications or had a history of serious or mental diseases, physical disabilities, apparent physical injuries, divorce, death, remarriage of parents, running away from home, or doing professional sports were excluded. In addition, failure to answer over 20% of the questions of the questionnaire was regarded as an exclusion criterion. Five questionnaires utilized in this study included demographic characteristics questionnaires, a 48-item food frequency questionnaire, the Depression Anxiety Stress Scale (DASS-21), the Pittsburgh Sleep Quality Index (PSQI), and a short version of the International Physical Activity Questionnaire (IPAQ). The researcher attended the considered classes and distributed the questionnaires. The students completed the questionnaires at intervals between classes and returned them to the researcher.

Ethical considerations

The Research Committee of Zanjan University of Medical Sciences approved the study. Before data gathering, written informed consent was obtained from the parents and students.

Dietary assessment

A 48-item food-frequency questionnaire was used for dietary assessment. The subjects reported their daily, weekly, or monthly frequency of consuming different food items over the preceding year in an open-ended format. They selected the "never/seldom" response if they had never eaten a given food item. The declared frequency of each food item was converted into daily consumption. Never and seldom were regarded as "zero" [23, 24].

Anthropometric evaluation

Height and weight measurements were taken following standard procedures, without shoes and wearing lightweight clothing, to the nearest 0.1 unit (cm for height and kg for weight). Body mass index (BMI) was computed from the weight and height [BMI = Wt (kg)/Ht(m^2)] [25]. Waist circumference (WC) was recorded directly on the skin, at the midpoint between the lower edge of the ribs and the top of the hip bone, at the end of a normal breath out, to the nearest 0.1 cm [26]. The measurement of hip circumference (HC) was done at the fullest part of the hips, level with the greater trochanter, and recorded to the nearest 0.1 cm.

Depression questionnaire

Symptoms of depression in our population were assessed using DASS. This questionnaire was conceptualized as a 42-item assessment including of three subscales with 14 items. The items assess experienced symptoms in the previous week and are scored on a Likert scale ranging from 0 ("does not apply to me at all") to 4 ("most of the time applies to me") [27]. The DASS-21 has three 7-item self-report scales obtained from the DASS full version [28].

Sleep quality evaluation

To evaluate sleep quality, we employed the validated PSQI. This tool quickly gathers self-reported data on sleep habits. Comprising 18 items, the PSQI gauges sleep quality and disruptions over the past few months. It provides insights into the participant's self-perceived sleep quality, time taken to fall asleep, sleep efficiency, sleep duration, daytime dysfunctions, sleep disturbance, and use of sleep medication. These seven components contribute to a cumulative score ranging from 0 to 21, with the score for each part ranging from 0 to 3 [29].

Table 1 Summary statistics of the study variables

Variable	Mean	SD
Age (year)	15.94	0.91
Weight (Kg)	68.53	15.28
Height (m)	1.75	0.06
WC [12]	78.24	11.54
HC [12]	94.03	9.04
Sitting Minute	449.25	322.06
Protein (gr)	79.12	32.75
Fat (gr)	85.65	31.62
Carbohydrate (gr)	332.38	117.85
Kilocalories (Kcal)	2379.71	757.69

Abbreviations: HC, Hip Circumference; SD, Standard Deviation; WC, Waist Circumference

Results

A total of 265 students were enrolled. The summary statistics of the variables are reported in Table 1. The mean ± standard deviation (SD) for age, weight, height, and sitting time was 15.94 ± 0.91 years, 68.53 ± 15.28 kg, 1.75 ± 0.06 m, and 449.25 ± 322.06 min, respectively. The average weight (g) of macronutrients and calorie intakes are also reported in Table 1.

The mean and SD of depression, anxiety, and stress variables in the two groups of poor and good sleep quality are reported in Table 2.

Students with poor sleep quality had higher depression rates compared to those with good sleep quality in the low and high physical activity groups ($p < 0.05$). No significant difference was detected between the depression of the two sleep quality groups in the moderate physical activity cohort. Moreover, the anxiety and stress levels of students with poor sleep quality were higher in the moderate physical activity group ($p < 0.05$) compared to the high physical activity group. The two sleep quality groups had no significant differences in terms of Table 1 variables.

