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Association between consumption of tryptophan with sleep quality in King Saud University students

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ABSTRACT

This study aimed to evaluate the relationship between sleep quality and tryptophan consumption in King Saud University students by using a PSQI questionnaire. This study was conducted during the COVID-19 pandemic, and it included 122 Saudi students, who received the PSQI questionnaire via Twitter, Telegram, and WhatsApp. All data was encoded in Excel for statistical analysis. Generally, low consumption levels were noted for tryptophan, coffee/tea, and soft and energy drinks in 42.6 %, 47.5 %, and 76.2 % of the participants, respectively, whereas dairy consumption was high in 32 % of the participants. Moderate consumption of caffeinated drinks was noted in 50.8 % of the participants. Meanwhile, moderate scores were noted for sleep quality, sleep duration, sleep delay, and fatigue during day time; high scores for inability to sleep within 20 mins after going to bed were noted in only 25.4 % of the participants. When the obtained data was examined in three groups, gender ($p = 0.02$), specialization ($p = 0.02$), not falling asleep within 20 min ($p = 0.003$), sleep delay ($p = 0.01$), feeling cold during sleep ($p = 0.02$), and having a good sleep in the previous month ($p = 0.04$) were associated. By contrast, no association was observed between tryptophan consumption and sleep quality. Interventional studies involving a large sample size, gender bias, other age groups, and other ethnic populations should be carried out in the future.

1. Introduction

Sleep is one of the fundamentals of health and wealth, and it is involved in memory consolidation, immune system regulation, and energy restoration (Christensen, 2022). Despite the lack of a definitive consensus in the field of sleep medicine, the term "sleep quality" has been used to refer to various sleep-related factors that are closely associated with sleep disorders (Hwang and Park, 2018). A good sleep is frequently defined as having 7–9 h of sleep daily for a short sleep latency and good sleep efficiency (Binks, 2020). Consistent with the widely acknowledged role of sleep in the regulation of biological processes pivotal to health. Prevalence rates ranging from 50 % to 70 % have been reported across large studies conducted in various sociocultural contexts (Carpi et al., 2022). The sleep–wake circadian rhythm is established by two key physiological processes: sleep–wake homeostasis and circadian clock. Physiological, psychological, and behavioral shifts all occur on a daily basis (24-hour cycle) with the majority of shifts occurring in response to light/dark cycle; additionally, the social time for a given day should be taken into account (Wang, 2022).

The concept of quality sleep is crucial in the medical field for two main reasons. First, epidemiological surveys revealed that 15–35 % of the adult population frequently report some form of sleep disturbance, such as trouble falling asleep or staying asleep. Second, poor sleep quality is a key symptom of many sleep and medical disorders. Sleep duration is a common indicator of sleep quality, and it may be directly related to mortality (Buysse, 1989). Many age-related chronic diseases can be avoided or their onset may be delayed by improving one's sleep habits (August, 2022). In many countries, the prevalence of sleep disorders has increased in recent years (Hwang and Park, 2018). The prevalence of poor sleep quality in adult population varies across countries, ranging from 29 % to 38 % (Madrid-Valero, 2017; Knutson, 2017). A study found that 70 % of Saudi medical students at the King Abdulaziz University in Jeddah experience poor sleep quality (Sk, 2017). The same is true for 74 % of medical students at the King Khalid University in Riyadh (Siddiqui, 2016). Both studies assessed the students' sleep quality using PSQI, and they both showed high percentages of poor sleep quality (Sk, 2017; Siddiqui, 2016).

