

Exploration of the Association Between Sleep Quality and Dietary Nutrition in Adolescents/Research Advances

Xinyu Huang¹, Lin Xu² and Haoxi Yang^{1,*}

¹ School of Food Science and Engineering, South China University of Technology, Guangdong, 510641, China

² School of Light Industry and Chemical Engineering, Guangdong University of Technology, Guangdong, 510006, China

* Corresponding author: feyhx2002@mail.scut.edu.cn

Abstract. Nowadays, there are many problems in the dietary nutrition of teenagers, such as unbalanced intake of nutrition, unbalanced diet types, a lack of dietary knowledge, and unreasonable eating habits. At the same time, the problem of the sleep quality of teenagers is becoming more and more serious, so the preliminary judgment is that there is a certain relationship between dietary nutrition and the sleep quality of teenagers, and a specific analysis is carried out. After consulting the research results and data at home and abroad, this paper analyzed and discussed the relationship between dietary nutrition and the sleep quality of adolescents and clarified the influence on sleep quality from the aspects of eating pattern, eating behavior, nutrient composition, and intake frequency, as well as the direct or indirect influence of supplementing macronutrients and micronutrients on sleep. It also analyzes and discusses how to supplement dietary nutrition and improve teenagers' sleep problems, and puts forward solutions based on dietary problems to solve specific problems, supplement dietary nutrition intake, and rationally plan teenagers' eating ways.

Keywords: Sleep quality, dietary nutrition, teenager.

1. Introduction

Sleep disorders are manifestations of abnormal amounts of sleep and abnormal behaviors during sleep, and the International Classification of Sleep Disorders-Third Version (ICSD-3) which is developed by the American Academy of Sleep Research, classifies sleep disorders into seven categories: Insomnia, sleep related breathing disorder, central disorders of hypersomnolence, and circadian rhythms sleep-wake disorders, Parasomnias, sleep related movement disorders, and other sleep disorders. According to the National Health Commission of the People's Republic of China, sleep problems refer to abnormalities in sleep initiation, sleep process, sleep duration and sleep quality under appropriate sleep conditions, such as difficulty in falling asleep, night wakings, etc. A variety of methods can be used to assess sleep conditions, especially the Pittsburgh sleep quality index (PSQI) which is often used in clinical practice.

High-quality sleep is essential for maintaining people's physical and mental health and improving their sense of well-being in life, especially among adolescents. However, in recent years, the phenomenon of sleep disorders has become extremely common among adolescents in China. Data shows that the overall incidence of sleep disorders among adolescent's ranges from 19.2% to 57.5%, with 12.1% of them sleeping less than 6 hours a day. Currently, there are many treatment plans for adolescents with sleep disorders, but all of them have certain limitations and are not effective in improving symptoms. As research continues, dietary nutrition is being recognized as an important intervention. Studies have shown that nutritional interventions can improve the quality of sleep, enhance one's physical and mental health, and thus improve the quality of life. However, the effectiveness of dietary nutritional interventions for sleep disorders in adolescents has not yet been sufficiently validated to be widely applied.

Therefore, this study explores and analyzes the association between specific dietary nutrition and eating patterns and sleep for adolescents under specific nutritional requirements, aiming to provide a theoretical basis for the overall correlation between dietary nutrition and sleep.

2. The Current Situation of Sleep and Nutrition among Adolescents

2.1. Existing Problems of Adolescent Sleep

As China's college entrance exams become more and more intense, the problem of sleep disorders in adolescents is also gradually being noticed. The PSQI is applicable to patients with sleep disorders, patients with mental disorders in evaluating the quality of sleep, as well as to the general population in assessing the quality of sleep, and a PSQI of >7 indicates that it is very likely to be accompanied by sleep disorders. Clinical surveys have shown that in a college with an average of 300 students in one grade, the PQSI of freshmen is about 10.1, while that of sophomores is about 9.3, and that of juniors is about 8.2. It is thus clear that sleep disorders are a common problem among adolescents. Meanwhile, in that survey, it was found that the average PQSI of college students was about 5.5, but from an individual point of view, there were still a number of college students whose PSQI was >7 at the time [1].

2.2. Nutritional Status of Adolescent Diets

With the economic development, the type and quality of diet of our adolescents have been greatly improved, and the intake level of essential supplemental nutrients of human body is also increasing. However, according to professional research reports, the physical health indicators of China's adolescents have been declining for more than 20 consecutive years, which, to a certain extent, indicates that there are still some poor dietary habits in the current situation of adolescent diets that are contrary to nutritional balance [2].