The internal reliability of all scales was good. Cronbach's alpha was 0.77 for the PSQI and 0.83 for DASS-21.

Before establishing multivariate regression models, correlations between the studied variables were assessed. The depression, anxiety, and stress scores were significantly correlated with sleep quality in the physical activity groups ($p < 0.05$; Table 3). Sleep quality and depression correlation coefficient were 0.4,0.372 and 0.454 in Low, moderate, and high physical activity groups, respectively. Correlation coefficient of sleep quality and anxiety were 0.265,0.424 and 0.242 in Low, moderate, and high physical activity groups, respectively.

The structural equation model was made to describe possible relationships between sleep quality and the studied variables. The model and the detailed path coefficients are presented in Fig. 1.

The indices were two goodness of fit of the model were two good: $\chi^2/df = 1.167$, CFI, GFI, and RMSEA were 0.905, 0.992, and 0.025, respectively.

The model showed that mental health had a direct effect on sleep quality. This association was significant just in the low physical activity group. Mental health standardized regression coefficients were 1.055,0.730,

Table 2 Comparison of the mean of depression, anxiety, and stress variables in good and poor sleep quality by different groups of physical activity

Variable	PSQI ≥ 5		PSQI < 5		*P*-value
	Mean	SD	Mean	SD	a
Depression	13.86	8.52	9.31	7.39	0.012
Anxiety	9.23	6.22	8.15	6.88	0.306
Stress	16.36	7.96	13.62	7.39	0.107
Low Physical Activity Group	*N* = 73		*N* = 26		
Depression	14.69	8.15	10.90	8.11	0.063
Anxiety	10.19	6.37	6.20	4.85	0.016
Stress	18.19	7.97	12.90	5.60	0.010
Moderate Physical Activity Group	*N* = 52		*N* = 20		
Depression	15.18	8.02	9.94	8.10	0.002
Anxiety	8.79	7.05	6.55	5.41	0.162
Stress	15.28	7.20	13.45	8.83	0.112
High Physical Activity Group	*N* = 61		*N* = 33		

Abbreviations: SD, Standard Deviation, PSQI, Pittsburgh Sleep Quality Index

[a] Using Mann-Whitney U Test

and 0.937 for low, moderate, and high physical activity group respectively. The fat variable standardized regression coefficient was 0.316 in low, 3.278 in moderate, and 1.340 in high physical activity group.

Discussion

Our study showed that sleep quality affects stress and anxiety, especially in the moderate physical activity group. Furthermore, a positive correlation was detected between the students' sleep quality and their depression, stress, and anxiety in the physical activity groups. A structural equation model evaluated the association between sleep quality and macronutrients in the physical activity groups. The analysis showed that mental health was associated with sleep quality in the low physical activity group. This study hypothesizes that mental health mediates the longitudinal relationship between dietary intake and sleep quality.

It has been confirmed that the consumption of nutrients is associated with sleep quality and mental health. Based on our knowledge, the present study is the first to assess dietary intake's direct and indirect effects on adolescents' mental health and sleep quality using structural equation modeling in Iran. Consistent with the literature, our analysis supports the mediation effects of mental health on the association between dietary intake and sleep quality [30]. Contrary to our research, the association between mental health symptoms and sleep quality in female adolescents was shown in another study. In this study, the relationship between macronutrient intake and mental health in male students has been established but is not significant.

Sleep quality was not significantly associated with macronutrient intake in the present study. Previous investigations have demonstrated that sleep quality is not related to increased energy intake [31]. However, some studies found that shorter sleep duration was associated with higher energy intake among adolescents [32]. We also found an indirect negative effect of carbohydrate consumption on sleep quality. A previous study reported that energy intake from carbohydrates was not significantly associated with sleep quality [31]. In another research, adolescents having shorter sleep duration consumed more carbohydrates [32].