Sleep time and other sleep quality components are linked to mental

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discomfort and chronic disease symptoms in humans (Sutanto, 2022). Studies have shown that intake of food (including macronutrients and micronutrients), such as milk and dairy products, can alter sleep quality. In heathy adults, the recommended daily intake of milk and dairy products is three cups (Hess et al., 2020). Among Saudis, consumption of dairy products is approximately one cup per day (Adam et al., 2014), translating to a tryptophan intake of 2–2.6 mg/kg, which is low. Low tryptophan consumption can have negative health consequences, such as insomnia, depression, and poor sleep quality (Alkhatatbeh et al., 2021). Studies have investigated the association between tryptophan consumption and sleep quality. These studies demonstrate a relationship between optimal tryptophan consumption and improved sleep quality (Kitano, 2014; Nisar, 2019; Yasuda, 2019). However, no studies conducted in Saudi Arabia have ever investigated the relationship between tryptophan consumption and sleep quality. Thus, this study aimed to investigate the association between sleep quality and consumption of tryptophan among King Saud University (KSU) students by using a PSQI questionnaire.

2. Materials and methods

This cross-sectional study evaluated the association of tryptophan consumption with sleep quality among KSU students aged 22–25 years (mean age: 23.41 ± 12.31 years). This investigation was conducted in Riyadh, Saudi Arabia, from January 17, 2021 to April 17, 2021. Saudi KSU students without any sleeping disorders and other health complaints were included in this study. Non-Saudi students, pregnant women, those using psychotropic drugs or sleeping drugs, those with psychiatric/chronic complications, those with a daily coffee intake of at least six cups, and those allergic to tryptophan were excluded from this study. The sample size was calculated as previously described (Zaid et al., 2018). The sample initially included 190 male and female students.

Data were collected using a self-administered questionnaire consisting of 32 closed- and open-ended questions grouped into three sections. The first section consisted of 10 questions that examined the students' attributes and identified those who do not satisfy the inclusion criteria. The survey was automatically terminated when the participants failed to meet the inclusion criteria based on the first 10 questions. The second section consisted of four questions that assessed tryptophan consumption. The third section included 19 questions based on the validated PSQI questionnaire; these questions assessed sleep quality. After the screening, 122 students qualified, all of whom provided a written informed consent. This study was approved by the Institutional Review Board of the College of Medicine at KSU. To improve the validity of the questionnaire, a pilot study was undertaken prior to the conduct of this study. The survey was distributed to the students via Twitter, WhatsApp, and Telegram.

PSQI is a self-reported questionnaire consisting of 19 items divided into seven components (Buysse, 1989);(Suleiman, 2010).

The participants' characteristics and tryptophan intake were analyzed using descriptive statistics. Mean and percentage frequencies were determined to explore the relationship between tryptophan consumption and sleep quality.

2.1. Statistical analysis

Categorical data are presented as total numbers and percentages. Student *t*-test was used to determine the p values presented in Table 1. One-way ANOVA was performed to analyze the data in Tables 2–4 (Alkudmani et al., 2023). A p value of < 0.05 indicated statistical significance.

3. Results

This study included 122 participants, the majority of whom were female (69.7 %) (Fig. 1). Only four students with specialty expressed interest to participate in this study; the other participants were regular medical students (57.4 %), science students (19.7 %), management students (13.9 %), and humanities students (9 %) (Fig. 2). In this study, gender and specializations were significantly associated when compared ($p = 0.21$). All of the 122 participants were Saudi nationals ($p = 0.99$), which was one of the inclusion criteria for this study.

Table 1
Basic participant information for university students.

	All (n = 122)	Female (n = 85)	Male (n = 37)	P value
Gender (Female: Male)	37 (30.3 %): 85 (69.7 %)	85 (69.7 %)	37 (30.3 %)	0.02
Specialization				
Medical College	70 (57.4 %)	43 (50.6 %)	27 (73 %)	0.021
Science College	24 (19.7 %)	17 (20 %)	07 (18.9 %)	
Management College	17 (13.9 %)	17 (20 %)	00 (0 %)	
Humanity College	11 (9.0 %)	08 (9.4 %)	03 (8.1 %)	
Saudi Nationality	122 (100 %)	85 (100 %)	37 (100 %)	0.99

Table 1 shows the characteristics of the participants, and Table 2 shows the consumption levels of tryptophan-containing products. Tryptophan consumption was low in 42.6 % of the participants but was very high in 24.6 % and was moderate and high in 16.4 % of the participants. Coffee and tea consumption levels were low in 47.5 %, moderate in 27 %, and low in 25.4 % of the participants, whereas energy and soft drink consumption levels were low in 76.2 %, moderate in 19.7 %, and high in 4.1 % of the participants. None of the students consumed excessive amounts of tea, coffee, soft drinks, or energy beverages.

