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Original Research Article

The Relationship between Sleep Quality with Hemoglobin Levels and Erythrocyte Index of Medical Students at Universitas Nusa Cendana

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Abstract: ***Background****:* Sleep is an essential primary need where recovery occurs in the body and brain to achieve optimal health. Medical student' sleep quality tends to be poor due to a more busy schedule of lectures and practicums than other study programs. Disruption of sleep will affect the formation of hemoglobin and erythrocyte index, which is the cause of anemia. ***Aim****:* Analyzing the relationship between sleep quality and hemoglobin levels and erythrocyte index in medical students at the Universitas Nusa Cendana. ***Method****:* An observational analytic study with a Cross-Sectional design conducted on MEDICAL students of the Faculty of Medicine and Veterinary Medicine, Universitas Nusa Cendana. Sleep quality data were obtained by filling out the Pittsburg Sleep Quality Index questionnaire. Hemoglobin levels and erythrocyte index were obtained through complete blood examination with a Hematology Analyzer on 54 samples that met the inclusion criteria. Sampling was done by using the Stratified Random Sampling technique. The results were analyzed univariately and bivariate using the Chi-Square test. ***Results****:* The prevalence of poor sleep quality is 68%. Anemia occurs in 35.2% of subjects, and the most morphological features of erythrocytes were normochromic normocytic (72.2%). Bivariate analysis with the Chi-Square test showed $p = 0.028$ ($p < 0.05$) on the relationship between sleep quality and hemoglobin levels and $p = 0.037$ ($p < 0.05$) on the relationship between sleep quality and erythrocyte index. ***Conclusion****:* There is a significant relationship between sleep quality with hemoglobin levels and erythrocyte index in medical students at Nusa Cendana University.

Keywords: Sleep Quality, Hemoglobin, Anemia, Erythrocyte Index, Medical Students.

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INTRODUCTION

The curriculum used in medical education programs in Indonesia requires students to study for a longer time in a day compared to other disciplines. This refers to a busy lecture schedule and is always interspersed with laboratory practice, clinical skills practice, assignments, and exam schedules, causing students to feel more easily exhausted due to a lack of time to rest [1].

Sleep is a fundamental primary need for every human being. When falling asleep, there is a recovery process in the body and the brain to achieve optimal health. A simple indicator to assess the quality of a person's sleep is the body condition. When waking up, the body feels refreshed, indicating that the fulfillment of sleep quality is sufficient [2]. Poor sleep quality can also result from high stress [3]. Many factors contribute to the high-stress levels of the medical students, such as a broad curriculum, numerous academic demands, and

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various difficult exams. The proportion of high-stress levels among medical students in Pakistan is around 60%, in Thailand 61%, in Malaysia 42%, and in the United States 57% [4]. Systematic literature research involving 57 studies and 25,735 medical students worldwide using the Pittsburgh Sleep Quality Index (PSQI) questionnaire instrument showed that 52.7% of medical students had poor sleep quality [5]. The proportion of poor sleep quality among Universitas Nusa Cendana medical students in 2019 was 81.2%; in 2020, it was 87.1%, and in 2021 it was 93.1% [2, 6, 7].

The intensity of sleep affects the biological processes that occur during sleep, one of which is the formation of hemoglobin. Hemoglobin plays the role of transporting oxygen from the lungs to all body tissues and carbon dioxide from body tissues back to the lungs [1, 8]. Low hemoglobin levels impact the incidence of anemia, where there is a decrease in the number of red blood cells in circulation, abnormality of the hemoglobin content of red blood cells, or both. The erythrocyte index is a limitation used to determine the size and content of erythrocyte hemoglobin. This examination consists of mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC). Anemia is a condition of decreasing the number of red cell mass, practically characterized by a decrease in hemoglobin, hematocrit, or erythrocyte count [9, 10].