Seven aspects of sleep quality were assessed in this research. No significant association was detected between dietary intake and sleep quality. The relationship between diet and sleep quality is important because of the role of macronutrients in the secretion of hormones. Some studies have shown that insomnia is associated with weight gain [33, 34]. These observations may be due to appetite-mediating hormones, such as leptin and ghrelin. However, other studies do not support this view [35]. On the other hand, two important neurotransmitters regulating the sleep/wake cycle are serotonin and melatonin [36, 37]. Tryptophan is the precursor amino acid of melatonin and serotonin [38]. Foods that contain carbohydrates play a role in relaxation through serotonin, and protein makes sleep easier. Therefore, protein intake plays a role in improving sleep quality [38].

This is a cross-sectional study, and we suggest that it be conducted as a multicenter interventional study to investigate the effect of macronutrients and physical activity on sleep quality, anxiety, and depression.

Limitation

One of our limitations was the cross-sectional design of the study. In this study design, the causal relationship between sleep quality and dietary intake cannot be defined. The restriction in sample size is another

Table 3 Correlations between study variables in physical activity groups

	Depression	Anxiety	Stress	Protein	Fat	Carbohydrate	Kilocalories	Sitting Minute	WHR	BMI
Sleep Quality	0.399***	0.265**	0.418***	0.084	0.170	0.006	0.084	0.053	0.028	0.036
Depression	-	0.364***	0.478***	0.133	0.201*	0.084	0.151	-0.194	-0.040	0.121
Anxiety		-	0.528***	0.081	0.059	0.004	0.046	-0.191	-0.019	-0.009
Stress			-	0.048	0.195	0.056	0.120	0.012	0.067	0.105
Protein				-	0.770***	0.792***	0.916***	0.026	0.171	0.294**
Fat					-	0.571***	0.846***	0.103	0.139	0.226*
Carbohydrate						-	0.900***	0.014	0.112	0.301**
Kilocalories							-	0.056	0.165	0.303**
Sitting Minute								-	0.240*	0.267**
WHR									-	*0.718***
Low Physical Activity Group										
Sleep Quality	0.372***	0.424***	0.489***	0.140	0.175	0.105	0.165	-0.032	-0.201	-0.178
Depression	-	0.455***	0.689***	0.033	0.092	-0.116	-0.037	-0.134	0.050	-0.178
Anxiety		-	0.609***	0.016	0.140	-0.080	0.021	-0.118	-0.060	-0.101
Stress			-	0.061	0.155	0.003	0.064	-0.095	-0.061	-0.092
Protein				-	0.728***	0.781***	0.894***	-0.231	0.088	0.267*
Fat					-	0.508***	0.781***	-0.209	0.046	0.258*
Carbohydrate						-	0.920***	-0.186	0.166	0.206
Kilocalories							-	-0.200	0.110	0.252*
Sitting Minute								-	0.026	-0.070
WHR									-	*0.519***
Moderate Physical Activity Group										
Sleep Quality	0.454***	0.242*	0.295**	-0.074	-0.020	-0.005	-0.022	-0.029	0.139	0.124
Depression	-	0.569***	0.472***	0.029	0.043	0.061	0.071	-0.301**	0.128	0.003
Anxiety		-	0.620***	0.115	0.197	0.118	0.163	-0.232*	0.097	0.029
Stress			-	0.110	0.264*	0.101	0.159	-0.37***	0.068	0.026
Protein				-	0.758***	0.873***	0.944***	0.112	0.131	0.071
Fat					-	0.587***	0.785***	-0.043	0.265*	0.140
Carbohydrate						-	0.949***	0.141	0.158	0.148
Kilocalories							-	0.097	0.212*	0.159
Sitting Minute								-	0.191	0.067
WHR									-	*0.506***
High Physical Activity Group										

Notes: * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Abbreviations: BMI; Body mass index, WHR; Waist-Hip Ratio

limitation of this study. In addition, we cannot determine the interaction of consuming some nutrients with the intake of other nutrients. All participants in this study were young Iranian men. Therefore, the findings should not be generalized to females. Finally, we did not know about the stress experienced, socioeconomic factors, or the use of medications, such as adjuvants, which can affect eating behaviors and sleep quality.

