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Differences in Serotonin Level and Sleep Quality at The Community Based on Dieting (Vegetarian and Non-Vegetarian)

I Made Odie Lastrawan[1], Desak Ketut Indrasari Utami[1], Kumara Tini[1], I Made Oka Adnyana[1], AAA Putri Laksmidewi[1], Ketut Widyastuti[1]

[1]Department of Neurology, Udayana University/Prof. Dr. IGNG Ngoerah Hospital, Denpasar, Bali, Indonesia

Corresponding Author: Desak Ketut Indrasari Utama

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ABSTRACT

Backgrounds: The food-derived serotonin precursor, Trp, is found in plant proteins that supplement the quantity and quality of night sleep assessed in older adult men and women with difficulty sleeping.
Aim: Knowing differences in serum serotonin levels and sleep quality at communities based on diet (vegetarian and non-vegetarian) at Denpasar Bali.
Methods: This observational analytic study used a cross-sectional research design with data collection from March 2022. Serotonin D levels were obtained from the subject's blood as much as 3 ml and then checked in the laboratory with serotonin markers. Sleep quality was assessed using the PSQI. Data analysis in this study using independent t-test using SPSS IBM version 23.
Results: Mean Serotonin Levels ± SD(ng/dl) in the vegetarian group was 263.74±24.45 while the non-vegetarian group was 202±80. The results of data analysis using an independent t-test showed a mean difference of 73.70 (95% CI 21.56-125.83), p=0.006. Sleep quality with PSQI results in an average± SD of 4.58 ± 2.22 in vegetarians, while in non-vegetarians with PSQI average± SD is 7.13±3.98. The results of the independent t-test analysis showed that the mean difference was 2.55 (95% CI 1.11-3.98), p = 0.001
Conclusion: There are differences in serum serotonin levels and sleep quality in the community based on diet (vegetarian and non-vegetarian), with more high serotonin levels in the vegetarian community and more good sleep quality in the vegetarian community.

Keywords: sleep quality, non-vegetarian, diet, serotonin, vegetarian

INTRODUCTION

Sleep is a physiological process important for energy restoration and regeneration of tissues and the central nervous system. Approximately 20-30% of the general population is estimated to experience some sleep disorder. The conditions most often associated with sleep disorders include; narcolepsy, insomnia, hypersomnia, delayed sleep phase syndrome (delayed sleep at night), daytime sleepiness (drowsiness in the morning and during the day), and nightmares. Poor sleep quality has been linked to decreased attention and cognitive performance, poor academic performance, anxiety, stress, depression, poor social relations, cardiovascular disease, and poor overall health. The prevalence of sleep disorders can be caused by delays in circadian rhythms (resulting in an irregular sleep schedule), psychological conditions, environmental and social factors, and physical factors such as lack of exercise and insufficient or inconsistent diet.

Pharmacological treatment can improve sleep quality, and non-pharmacological treatment, such as improving sleep hygiene, is very helpful in improving sleep quality. Diet patterns can enhance sleep quality and

avoid chronic diseases, including using a plant-based diet or becoming a vegetarian.[1] A vegetarian diet is a diet with or without eggs or dairy products, and this definition is still used by the Vegetarian Society now. Vegetarian is a term for people who only eat plants and do not consume food derived from living things such as meat, poultry, fish, or processed products. Vegetarian food contains many nutrients, such as protein, carbohydrates, vitamins, and minerals. The results of a survey conducted by the American Dietetic Association (ADA) showed the number of vegetarians in 2006 was about 4.9 million (2.3%) of the population in America, and about 1.4% were vegan, while in Canada, approximately 900 adults. Various surveys also say that almost 10% of the world's population (700 million) has consumed plant-based foods.[2] The number of vegetarians in Indonesia registered with the Indonesia Vegetarian Society (IVS) when it was founded in 1998 was around 5,000 members and has increased to more than 1.6 million members to date.[3] In Bali, there are vegetarian groups that are developing according to spiritual and religious aspects, such as the Sri Sathya Sai Bali Foundation (Sai Study Group Denpasar), other socio-spiritual organizations, such as Ananda Marga, Krishna Awareness, Japa Yoga, Reyki, Rada Swami, Tao, Loving Hurt, Supreme Master Ching Hai Association, and Sai Study Group. An interview with the manager of vegetarian stalls in Singaraja city revealed that the average daily visitor is around 40 people, and a rough calculation of the number of vegetarian people in Singaraja city is 1,700 people and tends to increase every year while in Denpasar, there is no data on the number of vegetarians.[4]