The incidence of anemia in the age group of 15-24 years in Indonesia has increased since 2007, 2013, and 2018. The Basic Health Research (RISKESDAS) data in 2018 showed around 32% of adolescents with anemia in Indonesia which increased from the previous data in 2013 of approximately 18.4% [11].

In a study by Mawo PR *et al*., Poor sleep quality impacts low hemoglobin levels [2]. Research in Manado by Sarjono L *et al*., shows no difference in hemoglobin levels between poor and good sleep quality students [12]. Based on the research above, researchers are interested in continuing and proving the relationship between sleep quality and hemoglobin (Hb) levels and erythrocyte index in Universitas Nusa Cendana Medical Students.

METHODS

The study starts from August 30th to September 27th, 2022, in the Faculty of Medicine and Veterinary Medicine, Medical Study Program Universitas Nusa Cendana, and the Clinical Pathology Laboratory of SK LERIK Hospital. This study population was Medical students, which comprised 60 students from the class of 2019, 80 students from 2020, and 82 students from the class of 2021.

This study used proportionate stratified random sampling. The calculation of the minimum sample size is determined using the formula. Test hypotheses against unpaired categorical analytical research.

The inclusion criteria in this study are active students of 2019-2021 in the Medical Education Study Program, willing to be the subject of research, healthy and have no history of chronic diseases [10, 13], not in menstrual period [14], not donated blood in the last 59 days [15, 16], not take blood-added drugs, have no history of diagnosed anemia [7, 14], are not active smokers [18], do exercise activities less than three times a week [19].

This study used the Pittsburgh Sleep Quality Index (PSQI) Questionnaire instrument, which has been validated and has been used in various previous studies. The questionnaire consisted of 9 lists of questions with seven assessment components such as subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, medication (use of drugs for sleep), daytime dysfunction (sleep disturbance experienced during the day) related to sleep state during the day last month [20, 21].

For Hemoglobin and Erythrocyte Index levels, researchers used 3cc venous blood samples after the sample filled out a questionnaire entirely on the same day. The blood sample was inserted into the EDTA tube and taken to the Clinical Pathology Laboratory of SK Lerik Kupang Hospital. Analysis using the Sysmex XNL Series Automated Hematology Analyzer method by combining recognized technologies, namely fluorescence flow cytometry, hydrodynamic focussing, and SLS cyanide-free methods.

The data were then analyzed univariately and bivariate using the Chi-Square test.

RESULTS

This study used the characteristics of respondents that included gender, age, entry year, and sleep quality. The characteristics of these respondents write in Table 1.

Table 1: Characteristics of Respondents

	n	%
Age		
18	7	13
19	15	27,8
20	19	**35,2**
21	8	14,8
22	5	9,2
Entry Year		
2019	15	27,8
2020	19	35,2
2021	20	**37**
Gender		
Male	14	25,9
Female	40	**74,1**
Sleep Quality		
Good	19	35,2
Poor	35	64,8

Data in Table 1 shows the highest distribution at the age of 20 years (35.2%), the highest sex distribution of more women (74.1%) with the origin of the most batches of the class of 2021 (37%), followed by the class of 2020 (35.2%) and 2019 (27.8%). 19 samples (35.2%) had good sleep quality, and 35 (64.8%) had poor sleep quality.

Table 2: Cross-Distribution Table of Hemoglobin Levels and Erythrocyte Index

Erythrocyte Index	**Hemoglobin**				**Total**	
	Anemia		**Not Anemia**			
	n	**%**	**n**	**%**	**n**	**%**
Hypochromic Microcytic	13	24,1	2	3,7	15	27,8
Normochromic Normositic	6	11,1	33	61,1	39	72,2
NormochromicMacrocytic	0	0	0	0	0	0
Total	19	35,2	35	64,8	54	100

Data in Table 2 obtained from 54 medical students of the Universias Nusa Cendana, 19 samples (35.2%) were anemic, and 35 (64.8%) were not anemic. Attributed to the erythrocyte index based on Table 3, 15 samples (27.8%) had a picture of the hypochromic microcytic erythrocyte index, 39 samples (72.2%) had a normochromic normocytic erythrocyte index, and none of the samples had hypochromic macrocytic erythrocyte index.