Conclusion

This study revealed that sleep quality was independently related to mental health in young Iranian men. However, dietary intake was not a significant predictor of mental health or sleep quality. More studies are needed to evaluate the relationship between dietary intake and sleep quality in adults.

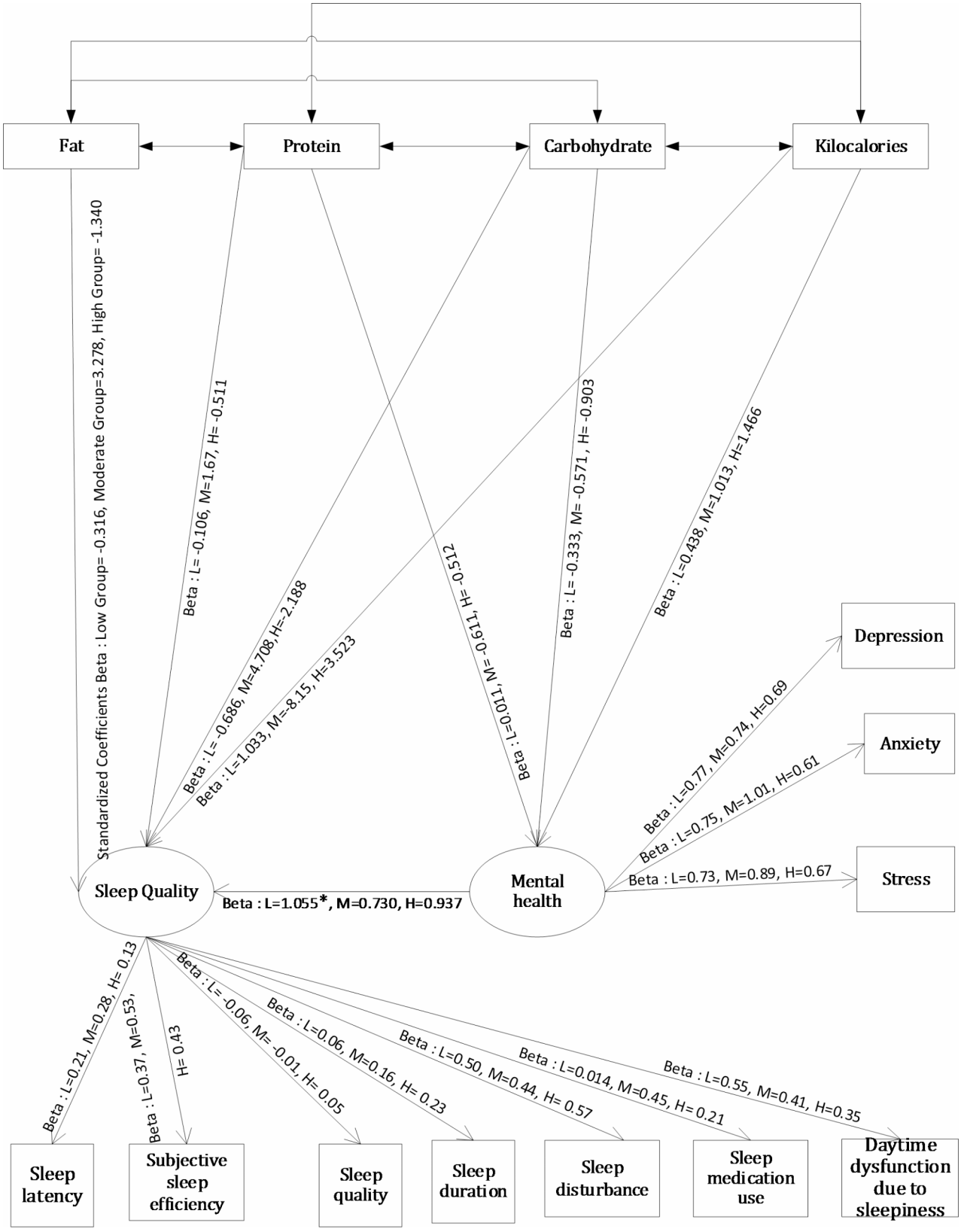

Fig. 1 Final SEM model describing the Standardized direct effects between variables (Significance levels: * $p < 0.001$)
(Significance levels: * $p < 0.001$)