The food ingredients consumed by non-vegetarian diets are generally almost the same as vegetarians; the difference only lies in the proportion of food consumed. Non-vegetarians typically consume foods rich in fat, while for vegetables and fruits, the ratio is smaller than for vegetarians.[1,2] The nutrient intake level on a non-vegetarian diet also differs from that of a vegetarian diet. According to Sengul (2020), foods in a non-vegetarian diet are generally rich in animal protein and fat but low in fiber and carbohydrates. Based on data from National Health & Nutrition Examination Survey (NHANES) in the United States, high-fat foods are known to have a shorter sleep duration (sleep <7 hours/night) compared to consuming foods high in protein and fiber.[4]

Nutritional interventions acting on the neurotransmitters serotonin, gamma-aminobutyric acid (GABA), orexin, melanin concentration hormones, cholinergic, galanin, noradrenaline, and histamine in the brain can affect sleep. A vegetarian diet produces serotonin (5-HT) and melatonin in the central nervous system, which affects sleep. The synthesis of 5-HT depends on the availability of its precursor in the brain, the amino acid L-tryptophan (Trp). Trp and Large Neutral Amino Acids (LNAA) are transported across the blood-brain barrier. The ratio of Trp / LNAA in the blood is critical to increasing melatonin and serotonin; it affects sleep quality.[3] This Serotonin precursor is found more in vegetarians than non-vegetarians, making sound sleep quality.[6] In addition, high circulating levels of LNAA compete for entry into the brain because they use the same transporter, so a protein-rich meat diet causes an increase in the amount of other amino acids in the blood resulting in a low tryptophan-LNAA ratio resulting in low serotonin production. Dietary carbohydrates alone increase circulating insulin concentrations, which promote LNAA uptake into muscle cells in the postprandial period. Therefore, a vegetarian diet, which tends to have a high carbohydrate-to-protein ratio, may facilitate the entry of tryptophan into the brain and higher serotonin production and reduce sleep disturbances, anxiety, and depression.[4]

Food can indirectly produce serotonin in the body. The food-derived serotonin precursor, Trp, is found in plant proteins that supplement the quantity and quality of night

sleep assessed in elderly men and women with difficulty sleeping.[7] St-Onge et al. (2016)studied participants on a vegetarian diet for a 3-week period in which they were given a control cereal to consume daily at breakfast and dinner (22.5mg tryptophan/30g cereal) for one week, followed by one week of daily tryptophan-fortified consumption. Sleep was measured by actigraphy on the wrist, and melatonin and serotonin levels were determined indirectly through urine metabolites. After one week of consuming Trp-fortified cereals, total sleep time and efficiency improved, and sleep onset latency, wakefulness attacks, and sleep fragmentation were reduced relative to controls.

The function of serotonin on sleep-wake cycles and sleep quality is still controversial, although many questions remain about the intricate role of 5-HT and its receptors in regulating sleep and wakefulness (W); recent studies have revealed a wealth of detailed information about this process. In the 1970s, based on neuropharmacological studies and analyses, 5-HT was hypothesized to be responsible for the initiation and maintenance of slow wave sleep (SWS). But recent studies say that serotonin (5-HT) functions more in maintaining wake time (W) and inhibiting REM and melatonin synthesis, which plays a role in regulating circadian rhythm.[4]

A cross-sectional study was conducted on 73 nurses at a tertiary hospital in Cairo, Egypt, to assess the sleep quality between hours of work nurses (SWNs) to determine blood serotonin levels and their relationship to hours worked and sleep quality. The study results showed a significant difference in serotonin levels between nurses with poor and good sleep quality, and most nurses with poor sleep quality (62.7%) had low serotonin levels. Abnormal serotonin levels and years of work were statistically significant predictors of poor sleep quality. In conclusion, shift nurses and night shifts suffer from poor sleep quality associated with abnormal blood serotonin levels.[5]

Based on the description above, the researcher wanted to examine serum serotonin levels and differences in sleep quality in communities based on eating patterns (vegetarian and non-vegetarian) in Denpasar Bali.