In this study, dairy products or tryptophan-containing food products were categorized into butter, cheese, ice cream, yogurt, condensed milk, and dried milk. Overall, dairy product intake was high in 32 %, low in 27.9 %, moderate in 24.6 %, and extremely high in 15.6 % of the participants. Among the tryptophan-containing products, yogurt was found to be highly consumed by the participants. The participants also consumed cheese (n = 22, 18 %), butter (n = 15, 12.3 %), ice cream (n = 5, 4.1 %), condensed milk (n = 2, 1.6 %), and dried milk (n = 3, 2.5 %) in addition to yogurt (n = 75, 61.5 %). Meanwhile, the average daily coffee intake was 240 ml, and coffee intake was moderate in 50.8 %, low in 47.5 %, and high in 1.6 % of the participants. None of the participants was considered heavy coffee drinker.

Tryptophan consumption was found to be high in both males (40.5 %) and females (43.5 %); specifically, butter consumption was found to be high among females (5.9 %) and males (5.4 %). Cheese consumption was found to be moderate (5.9 %) among females and high (16.2 %) among males. Yogurt consumption was high among females (28.2 %) but low among males (27 %). Caffeine consumption was moderate in 55.3 % of the female participants but was low in 56.8 % of the male participants. No significant differences in daily milk ($p = 0.37$), butter ($p = 0.64$), cheese ($p = 0.58$), yogurt ($p = 0.58$), or caffeine consumption ($p = 0.29$) were observed between the three groups.

4. Discussion

This study examined the effect of tryptophan consumption on sleep quality among KSU students by using a PSQI questionnaire. Tryptophan consumption was classified as low, moderate, high, and very high. This Riyadh-based study included 122 university students aged 22–25 years. Low consumption levels for tryptophan, coffee/tea, and energy and soft drinks were noted in 42.6 %, 47.5 %, and 76.2 % of the participants, respectively. High tryptophan consumption was observed in 24.6 % of

Table 2
Description of Consumption of milk and Dairy Products.

S. No	Total (n = 122)				Female (n = 85)				Male (n = 37)				P Value
	Low	Moderate	High	Very High	Low	Moderate	High	Very High	Low	Moderate	High	Very High	
Consumption of tryptophan	52 (42.6 %)	20 (16.4 %)	20 (16.4 %)	30 (24.6 %)	37 (43.5 %)	16 (18.8 %)	11 (12.9 %)	21 (24.7 %)	15 (40.5 %)	04 (10.8 %)	09 (24.3 %)	09 (24.3 %)	0.37
Dairy Products													
Consumption of Butter	04 (3.3 %)	02 (1.6 %)	07 (5.7 %)	02 (1.6 %)	04 (4.7 %)	01 (1.2 %)	05 (5.9 %)	01 (1.2 %)	0 (0 %)	01 (2.7 %)	02 (5.4 %)	01 (2.7 %)	0.64
Consumption of Cheese	04 (3.3 %)	06 (4.9 %)	08 (6.6 %)	04 (3.3 %)	03 (3.5)	05 (5.9 %)	04 (4.7 %)	02 (2.4 %)	01 (2.7 %)	01 (2.7 %)	06 (16.2 %)	02 (5.4 %)	0.58
Consumption of Yogurt	26 (21.3 %)	21 (17.2 %)	19 (15.6 %)	09 (7.4 %)	16 (18.8 %)	14 (16.5 %)	24 (28.2 %)	06 (7.1 %)	10 (27 %)	07 (18.9 %)	03 (8.1 %)	03 (8.1 %)	0.58
Average Caffeine per day	58 (47.5 %)	62 (50.8 %)	02 (1.6 %)	00 (0 %)	37 (43.5 %)	47 (55.3 %)	01 (1.2 %)	0 (0 %)	21 (56.8 %)	15 (40.5 %)	01 (2.7 %)	0 (0 %)	0.29

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Table 3
Explanation of Sleep Disorders and issues.