2.2.1. Unbalanced ratio of macronutrient intake

Macronutrients, also known as energy-yielding nutrients, include the three main categories of carbohydrates, fats and proteins. Surveys have found large disparities in the proportion of macronutrient intake among adolescents, with serious problems of under-eating and overeating. Epidemiological surveys showed that among adolescents in schools, the average daily dietary intake of staple foods, legumes, and dairy was unbalanced among boys and girls, resulting in each nutrient being lower than the recommended amount in the Dietary Reference Intakes for Chinese Residents (DRIs) (of which the adolescent intake of protein is 75g/d for males and 60g/d for females; the requirement for carbohydrates is 50-65 AMDR; the requirement for fats is 50-65 AMDR; the requirement for fats is 50-65 AMDR; and the requirement for fats is 50-65 AMDR). The requirement for carbohydrates is an AMDR value of 20-30), of which 35.56% of boys and 38.33% of girls had excessive fat intake and 50.56% of boys and 48.33% of girls had relatively inadequate carbohydrate intake [3].

2.2.2. Unbalanced variety of diet and lack of dietary knowledge

Many adolescents have the bad habit of picky eating, resulting in an imbalance in the types of nutrients they consume. This is coupled with the fact that adolescents neglect to pay attention to their daily nutritional dietary knowledge and have a lack of knowledge. Green vegetables, meat, beans or seafood, and fruits have become picky food groups when it comes to adolescents' intake. 63% of the students could not have breakfast every day. Vegetables, fruits, and milk/dairy products (fresh milk, yogurt, cheese) were consumed less than once a day by 39.9%, 67.5%, and 73.9% of the students, respectively [4].

The imbalance in food intake leads to a lack of nutrients such as protein, carbohydrates and fats, which negatively affects the health of adolescents and young people, and even diseases such as growth retardation, rickets and anemia. Monitoring by the Hangzhou Health and Wellness Committee shows that the incidence of nutritional diseases related to malnutrition and overweight and obesity in both directions remains high among adolescents, with an overall malnutrition rate of 6.61%, of which 7.39% and 5.80% are for male and female students respectively; and an overall overweight rate of 15.72%, of which 18.84% and 12.43% are for male and female students respectively. The overall obesity rate was 12.34%. Of these, 15.99% and 8.51% were male and female students respectively. The overall

rate of anemia among students was 8.6%. The overall prevalence of malnutrition in 2020 was 8.1% (an increase of 1.02 percentage points from 2019), overweight rate was 13.1% (an increase of 0.22 percentage points from 2019), obesity rate was 10% (a decrease of 0.17% from 2019), and anemia rate was 5.4% [5].

2.2.3. Poor distribution of dietary habits

Many adolescents have problems with the distribution of meals and snacks, often consuming too many junk snacks at non-meal times, resulting in a lack of appetite, anorexia, and picky eating at meal times. In the Study on Health Behavior of Chinese Adolescents: Analysis of Survey Data Based on Ten Provinces and Municipalities, it was found that nearly 50% (49.4%) of adolescents ate three times a day, which is at a normal level. 36% of adolescents ate more than three times a day, i.e., they had additional meals. The highest percentage of adolescents (22.3%) ate 1 additional meal (eating 4 times a day), and 7.2% ate 2 additional meals (eating 5 times a day). The data on adolescents adding meals has improved compared with previous studies, which reflects the general improvement in diet and nutrition levels of our adolescents. However, there are still 14.6% of adolescents who eat less than three times a day, and this group of adolescents may be at risk of malnutrition. This poor dietary habit leads to a lack of nutrients needed for growth and development, which can cause adverse effects on health or even more serious physical illnesses.

3. Dietary Influences on Sleep

3.1. Diet Affects Sleep Quality

Dietary patterns, behaviors, and the frequency of their intake all affect sleep in different ways.