METHODS AND PROCEDURES

This study used an analytic observational study using a cross-sectional method. The results were 80 subjects, of which 40 were vegetarian, and 40 were non-vegetarian. The study was conducted in March 2022 in the Denpasar Bali area. The ethical license No. 474/UN 14.2.2VII.14/LT/2022 from the Faculty of Medicine ethics committee, Udayana University/ Prof. Dr. IGNG Ngoerah Hospital Denpasar. Inclusion criteria of (1) All vegetarian and non-vegetarian eating communities in Denpasar Bali, (2) Age 20-50 years, (3) vegetarian for at least 1 year, (4) Willing to sign an informed consent. The exclusion criteria in this study are: (1) Having depression, anxiety, and stress, gastrointestinal disease, pain (2) Taking drugs that affect sleep and taking psychiatric drugs (3) Having a smoking habit (> 10 cigarettes per day), consuming alcohol > 3 drinks per day, and consuming caffeine >3 cups of coffee per day. Descriptive data using independent t-test. All data from this study were analyzed using the SPSS 20.0 for Windows program. The significance level with $p<0.05$ and a 95% confidence interval.

RESULTS

The characteristics of the samples assessed in this study included age, gender, nutritional status (BMI), and physical activity (IPAQ), the results of which are shown in Table 1.

Table 1 Characteristics of research subjects

Demographic Profile		Vegetarian	Non-Vegetarian	p
Gender n (%)	Man	26 (65)	22 (55)	0.362
	Woman	14 (35)	18 (45)	
Mean Age ± SD (years)		37.43 ±1.35	36.95 ±0.96	0.809
Average nutritional status (BMI)(kg/m2)		23.66±0.69	25.21±0.68	0.118
Average± SD IPAQ Score (Physical Activity)		2987.50±1099.16	2446.25±1041.65	0.706

Based on the characteristic data after the Kolmogorov-Smirnov normality test, it was found that the P value> 0.05 (average distribution data) on the age profile, BMI, and IPAQ (physical activity) in the vegetarian group and the non-vegetarian group, the same results were obtained.

Based on gender category, in the vegetarian group, there were 26 (65%) male subjects and 14 (35%) female, while in the non-vegetarian group, 22 (55%) subjects were male and 18 (45%) female. The chi-square test results showed no difference in the two groups between men and women, with p = 0.362.

In the vegetarian group, the mean age ± SD (years) was 37.43 ±1.35, while in the non-vegetarian group, it was 36.95 ±0.96. The results of the independent t-test analysis were obtained with p = 0.809, which means there was no difference between the two groups.

Body mass index (BMI) in the standard vegetarian group with mean nutritional status (BMI)± SD (kg/m2) 23.66±0.69 and non-vegetarian 25.21±0.68. The results of the independent t-test analysis were obtained with p = 0.118, which means there was no difference between the two groups.

Results physical activity in the vegetarian group with light-moderate IPAQ± SD 2987.50±1099.16 and in the non-vegetarian group IPAQ average light-medium± SD 2446.25±1041.65. The results of the independent t-test analysis were obtained with 0.706 results, which means there is no difference between the two groups.

The results of this study about differences in serum serotonin levels in the community based on diet (vegetarian and non-vegetarian) are shown in Table 2.

Table 2 Differences in serum serotonin levels in the community based on diet (vegetarian and non-vegetarian) in Denpasar Bali.

Serotonin Level(ng/dl)					95% CI		p
	N	Average± SD	Range (min-max	Average Difference	Min	max	
Vegetarian	40	263.74±24.45	207.52-296.88	61.69	21.56	125.83	0.006
Non-Vegetarian	40	202.05±80.34	150.05-266.95				

The results of the examination of serotonin levels in the vegetarian group on average 263.74±24.45 while in the non-vegetarian group, 150.05-266.95. The results of the independent t-test analysis in Table 5.2 show that the vegetarian diet causes an average serotonin level significantly higher than in the non-vegetarian group (p<0.05).

The results of this study regarding differences in sleep quality in communities based on diet (vegetarian and non-vegetarian) are shown in Table 3.

Table 3 Differences in sleep quality in communities based on diet (vegetarian and non-vegetarian) in Denpasar Bali.

PSQI Score					95% CI		p
	N	Average± SD	Range (min-max	Average Difference	Min	max	
Vegetarian	40	4.58±2.22	3.86-5.29	2.55	1.11	3.98	0.001
Non-Vegetarian	40	7.13±3.98	5.85-8.40				

Results of sleep quality examination with PSQI in the vegetarian group on average4.58 ± 2.22 while in the non-vegetarian group, it was 7.13 ± 3.98. The results of the independent t-test analysis in Table 5.3 show that the vegetarian diet causes the mean PSQI to be significantly higher than in the non-vegetarian group (p<0.05).