Table 3: Distribution of Animal Protein Intake Patterns

No.	**Groceries**	Frequency												**Total**	
		≥3× /day		1-2 ×/day		3-6× /week		1-2× /week		2 ×/ month		Never			
		N	%	N	%	N	%	N	%	N	%	N	%	**N**	**%**
1.	Chicken Meat	1	2	16	30	16	30	16	30	4	7	1	2	54	100
2.	Beef	0	0	4	7	2	4	14	26	18	33	16	30	54	100
3.	Goat Meat	0	0	0	0	1	2	1	2	13	24	39	72	54	100
4.	Chicken Eggs	1	2	11	20	23	43	12	22	5	9	2	4	54	100
5.	Quail Eggs	0	0	0	0	1	2	2	4	11	20	40	74	54	100
6.	Shrimp	1	2	0	0	2	4	3	6	14	26	34	63	54	100
7.	Sea Fish	2	4	8	15	13	24	19	35	8	15	4	7	54	100
8.	Salted fish	0	0	2	4	5	9	4	7	10	19	33	61	54	100
9.	Milk Flour	1	2	9	17	1	2	6	11	8	15	29	54	54	100
10.	Rousong	0	0	3	6	2	4	5	9	14	26	30	56	54	100
Total		6	1	53	10	66	12	82	15	105	19	228	42	540	100

Based on the results of the Table 3 study, the frequency of animal protein intake in Medical Student Universitas Nusa Cendana, which is most frequent and consumed by the majority of students, is fresh fish as many as 2 people (4%) with a consumption pattern of ≥ 3× / day. Followed by chicken meat (2%) with a consumption pattern of ≥ 3× / day, and chicken eggs (2%) with a consumption pattern of ≥ 3× / day. Meanwhile, the highest frequency is fresh fish consumption, by 1-2× / week, with as many as 19 students (35%). Consumption of animal protein sources from quail eggs was the lowest, where 40 students (74%) had never consumed quail eggs in the last two weeks, followed by mutton as many as 39 students (72%).

Table 4: Distribution of Plant-Based Protein Intake Patterns

No.	Groceries	Frequency												Total	
		>3× /day		1-2 ×/day		3-6× /week		1-2× /week		2 ×/ month		Never			
		N	%	N	%	N	%	N	%	N	%	N	%	**N**	**%**
1.	Green Beans	0	0	3	6	2	4	6	11	25	46	18	33	54	100
2.	Red beans	0	0	1	2	3	6	3	6	14	26	33	61	54	100
3.	Soybeans	0	0	0	0	5	9	4	7	7	13	38	70	54	100
4.	Long Beans	0	0	3	6	6	11	7	13	21	39	17	31	54	100
5.	Peanut	0	0	1	2	3	6	8	15	19	35	23	43	54	100
6.	Tofu	0	0	14	26	17	31	14	26	5	9	4	7	54	100
7.	Tempeh	1	2	18	33	17	31	14	26	3	6	1	2	54	100
Total		1	0,3	40	11	53	14	56	14,8	94	24,9	134	35	378	100

Based on the results of the Table 4 study, the pattern of vegetable protein intake in Universitas Nusa Cendana Medical students most often consumed tempeh as much as 1 person (2%) with a consumption pattern of ≥ 3× / day and followed by tofu as many as 14 people (26%) with a consumption pattern of 1-2 × / day and long beans as many as 3 people (6%) with a consumption pattern of 1-2 × / day. Meanwhile, the highest frequency is the consumption of green beans, with a consumption pattern of 2× / month, with as many as 25 students (46%). Consumption of vegetable protein sources from soybeans was the lowest, where 38 students (70%) had never consumed soy in the past two weeks, followed by red bean consumption by 33 students (61%).