3.1.1. Dietary patterns

Regression analysis found that dietary patterns had a relatively greater impact on adolescent sleep quality than individual factors, accounting for the first place of all factors. Cao Xia et al. categorized dietary patterns into four types: healthy patterns, snack patterns, roughage patterns, and oil and meat patterns. According to the degree of poor sleep quality caused by dietary patterns in descending order, they were the oil-vegetable pattern, the coarse food pattern, the healthy pattern, and the snacking pattern [6]. This may be due to the fact that a healthy dietary pattern ("fish, egg, milk, and vegetarian" pattern) ensures the intake of essential micronutrients and maintains intestinal patency, whereas maintaining a snacking pattern (sugary drinks, coffee, and snacks) and a non-vegetarian pattern (meat, fried, and pickled vegetables) for a long period of time may increase the risk of sleep disorders and increase the burden on the human body, even affecting health body burden and even affect health status.

3.1.2. Eating behavior

Dietary behaviors include eating three meals a day or not, having a light dinner, frequency of taking out, and late-night snacking habits. Three meals a day are advocated by the public, but the proportion of today's young people who take three meals a day on time and in quantity is relatively small, which has a certain impact on their physical health as well as the quality of their sleep. In addition, the phenomenon of young people often dining out of school and eating outside can cause unstable meal times and excessive intake of high-fat, high-oil, and high-sugar foods. One-way logistic regression analysis showed that the likelihood of poor sleep quality increased when adolescents ate breakfast <3 times per week, did not eat Chinese food every day, did not eat dinner every day, and ate at out-of-school restaurants ≥ 4 times per week (all $P < 0.05$) [7].

3.1.3. Frequency of nutritional intake

Nutritional intake is extremely important as a prerequisite for nutrients to be absorbed and act on the body. Nutritional intake was categorized into fruits (times/week), vegetables (times/week), aquatic products (times/week), poultry (times/week), livestock (times/week), carbonated beverages

(times/week), tea (times/week), and coffee (times/week), and multifactorial logistic regression analysis showed that aquatic products and poultry intake less than once per week were the risk factors for poor quality of sleep in adolescents. In addition, numerous studies have shown that caffeine intake affects sleep quality. Studies have shown that intake of milk, eggs, fish, fruits, instant noodles, and soft drinks were associated with sleep quality among the respondents, in which intake of milk, eggs, and fish once a day or more was associated with a lower risk of poor sleep compared with intake of <1 time/week (milk 29% (OR = 0.71, $P < 0.05$), eggs 36% (OR = 0.64, $P < 0.05$), fish 48% (OR = 0.52, $P < 0.05$), while instant noodles and soft drinks increased the risk of poor sleep (instant noodles 110% (OR = 2.10, $P < 0.01$) and soft drinks 85% (OR = 1.85, $P < 0.01$) [7]. At the same time, fruit intake also helps to promote sleep quality, in which the occurrence of poor sleep among college students who consumed 1 to 6 times/week decreased by 34% (OR = 0.66, $P < 0.01$) compared to those who consumed < 1 time/week, while consuming instant noodles and drinking soft drinks 1 to 6 times/week increased the risk of poor sleep by 39% and 56%, respectively [8].

3.2. Effect of Nutrients on Sleepiness

In the process of dietary nutrition, some of the nutrients ingested can, to a certain extent, directly affect or indirectly regulate sleep. In the process of food intake, dietary imbalance leads to an imbalance of the corresponding substances, which in turn triggers sleep problems.

3.2.1. Macronutrients

Macronutrients, also known as energy-yielding nutrients, include the three main categories of carbohydrates, proteins, and fats. It was found that there is a wide gap in the proportion of macronutrient intake among adolescents, with serious problems of undereating and overeating. The imbalance in the proportion brought about will affect the nutritional status of the diet. There is a great deal of clinical information on the effects of nutrients, especially protein and carbohydrates, on sleep.

The results of some investigations and studies have shown that protein intake is closely related to sleep duration, sleep quality, and sleep habit development [9,10]. However, there may be controversy about the association between the two, and some scholars believe that protein intake is positively correlated with sleep duration and that high protein intake can effectively improve sleep quality [11]. People with longer sleep durations usually consume more protein than those with shorter sleep durations [12]. Low protein intake, on the other hand, leads to reduced SWS (slow wave sleep). However, some studies have concluded that protein intake is negatively correlated with sleep duration, and the higher the protein intake, the longer the SOL (Sleep Onset Latency). Excessive protein intake also causes secondary hyperproteinemia, which significantly increases plasma albumin and globulin and affects metabolic stabilization, thereby affecting the duration of sleep [13,14]. Also, interference with the digestive system and aggravation of cardiovascular burden are responsible for its impact on sleep.