DISCUSSION

In this study, 80 research subjects who met the inclusion and exclusion criteria were divided into two groups: vegetarians (40 subjects) and non-vegetarians (40 subjects). The highest gender is male in vegetarians and non-vegetarians, where the average age for vegetarians is 37 years, and for non-vegetarians is 36 years. This is to a study conducted by Sukmawati (2021) regarding differences in energy intake, macronutrients,

and fiber-based on total cholesterol levels in young vegetarian adults in Indonesia, with the highest age group being 36-40 years 33 (47.1%) subjects with men. the most men were 40 (57.1%). In Burhani's (2014) study, age is vital in determining a person's food choices. It influences individual consumption behavior, with the results of the young adult vegetarian age group in the Indonesian Vegetarian Society Jakarta with the respondents aged 20 to 40. Research according to Kakilo et al. (2016) entitled the difference in blood glucose levels and lipid profiles of patients given a lacto-ovo vegetarian and non-vegetarian diet with the highest frequency distribution results in male respondents of 58.3% who underwent a vegetarian diet. The majority of the characteristics of vegetarians, 8420 subjects from 118 countries, mainly were aged 25-34 years, with 2477 (33.7%) women and 376 (35.1%) men.[10]

The body mass index in the vegetarian community has an expected average result, and non-vegetarians with a moderate impact of being overweight; this is related to diet and also physical activity, with the most results in the vegetarian community with activity weight 23 (57.5%) while non-vegetarians in action low-medium24 (60%). The relationship between food consumption of calcium sources and physical activity with the bone density of lacto ovo vegetarians at the Buddhist Tzu Chi Foundation in Surabaya found that most respondents had a moderate physical activity with a percentage of 61.3%. Most Lacto ovo vegetarian respondents at the Buddhist Tzu Chi Foundation Surabaya do physical activities such as sitting, carrying light weights, and doing light exercises.[11] Siwi and Nindyan's research on body image related to body mass index, but not with the waist-to-hip ratio in female vegetarians in Surabaya, 23 respondents (71.9%) had a positive body image perception. A total of 22 respondents (68.7%) had a WHR value < 0.8 cm, and as many as 19 respondents (59.3%) had a normal BMI. The results of this study obtained serotonin levels in vegetarians and non-vegetarians and found a significant difference. The highest value of high serotonin levels was found in vegetarians 21 (52.5%).[9]

Serotonin is important because it affects several organs, including the brain and intestines. Other bodily processes also greatly benefit from serotonin, such as social behavior, sex drive, a busy sleep schedule, and learning and memory. A lack of serotonin levels can lead to anger. Indigestion (including constipation), increased sensitivity to pain, dietary changes, separation anxiety or dependence, disturbed sleep schedule, problems with self-esteem, headaches and migraines, and general bad mood.[10] Serotonin levels are about 90% of the human body produced in the GI tract; about 8% are found in platelets and 1-2% in the CNS. Peripheral serotonin is made in the gut by enterochromaffin cells, as well as by specific immune cells and gut neurons. Serotonin produced in the brain is made by the raphe cells that directly supply the brain.[11,12]

Serotonin synthesis depends on the availability in the brain of its precursor, the amino acid L-tryptophan (Trp). Trp is transported across the blood-brain barrier by systems that share other transporters, including many neutral amino acids (LNAAs). The LNAA ratio is influenced by carbohydrate requirements, where carbohydrates will increase insulin in the blood, increasing the uptake of other LNAA, increasing the ratio of Trp/LNAA. The Trp/LNAA ratio in the blood is critical for transporting Trp to the brain, and an increase in this ratio can be achieved by the intake of pure tryptophan or tryptophan-rich protein [5].

The World Health Organization (WHO) Recommended Daily Allowance (RDA) for tryptophan is a daily intake of 3.5 milligrams per kilogram of body weight, about 225 milligrams for a 140-pound woman. Some plant foods that can increase tryptophan levels, thereby increasing serotonin levels, are: Butternut Pumpkin Seeds (Serotonin levels are best increased with tryptophan and

protein sources, whole grains are a good choice, especially butternut pumpkin seeds), Sea Vegetables (Vegetables such as seaweed, and spirulina), Soybeans (Soy content from processed tofu and soy milk), Oats, Walnuts, Green Vegetables (Green vegetables such as spinach are high in tryptophan), Potatoes, Cauliflower, Mushrooms, Cucumbers, Bananas, and Tomatoes.[7,8]