Table 5: Distribution of Vegetable Intake Patterns

No.	Groceries	Frequency												Total	
		>3× /day		1-2× /day		3-6× /week		1-2× /week		2 × /month		Never			
		N	%	N	%	N	%	N	%	N	%	N	%	**N**	**%**
1.	Cabbage	1	2	5	9	9	17	12	22	12	22	15	28	54	100
2.	Spinach	0	0	7	13	5	9	19	35	16	30	7	13	54	100
3.	Cauliflower	1	2	3	6	3	6	8	15	15	28	24	44	54	100
4.	Cassava Leaves	0	0	3	6	7	13	12	22	15	28	17	31	54	100
5.	Water spinach	1	2	9	17	14	26	17	31	6	11	7	13	54	100
6.	Chickpeas	0	0	1	2	4	7	4	7	11	20	34	63	54	100
7.	Cucumber	1	2	7	13	9	17	16	30	8	15	13	24	54	100
8.	Siamese Pumpkin	1	2	1	2	10	19	13	24	9	17	20	37	54	100
9.	Bitter melon	0	0	0	0	3	6	3	6	12	22	36	67	54	100
10.	Mustard	2	4	5	9	12	22	14	26	6	11	15	28	54	100
11.	Eggplant	1	2	3	6	9	17	11	20	9	17	21	39	54	100
12.	Beansprouts	0	0	4	7	6	11	10	19	19	35	15	28	54	100
13.	Tomato	2	4	12	22	13	24	13	24	9	17	5	9	54	100
14.	Carrot	1	2	7	13	15	28	13	24	11	20	7	13	54	100
Total		11	1	67	9	119	16	165	22	158	21	236	31	756	100

Based on the results of Table 5 study the pattern of vegetable intake in medical students of the Universitas Nusa Cendana, which most frequently consume tomatoes, as many as 2 people (4%) with a consumption pattern of ≥ 3× / day and 12 people (22%) with a consumption pattern of 1-2× / day. Followed by mustard for 2 people (4 %) with a consumption pattern of ≥ 3× / day and 5 people (9%) with a consumption pattern of 1-2 × / day, Then kale for as many as 1 person (2%) with a consumption pattern of ≥ 3× / day and 9 people (17%) with a consumption pattern of 1-2× / day. The pattern of vegetable intake from bitter gourd was the lowest, where 36 students (67%) had never consumed bitter gourd in the last two weeks, followed by chickpeas as many as 34 students (63%).

Table 6: Distribution of Fruit Intake Patterns

No.	Groceries	Frequency												Total	
		>3× /day		1-2× /day		3-6× /week		1-2× /week		2 × /month		Never			
		N	%	N	%	N	%	N	%	N	%	N	%	N	%
1.	Avocado	0	0	0	0	1	2	5	9	19	35	29	54	54	100
2.	Apple	1	2	2	4	2	4	9	17	17	31	23	43	54	100
3.	Watery Rose Apple	0	0	0	0	0	0	2	4	11	20	41	76	54	100
4.	Orange	0	0	1	2	4	7	11	20	15	28	23	43	54	100
5.	Manggo	1	2	2	4	5	9	12	22	11	20	23	43	54	100
6.	Pineapple	0	0	1	2	0	0	5	9	10	19	38	70	54	100
7.	Jack Fruit	0	0	1	2	1	2	3	6	7	13	42	78	54	100
8.	Papaya	4	7	3	6	6	11	12	22	12	22	17	31	54	100
9.	Saba Banana	0	0	1	2	5	9	9	17	6	11	33	61	54	100
10.	Cavendis Banana	0	0	2	4	10	19	8	15	10	19	24	44	54	100
11.	Latundan Banana	0	0	2	4	2	4	6	11	9	17	35	65	54	100
12.	Watermelon	1	2	0	0	9	17	10	19	16	30	18	33	54	100
13.	Coconut	0	0	0	0	3	6	11	20	20	37	20	37	54	100
14.	Pear	0	0	3	6	1	2	7	13	10	19	33	61	54	100
15.	Dragon Fruit	0	0	1	2	2	4	0	0	15	28	36	67	54	100
16.	Guavas	0	0	1	2	2	4	6	11	5	9	40	74	54	100
Total		7	1	20	2	53	6	116	13	193	22	475	55	864	100