The effect of protein on sleep is still being explored in research, and a better and more rigorous research component is needed if the positive or negative correlation of protein on sleep is to be determined; however, there is no doubt that protein intake alters the structure and quality of sleep to a certain extent.

There is a large body of evidence that carbohydrate intake has an effect on sleep. Reduced carbohydrate intake leads to a drop in blood glucose at night. When blood sugar drops, the body raises blood sugar levels by secreting hormones (mainly cortisol and adrenaline from the adrenal glands), which are secreted on a biological clock that is lowest at 2:00 a.m. and highest at 8:00 a.m. The hormones that are secreted by the adrenal glands, such as cortisol and epinephrine, cause the body to be in a state of arousal, which affects sleep. The secretion of adrenaline causes the organism to be in a state of arousal and interferes with sleep. In addition, the level of carbohydrate intake also affects sleep to some extent, as the intake of low-carbohydrate foods significantly increases the amount of REM (rapid eye movement) sleep and reduces SWS, while high-carbohydrate foods shorten the SOL instead [14].

At the same time, it has been shown that foods containing both protein and carbohydrates have a more pronounced effect on sleep [15]. Compared to foods containing only carbohydrates, the material components of foods that combine protein-derived tryptophan with carbohydrates synergistically affect sleep. It has been found that low-protein, high-carbohydrate foods promote sleep and may be associated with elevated insulin (blood glucose) and tryptophan levels in the body after meals [16]. In recent years, it has been found that tryptophan in the human body, catalyzed by tryptophan hydroxylase, first generates 5-hydroxytryptophan(5-HT) and then is catalyzed by 5-hydroxytryptophan decarboxylase to produce 5-hydroxytryptophan. 5-hydroxytryptophan enters the brain through the blood circulation, which increases the amount of 5-hydroxytryptophan in the medulla oblongata and thus produces a pronounced hypnotic effect and can cause people to enter the period of quiet sleep-in advance [17]. However, the specific mechanism of how carbohydrates and proteins form a synergistic system that affects sleep formation cannot be determined. Although many studies illustrate the existence of a relationship between the two, the process of interaction between water compounds and proteins in vivo is very complex and still needs to be explored and researched.

The relationship between fat in macronutrients and sleep quality has remained in a number of pathologic studies, such as the effect of adipokines on obstructive sleep apnea syndrome and the relationship between fatty liver disease and sleep disorders. What is known is that inappropriate fat intake affects physiological activity and nutritional metabolism in the body, but further research is underway on the relationship between fat and sleep quality.

3.2.2. Micronutrients

Micronutrients include vitamins and minerals, of which there are many types; vitamin B1 and vitamin B6 affect the quality of sleep in a certain way; minerals can also be subdivided; and iodine and iron are common elements that can be categorized as minerals.

Vitamins, as micronutrients required by the body, play a role in various ways, such as as antioxidants, effects on neurotransmitters, protecting the integrity of immune cells, and making their immune response good. Vitamin B1 (VB1) and Vitamin B6 (VB6), also known as pyridoxine, respond to the body in different mechanisms, macroscopically manifesting themselves in the body's moods, fluctuating mental states, and, in cases of severe deficiencies, even some neuropsychiatric symptoms, which indirectly affect the quality of sleep. Vitamin B1 will inhibit the hydrolysis of acetylcholine by cholinesterase, so that too much acetylcholine is accepted by the receptors on the postsynaptic cells, and acetylcholine, as an excitatory neurotransmitter, will make the organism continue to be excited, resulting in the inability of the organism to sleep normally, so the quality of sleep of people who consume diets with a high level of VB1 will be affected as a result. Vitamin B6 is regulated in the nervous system by its active form, pyridoxal phosphate (PLP), which is involved in a number of enzymatic reactions that maintain the activity of neurotransmitters such as dopamine, histamine, and 5-hydroxytryptophan, thereby maintaining the stability of the nervous system. This stabilization is, in part, a fundamental guarantee of restful sleep. EEG abnormalities have been found in people who consume diets low in VB6, and Guilarte suggests that when VB6 is deficient, there is a buildup of tryptophan metabolites in the brain, which can lead to convulsions, as well as negative feelings such as depression and confusion, which negatively affect the quality of sleep [18].