	Total participants (n = 122)				Female (n = 85)				Male (n = 37)				
	Low	Moderate	High	Very High	Low	Moderate	High	Very High	Low	Moderate	High	Very High	P value
Sleep Quality	09 (7.4 %)	69 (56.6 %)	14 (11.5 %)	30 (24.6 %)	7 (8.2 %)	47 (55.3 %)	10 (11.8 %)	21 (24.7 %)	02 (5.4 %)	22 (59.5 %)	04 (10.8 %)	09 (24.3 %)	0.94
Sleep Duration	34 (27.9 %)	58 (47.5 %)	21 (17.2 %)	09 (7.4 %)	20 (23.5 %)	41 (48.2 %)	18 (21.2 %)	06 (7.1 %)	14 (37.8 %)	17 (45.9 %)	03 (8.1 %)	03 (8.1 %)	0.21
Students won't fall asleep in 20 mins	35 (28.7 %)	27 (22.1 %)	29 (23.8 %)	31 (25.4 %)	18 (21.2 %)	16 (18.8 %)	26 (30.6 %)	25 (29.4 %)	17 (45.9 %)	11 (29.7 %)	03 (8.1 %)	06 (16.2 %)	0.003
Sleep Delay	18 (14.8 %)	49 (40.2 %)	31 (25.4 %)	24 (19.7 %)	09 (10.6 %)	30 (35.3 %)	27 (31.8 %)	19 (22.4 %)	09 (24.3 %)	19 (51.4 %)	04 (10.8 %)	05 (13.5 %)	0.01
Sleep Efficiency	86 (70.5 %)	17 (13.9 %)	07 (5.7 %)	12 (9.8 %)	54 (63.5 %)	15 (17.6 %)	05 (5.9 %)	11 (12.9 %)	32 (18.6 %)	02 (5.4 %)	02 (5.4 %)	01 (2.7 %)	0.05
Students woke-up in the middle of the night	45 (36.9 %)	19 (15.6 %)	32 (26.2 %)	26 (21.3 %)	33 (38.8 %)	10 (11.8 %)	21 (24.7 %)	21 (24.7 %)	12 (32.4 %)	09 (24.3 %)	11 (29.7 %)	05 (13.5 %)	0.19
Students awoke in night to use the restroom	64 (52.5 %)	31 (25.4 %)	16 (13.1 %)	11 (9.0 %)	39 (45.9 %)	25 (29.4 %)	13 (15.3 %)	08 (9.4 %)	25 (67.6 %)	06 (16.2 %)	03 (8.1 %)	03 (8.1 %)	0.16
Snoring	101 (82.8 %)	07 (5.7 %)	04 (3.3 %)	10 (8.2 %)	70 (82.4 %)	06 (7.1 %)	02 (2.4 %)	07 (8.2 %)	31 (83.8 %)	01 (2.7 %)	02 (5.4 %)	03 (8.1 %)	0.66
Students experience nighttime cold during the sleep	79 (64.8 %)	28 (23.0 %)	13 (10.7 %)	02 (1.6 %)	49 (57.6 %)	22 (25.9 %)	13 (15.3 %)	01 (1.2 %)	30 (81.1 %)	06 (16.2 %)	0 (0 %)	01 (2.7 %)	0.02
Students experience nighttime warm during the sleep	50 (41.0 %)	33 (27.0 %)	31 (25.4 %)	08 (6.6 %)	29 (34.1 %)	24 (28.2 %)	24 (28.2 %)	08 (9.4 %)	21 (56.8 %)	09 (24.3 %)	07 (18.9 %)	0 (0 %)	0.05
Students feel fatigue during the day time	14 (11.5 %)	59 (48.4 %)	38 (31.1 %)	11 (9.0 %)	10 (11.8 %)	39 (45.9 %)	25 (29.4 %)	11 (12.9 %)	04 (10.8 %)	20 (54.1 %)	13 (35.1 %)	0 (0 %)	0.14

the participants, whereas none (0 %) consumed excessive amounts of coffee, tea, and soft and energy drinks.