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Author contributions
A.R: Methodology, wrote the manuscript, Review and editingA.M: helped supervise the project, Review and editingM.M.N, F.H.B, and P.R: carried out the experimentS.G.M: Review and editingN.S: drafted the manuscript and designed the figures, submission the manuscriptM.B: Review and editing, submission the manuscriptG.KH.M: drafted the manuscript M.K: derived the models and analyzed the dataM.A: Review and editing, Data curationM.R.SH: designed and directed the project, Review and editingAll authors have read and agreed to the published version of the manuscript.

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Data availability
The article submitted for publication includes the datasets generated and analyzed during the current study and used for manuscript preparation.

Declarations

Ethics approval and consent to participate
The ethics committee of Qazvin University of Medical Sciences approved this study with the ethical code IR.QUMS.REC.1399.538. All subjects provided written informed consent. Written informed consent was obtained from the patients or legal representatives.

Consent for publication
Not applicable.

Conflict of interest
The authors declare no conflict of interest.

Competing interests
The authors declare no competing interests.

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References

1. Chattu VK, et al. *The global problem of insufficient sleep and its serious public health implications*. In *Healthcare*. Multidisciplinary Digital Publishing Institute; 2019.
2. Rabby AHR, A.H. and, Rabby R. *NUTRITIONAL STATUS OF ADOLESCENT BOYS AND GIRLS IN COASTAL AREA (COX'S BAZAR) OF BANGLADESH*. 2022.
3. Moeini B, et al. Prevalence of depression and its associated sociodemographic factors among Iranian female adolescents in secondary schools. BMC Psychol. 2019;7(1):25.
4. Fairchild G. The developmental psychopathology of motivation in adolescence. Dev Cogn Neurosci. 2011;1(4):414–29.
5. Hazell P. *Depression in children and adolescents.* BMJ Clin Evid, 2011. 2011.
6. Park SC, et al. Network analysis of the depressive symptom profiles in Asian patients with depressive disorders: findings from the research on Asian psychotropic prescription patterns for antidepressants (REAP-AD). J Neuropsychiatry Clin Neurosci. 2020;74(6):344–53.
7. Martinsen KD, et al. Prevention of anxiety and depression in school children: effectiveness of the transdiagnostic EMOTION program. J Consult Clin Psychol. 2019;87(2):212.
8. Nagabharana T, et al. What stresses adolescents? A qualitative study on perceptions of stress, stressors and coping mechanisms among urban adolescents in India. Wellcome open research; 2021. p. 6.
9. Wehmeier PM, Schacht A, Barkley RA. Social and emotional impairment in children and adolescents with ADHD and the impact on quality of life. J Adolesc Health. 2010;46(3):209–17.
10. Zahmatkesh R, et al. The impact of COVID-19 outbreak on the mental health of the pregnant women: a systematic review. Int J Pediatr. 2021;9(3):13185–92.
11. Gkintoni E, Ortiz PS. *Neuropsychology of generalized anxiety disorder in clinical setting: a systematic evaluation*. In *Healthcare*. MDPI; 2023.
12. McMakin DL, Alfano CA. Sleep and anxiety in late childhood and early adolescence. Curr Opin Psychiatry. 2015;28(6):483.
13. Kortesoja L, et al. Bidirectional relationship of sleep with emotional and behavioral difficulties: a five-year follow-up of Finnish adolescents. Journal of Youth and Adolescence; 2020.
14. Gohil A, Hannon TS. Poor sleep and obesity: concurrent epidemics in adolescent youth. Front Endocrinol. 2018;9:364.
15. Javadi M et al. Sleep habits and dietary intake among preschool children in Qazvin. J Compr Pediatr, 2014. 5(1).
16. Oukheda M, et al. Association between nutritional status, body composition, and fitness level of adolescents in physical education in Casablanca, Morocco. Frontiers in Nutrition; 2023. p. 10.
17. Kelishadi R, et al. Trend in the prevalence of obesity and overweight among Iranian children and adolescents: a systematic review and meta-analysis. Nutrition. 2014;30(4):393–400.
18. Countryman AJ, et al. Cardiometabolic risk in adolescents: associations with physical activity, fitness, and sleep. Ann Behav Med. 2013;45(1):121–31.
19. Szabo K, Piko BF, Fitzpatrick KM. Adolescents' attitudes towards healthy eating: the role of self-control, motives and self-risk perception. Appetite. 2019;143:104416.
20. Glabska D, et al. Fruit and vegetables intake in adolescents and mental health: a systematic review. Rocz Panstw Zakl Hig. 2020;71(1):15–25.
21. Gibson-Smith D, et al. Association of food groups with depression and anxiety disorders. Eur J Nutr. 2020;59(2):767–78.
22. Khalid S, Williams CM, Reynolds SA. Is there an association between diet and depression in children and adolescents? A systematic review. Br J Nutr. 2016;116(12):2097–108.
23. Mohammadifard N, et al. Validation of a simplified food frequency questionnaire for the assessment of dietary habits in Iranian adults: Isfahan Healthy Heart Program, Iran. ARYA Atherosclerosis. 2015;11(2):139.
24. Nazari E, et al. Association of dietary intake and cervical cancer: a prevention strategy. Infect Agents Cancer. 2023;18(1):42.
25. Conde WL, Monteiro CA. Body mass index cutoff points for evaluation of nutritional status in Brazilian children and adolescents. J Pediatr (Rio J). 2006;82(4):266–72.
26. Fernández JR, et al. Waist circumference percentiles in nationally representative samples of African-American, European-American, and Mexican-American children and adolescents. J Pediatr. 2004;145(4):439–44.
27. Vignola RCB, Tucci AM. Adaptation and validation of the depression, anxiety and stress scale (DASS) to Brazilian Portuguese. J Affect Disord. 2014;155:104–9.