Based on the results of Table 6 study the pattern of fruit intake in medical students of the Universitas Nusa. The most frequent and consumed by students is papaya, with as many as 4 people (7%) with a consumption pattern of ≥ 3× / day. Followed by mango, 1 person (2 %) with a consumption pattern of ≥ 3× / day, then apples, as much as 1 person (2%) with a consumption pattern of ≥ 3× / day. The jackfruit intake pattern was the lowest, where 42 students (78%) had never consumed jackfruit in the past two weeks, followed by guava as many as 41 students (76%).

Bivariate Analysis

The relationship between sleep quality with hemoglobin levels and erythrocyte index was statistically analyzed using the Chi-Square test with level of $\alpha = 0.05$ and a significance level of 95%. The Chi-Square test results are significant if the p-value is < 0.05, and the test results are insignificant if the p-value is > 0.05.

Table 7: Relationship of Sleep Quality to Hemoglobin Levels

Sleep Quality	Hemoglobin				Total	*p*
	Anemia		No Anemia			
	N	%	N	%		
Good	3	5,6	16	29,6	19 (35,2%)	0,028
Poor	16	29,6	19	35,2	35 (64,8%)	
Total	19	35,2	35	64,8	54 (100%)	

Table 7 shows that the student that had the poorest sleep quality without being accompanied by anemia was 19 people (35.2%). In comparison the student that had good sleep quality accompanied by anemia was 3 people. Based on statistical tests using the Chi-Square test, no cell has an expected count value of less than (< 5), which means this data is eligible to use the Chi-Square Test. The analysis result using the Chi-Square test has a significance level of $p = 0.028$ ($p < 0.05$), which means that there is a significant relationship between Sleep Quality and Hemoglobin Levels in Universitas Nusa Cendana Medical Students.

Table 8: Relationship of Sleep Quality to Erythrocyte Index

Sleep Quality	Erythrocyte Index				Total	*p*
	Hypochromic Microcytic		Normochromic Normositic			
	N	%	N	%		
Good	2	3,7	17	31,5	19 (35,2%)	0,037
Poor	13	24,1	22	40,7	35 (64,8%)	
Total	15	27,8	39	72,2	54 (100%)	

Data in Table 8 shows that the students that had poor sleep quality with Normochromic Normositic erythrocyte index were 22 people (40.7%). The student with Good Sleep Quality with Hypochromic Microcytic

Erythrocyte Index of as many as 2 samples (3.7%). Based on statistical tests using the Chi-Square test, no cell has an expected count value of less than (< 5), which is eligible to use the Chi-Square Test. The analysis using the Chi-Square test found that the significance level was p = 0.037 (p < 0.05), which means that there is a significant relationship between Sleep Quality and Erythrocyte Index in Universitas Nusa Cendana Medical Students.

DISCUSSION

The study involves 54 samples of Medical Students in the Faculty of Medicine and Veterinary Medicine, Universitas Nusa Cendana. The majority of the student (64.8%) had poor sleep quality. This study result is in line with the systematic literature research conducted by Rao *et al*. (2020), which analyzed 57 sleep quality studies with a total sample of 25,735 medical students from various countries in the world and found that 52.7% of medical students had poor sleep quality [5]. This is also in line with research conducted by Ghawa *et al*., (2021) at the Universitas Nusa Cendana Medical Student, where the prevalence of poor sleep quality is 93.1% [7].