According to the RDA, adequate nutrition in animal and plant diets in Asia in patients with chronic kidney disease found that food intake was sufficient for daily tryptophan levels. The highest amount of Trp was found in the plant/vegetable diet group [9]. The protein ratio in plant and animal diets is said to contain tryptophan in the same amount in vegetable and animal protein and high enough amounts when compared to requirements.[6] Concentrations of the amino acids methionine, lysine, tryptophan, and threonine are generally lower in protein from vegetable sources.[7] There was a statistically significant difference between vegetarians and non-vegetarians in sleep quality, where vegetarians had better sleep quality than non-vegetarians. This is to previous research linking sleep quality with dietary patterns. Diet is very influential on the quality of a person's sleep. Various food content types, such as high carbohydrates, high protein, and high fat, can affect sleep quality. NHANES data in the United States shows that people with short sleep duration (sleep <7 hours/night) consume foods with less protein and fiber content than people with typical sleep duration (7-8 hours sleep/night).[4]

Vegetarians were found to suffer from insomnia and sleepiness less frequently than non-vegetarians. This association is also statistically significant when comparing only women. In addition, consuming fruit and vegetables at least once a day was associated with a reduced prevalence of sleep disturbances when compared to drinking less fruit and vegetables.[9,10] Adolescents from Sicily who adhered to the Mediterranean Diet, higher fruit and vegetable consumption was positively associated with sleep quality.[8] Fish is linked to better sleep quality. The serotonin precursor, high in tryptophan, is obtained from vegetable protein, which affects the quantity and quality of night sleep assessed in elderly men and women who have difficulty sleeping.[7] A very significant difference in serotonin levels between poor and good sleep quality nurses, and most nurses with poor sleep quality (62.7%) had low serotonin levels. Abnormal serotonin levels and years of work were statistically significant predictors of poor sleep quality. Sleep quality is not related to vegetarianism. This study had different results because the subjects were in Jakarta, with 314 issues.[6]

In foods, tryptophan is an amino acid found in foods that contain plant protein. Amino acids are the building blocks of protein, but they also have other roles in the body. One of these roles is to produce molecules that help the body transmit signals. Tryptophan, in particular, can be converted into a molecule called 5-HTP (5-hydroxytryptophan) which is used to make serotonin and melatonin. Serotonergic or 5-hydroxytryptamine (5-HT) has an activity to promote wakefulness and inhibit REM sleep. So to increase serotonin levels, you need tryptophan, which is found in vegetarian foods and improves sleep quality, according to research results.

This study aimed to determine differences in sleep quality and serotonin levels in the vegetarian and non-vegetarian communities for which data has not been obtained in Bali. There is no data on differences in dietary patterns (vegetarian and non-vegetarian) with serotonin levels in Indonesia, so this research can add further research citations in the future. It uses homogeneous subjects on age, gender, nutritional status, and physical activity. The study has a parametric scale, so it has almost the same power if carried out elsewhere.

The weakness of this study is the availability of serotonin tests, often found in the laboratory, so serotonin levels cannot be checked at any time. In this study, there is no link between sleep quality and serotonin levels in the vegetarian and non-vegetarian

diet communities not looking for risk factors that affect sleep quality and serotonin levels. Does not specify the vegetarian groups in more detail, such as vegan, lacto ovo, Lacto-vegetarians, and Ovo vegetarians, Did not perform a multivariate test on confounding factors. I haven't been able to describe sleep disorders in vegetarians or non-vegetarians that most often occur, for example, insomnia, parasomnia, or other diseases. The study results a show that serum serotonin levels in vegetarian diets are higher than in non-vegetarians which can be used to increase food intake containing vegetables, nuts, milk, and eggs, which can help better sleep quality. Further research is needed to improve the results of this study, among others, conducting research using a larger sample size involving various types of vegetarian diets and using case-control research methods as well as cohort methods.

CONCLUSION

Based on the results of this study, it was concluded that

1. There is a statistically significant difference in serum serotonin levels in the community based on diet (vegetarian and non-vegetarian) in Denpasar Bali, with higher serotonin levels in the vegetarian community.
2. There is a statistically significant difference in sleep quality in the community based on diet (vegetarian and non-vegetarian) in Denpasar Bali, with better sleep quality results in the vegetarian community.

INFORMED CONSENT AND PATIENT DETAILS

The authors declare that this research does not contain any personal information that could lead to the identification of the patient(s) and/or volunteers.

Declaration by Authors

Ethical Approval: This research has received approval from the research ethics committee of the Faculty of Medicine, Udayana University/ Prof. Dr. IGNG Ngoerah Hospital Denpasar, with No. 474/UN 14.2.2VII.14/LT/2022

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Conflict of Interest: The authors declare no conflict of interest.

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