Minerals are essential micronutrients in the body, and mineral deficiencies may have a negative impact on sleep quality. Iron deficiency anemia occurs more frequently in Chinese adolescents. Iron deficiency anemia tends to cause poor cognitive development and bad moods such as frustration and anxiety. A controlled study comparing the effects of iron deficiency on the total amount of sleep and the number of nocturnal awakenings in infants showed that the total amount of sleep in the iron-deficient study group was greater than that in the iron-supplemented experimental group, and the number of nocturnal awakenings in the former group was predominantly higher, which indicates that iron-deficiency anemia reduces the quality of sleep to a certain degree [19]. Mg promotes melatonin synthesis through activation of 5-hydroxytryptophan and N-acetyltransferase and increases melatonin release from the pineal gland [20]. And Matt Walker's 2021 TED article stated that melatonin can

make people fall asleep earlier, roughly 3.9 minutes faster, and will improve sleep quality by an average of 2.2%.

4. Supplementing Dietary Nutrition to Improve Sleep Disorders

In terms of eating behavior, the choice of food as well as the time of eating should be made in a disciplined and regular manner rather than the tendency to adopt an unconditional gratification approach, which leads to more eating behavior problems in adolescents. Intake of milk, eggs, and fish 1 or more times per day reduces the risk of poor sleep, and fruit intake also helps to promote sleep quality. In addition, stress levels are a major contributor to sleep disorders, and food intake was significantly correlated with objective sleep quality. The low-stress group consumed more vegetables than the high-stress group, while the high-stress group consumed more grains, meat, eggs, soju, and coffee products than the low-stress group [21]. Experimental intervention studies have found that melatonin-rich milk, cherry juice, B vitamins, and kiwifruit improve sleep quality.

The dietary structures that are currently prevalent in countries all over the world are classified into four main types, namely, the Eastern dietary pattern, the dietary pattern of economically developed countries, the Japanese dietary pattern, and the Mediterranean dietary pattern, of which the Mediterranean pattern is recognized as one of the healthiest dietary patterns. Some studies have indicated that adolescents who better follow this dietary pattern have better sleep quality and fewer problems such as sleep disorders (OR=0.36, 95%CI: 0.21, 0.62, $P<0.001$) [22]. However, due to individual differences, a dietary pattern that is specifically modified for the individual may be able to maximize its effect.

From the micronutrient link to daily life, supplementation of micronutrients is the most direct, and the required nutrients can be taken from food. Vitamin B1 can be supplemented through the intake of foods such as yeast (dried), sunflower kernel, pork chops, etc., and Vitamin B6 can be supplemented through foods such as bananas, guava dragon fruits, etc., and of course, multivitamin tablets can be chosen, which are highly effective nutritional products. Regarding mineral supplementation, you can choose animal sources such as pig's blood, pig's liver, chicken liver, beef, and mutton, as well as plant sources such as shiitake mushrooms, fungus, etc. Iron is actually more important than the problem of absorption, and vitamin C can promote the absorption of iron to increase the level of iron in the organism, so the supplementation of iron at the same time pays attention to the supplementation of vitamin C. Its sources are also diversified, and it can be obtained from fruits such as kiwis, tomatoes, oranges, dates, and other fruits. The sources of vitamin C are diverse, either through kiwis, tomatoes, oranges, dates, and other fruits, or through vitamin C tablets. Magnesium, on the other hand, can be supplemented with dark green vegetables as well as coarse grains [23].

5. Conclusion

In this paper, a review of certain literature has revealed that dietary nutritional patterns and behaviors, among others, may influence the quality of sleep in adolescents to some extent. Some of the nutrients consumed may directly affect or indirectly regulate sleep to some extent. There is a great deal of clinical information on the effects of macronutrients and micronutrients on sleep, especially proteins and carbohydrates, among others. Adolescents need to pay attention to the intake of protein and carbohydrates in their nutritional intake, and at the same time, they should supplement vitamins and minerals as much as possible.

However, there is still some controversy about the positive and negative effects of proteins on sleep, and the specific mechanism of how carbohydrates and proteins form a synergistic system on sleep formation cannot be determined, and still needs to be explored and researched. It is suggested that schools and families should further understand the influence of nutrients on teenagers' sleep and rationally plan and manage teenagers' dietary nutritional intake. Meanwhile, it is also hoped that the relevant education and health departments need to formulate corresponding preventive and control

measures for the non-dietary and dietary factors of sleep disorders, so as to further improve the adolescents' sleep problems.

Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

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