Moderate scores were obtained in 56.6 % of the participants for sleep quality, sleep duration (47.5 %), sleep delay (40.2 %), and feeling fatigue during the day (48.4 %). Low scores were noted in 70.5 % of the participants for sleep efficiency, waking up in the middle of night (36.9 %) to use the restroom (52.5 %), snoring (82.8 %), and feeling cold (64.8 %) and warm (41 %) during sleep. High scores were obtained in 51.6 % of the participants for having a pleasant, full sleep for the past 30 days. By contrast, low scores were obtained from 95.1 % of the participants for the use of sleeping pills and for missing sleep at night due to certain activities (59.8 %). When the obtained data was examined in three groups, gender ($p = 0.02$), specialization ($p = 0.02$), not falling asleep within 20 min ($p = 0.003$), sleep delay ($p = 0.01$), feeling cold during sleep ($p = 0.02$), and having good sleep in the previous month ($p = 0.04$) were associated.

Table 4
Calculation of sleep disturbances in the last month.

	Total Participants (n = 122)				Female (n = 85)				Male (n = 37)				P value
	Low	Moderate	High	Very High	Low	Moderate	High	Very High	Low	Moderate	High	Very High	
Did you have a good sleep in the last month	33 (27.1 %)	19 (15.6 %)	63 (51.6 %)	07 (5.7 %)	28 (32.9 %)	28 (32.9 %)	37 (43.5 %)	06 (7.1 %)	05 (13.5 %)	05 (13.5 %)	26 (70.3 %)	01 (2.7 %)	0.04
How many times have you taken sleeping pills in the last month	116 (95.1 %)	04 (3.3 %)	01 (0.8 %)	01 (0.8 %)	79 (92.9 %)	79 (92.9 %)	01 (1.2 %)	01 (1.2 %)	37 (100 %)	0 (0 %)	0 (0 %)	0 (0 %)	0.12
How many times in the last month you did not sleep due to driving, eating meals, or engaging in social activities	73 (59.8 %)	24 (19.7 %)	20 (16.4 %)	05 (4.1 %)	49 (57.6 %)	49 (57.6 %)	14 (16.5 %)	05 (5.9 %)	24 (64.9 %)	07 (18.9 %)	06 (16.2 %)	0 (0 %)	0.32