28. Henry JD, Crawford JR. The short-form version of the Depression anxiety stress scales (DASS-21): construct validity and normative data in a large non-clinical sample. Br J Clin Psychol. 2005;44(2):227–39.
29. Harmat L, Takács J, Bódizs R. Music improves sleep quality in students. J Adv Nurs. 2008;62(3):327–35.
30. Kaneita Y, et al. Associations between sleep disturbance and mental health status: a longitudinal study of Japanese junior high school students. Sleep Med. 2009;10(7):780–6.
31. Matsunaga T, et al. Associations between dietary consumption and sleep quality in young Japanese males. Sleep and Breathing; 2020.
32. Weiss A, et al. The association of sleep duration with adolescents' fat and carbohydrate consumption. Sleep. 2010;33(9):1201–9.
33. Cheng FW, et al. Probable insomnia is associated with future total energy intake and diet quality in men. Am J Clin Nutr. 2016;104(2):462–9.
34. Spaeth AM, Dinges DF, Goel N. Effects of experimental sleep restriction on weight gain, caloric intake, and meal timing in healthy adults. Sleep. 2013;36(7):981–90.
35. Schmid SM, et al. Short-term sleep loss decreases physical activity under free-living conditions but does not increase food intake under time-deprived laboratory conditions in healthy men. Am J Clin Nutr. 2009;90(6):1476–82.
36. Doherty R, et al. Sleep and nutrition interactions: implications for athletes. Nutrients. 2019;11(4):822.
37. Pevet P, Challet E, Felder-Schmittbuhl M-P. Melatonin and the circadian system: Keys for health with a focus on sleep. Handb Clin Neurol. 2021;179:331–43.
38. Sanlier N, Sabuncular G. Relationship between nutrition and sleep quality, focusing on the melatonin biosynthesis. Sleep Biol Rhythms, 2020: pp. 1–11.

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