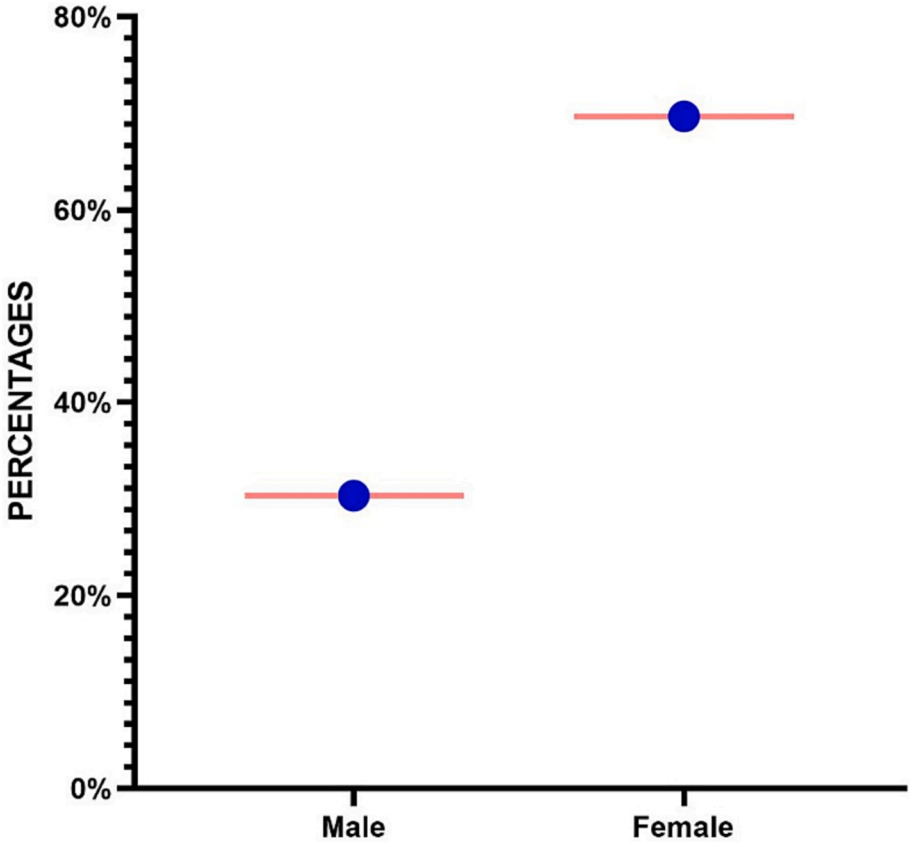

Fig. 1. Description of the gender distribution in this study.

Dairy consumption is critical in achieving a balanced diet at any age. Low-fat dairy products have recently been associated with weight loss and obesity prevention. Thus, paying attention to the dietary patterns of children and adolescents is vital, as these groups acquire eating habits that they will carry over into adulthood. The National Health and Nutrition Examination Surveys conducted in the United States in 1989–1991, 2005–2006, and 2007–2008 reported that the average daily milk intake in children and adolescents considerably dropped from 218 kcal to 170 kcal (Dror and Allen, 2014). A nationwide survey conducted in Canada showed that 61 % of boys and 83 % of girls aged 10–16 years consume less than the recommended daily serving for dairy products (three servings) (Harrison, 2019). This trend is also seen in the United States (Krebs-Smith, 2010). Among Americans aged 2 and above, 85 % consume only 1.9 servings of dairy products per day, and only 15 % of this population meet the dietary requirement for dairy products.

Milk and dairy products offer unique nutritional benefits. Milk is an excellent source of calcium, magnesium, selenium, riboflavin, vitamins B12 and B5, and other minerals. The protein in cow's milk, which is considered a high-quality protein, contains lysine, one of the essential amino acids (Taljić and Delalić, 2018). Some of the consequences associated with low tryptophan consumption include short stature, rickets, and increased risk of fracture, as low tryptophan consumption reduces bone mineral mass in children and causes osteoporosis in adults (Rozenberg, 2016). Furthermore, it raises the risk of metabolic risk factors, such as dyslipidemia, hypertension, abdominal obesity, type 2 diabetes, cardiovascular disease, depression, poor sleep quality, and insomnia (Alkhatatbeh et al., 2021).

As an essential amino acid, tryptophan cannot be produced by the human body and must be obtained from food. Tryptophan is essential in several physiological activities, including protein synthesis and

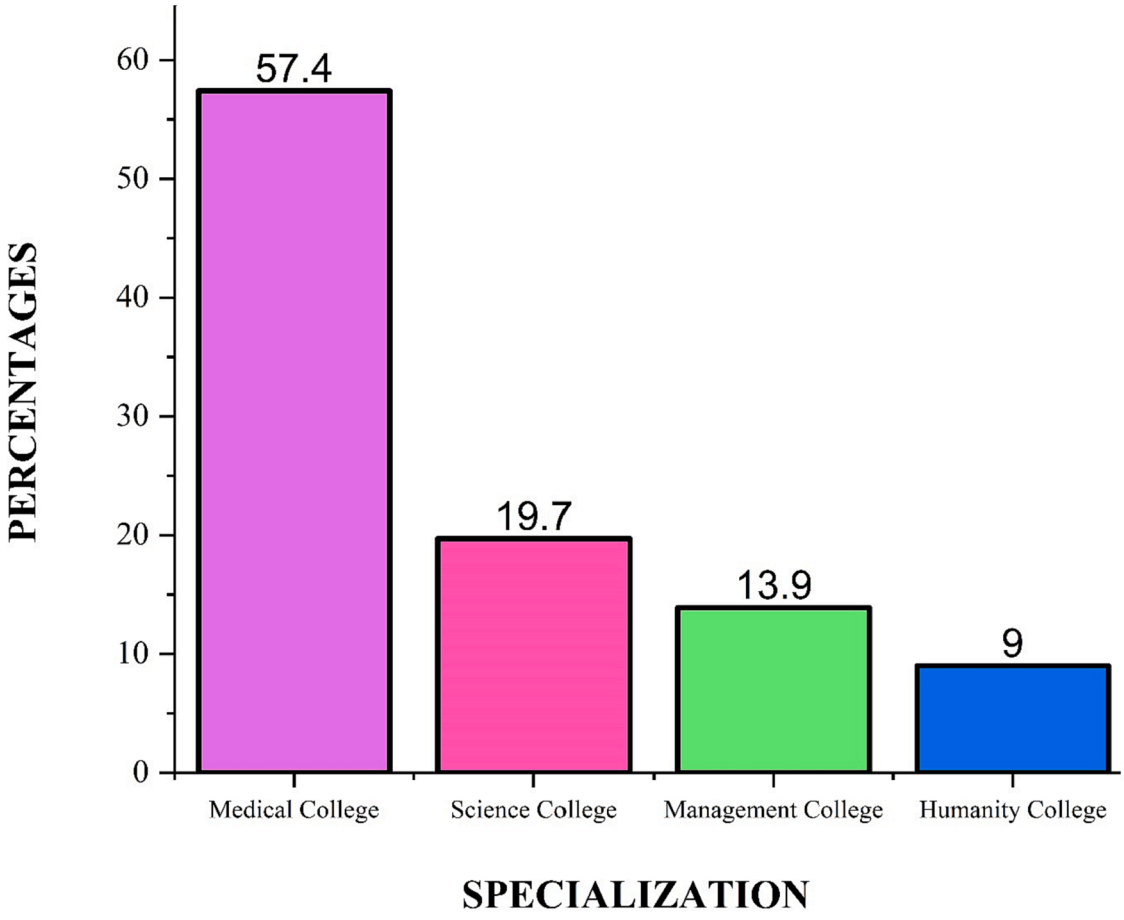

Fig. 2. Categorization of student from different colleges.

neurotransmitter generation. Serotonin, a neurotransmitter that affects mood, appetite, and sleep, is synthesized from tryptophan. The present results revealed that students consuming tryptophan-containing products had a better sleep provided they had no activities to do at night. However, this study showed no strong association between tryptophan consumption and sleep disturbances, and this finding could have been due to the low sample size and more importantly due to the timing of the study, which was carried out during the COVID-19 pandemic. Nevertheless, the present result is consistent with that of the studies on sleep and diet (Alzamil, 2019; Benaich, 2021; Kilani, 2013; Musaiger, 2017). While global studies on tryptophan consumption remain limited (Kitano, 2014; Nisar, 2019; Yasuda, 2019; Min, 2018; van Egmond, 2019), a cross-sectional study showed that young Japanese women with high tryptophan intake are more likely to fall asleep easily and have a younger chronotype (Sato-Mito, 2011). A Japan-based study also confirmed that daily intake of the Shirota strain of *Lactobacillus casei* may aid in maintaining sleep quality during times of increased stress (Takada, 2017). Moreover, a *meta*-analysis indicated that drinking balanced tryptophan improves sleep quality (Komada et al., 2020).

Meanwhile, the results of other *meta*-analyses and systematic reviews on tryptophan consumption and risk of mortality corroborated the negative association of tryptophan consumption with the risk of all-cause mortality (Cavero-Redondo, 2019). Lofti *et al.* confirmed that a balanced diet reduces sleep disturbances in 183 male university students in Iran (Lotfi et al., 2015). Previous findings support the current results, confirming that tryptophan intake is associated with better sleep (Thompson, 2017).

5. Conclusion

No association was found between tryptophan consumption and sleep quality. Future studies should be carried out as interventional studies involving a large sample size, gender bias, other age groups, and other ethnic populations.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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