Mawo PR (2019) states that sleep disorders can trigger oxidative stress. If it lasts more than 12 hours, it can cause erythrocyte lysis faster, resulting in anemia [2]. Another theory explains that sleep has a relationship with the mechanism of elimination of free radicals generated during the wakefulness phase. This theory explains that the level of oxidative stress will fluctuate with circadian rhythms. Antioxidant enzymes, such as glutathione peroxidase and reductase, peak in the morning, while lipid and melatonin peak in the evening [22]. As a result, oxidative stress will accumulate during the day while awake and be eliminated at night. Sleep disturbances can disrupt circadian rhythms, leading to increased free radicals and oxidative stress levels [23]. Oxidative stress results from an imbalance between the production of reactive oxygen species (ROS) and antioxidants. Increased ROS can cause lipid peroxidase, marked by increased in serum MDA levels (malondialdehyde). It is reactive that can damage cell membranes containing lipid compounds, including cell membranes from erythrocytes. Peroxidation in the erythrocytes cell membrane will result in hemolysis, lowering hemoglobin levels [23, 24].

This study, 19 samples were obtained from 54 (35.2%) of Universitas Nusa Cendana Medical Students experiencing anemia. This study's results align with the research conducted on India's medical students by Chinchole and Najan (2017) obtained an anemia prevalence of as much as 46.25% [25]. Another study by Andriani (2022) in Jakarta found that the percentage of anemia in medical students was 21.7% [26].

In this study, 15 samples (27.8 %) had hypochromic microcytic erythrocytes with an average MCV level in women of 66.56 fL (71.8-92 fL), and in men 68.6 fL (73.6-91 fL). In comparison, 39 samples (72.2 %) had normochromic normocytic erythrocytes, and none (0%) of the samples had normochromic macrocytic erythrocytes based on erythrocyte index data.

Based on the results of statistical tests using the Chi-Square test to assess the relationship between sleep quality and hemoglobin, significant results were obtained (p = 0.028). There is a significant relationship between sleep quality and hemoglobin levels in Universitas Nusa Cendana Medical students. This study is in line with *Mawo et al*. (2019) and Rosyidah *et al*. (2022) which state that there is a significant relationship between sleep quality and hemoglobin levels [2, 27]. Also supported by a theory that explains the relationship of sleep to the mechanism of elimination of free radicals produced during the wakefulness phase. Oxidative stress levels fluctuate in the circadian rhythm. Antioxidant enzymes, such as glutathione peroxidase and reductase, peak in the morning. While lipid and melatonin peroxidation peak in the evening. As a result, oxidative stress will accumulate during the day and eliminate at night. Sleep disturbances can disrupt circadian rhythms and increased free radicals and oxidative stress levels [23]. Oxidative stress result from an imbalance between the production of reactive oxygen species (ROS) and antioxidants. Increased ROS can cause lipid peroxidase marked by an increase in serum MDA levels (malondialdehyde) which is reactive so that it can damage cell membranes containing lipid compounds, including cell membranes from erythrocytes. Peroxidation that occurs in the cell membrane of erythrocytes will result in erythrocytes easily undergoing hemolysis lowerimg hemoglobin levels [24].

Based on the results of statistical tests using the Chi-Square test to assess the relationship between sleep quality and erythrocyte index. Significant results were obtained (p = 0.037); there is a significant relationship between sleep quality and erythrocyte index in Medical students of the Universitas Nusa Cendana. Sleep quality affects hemoglobin levels, so it influences the incidence of anemia. In the case of anemia, the erythrocyte index will decrease progressively in line with the severity of anemia [28]. However, this study's hemoglobin levels and erythrocyte index were also likely influenced by food intake or diet in the sample. Based on the results in Table 7, it can observe that the largest percentage were in samples with poor sleep quality but not anemia (35.2%).

Based on data from Table 7 found that 3 (5.6%) samples who had anemia had good sleep quality, while 19 (35.2%) did not have anemia but had poor sleep quality. The data in Table 8 showed that 2 (3.7%) samples with good sleep quality had hypochromic microcytic erythrocyte morphology, while 22 (40.7%) samples with poor sleep quality had normochromic normocytic erythrocytes.

Data in this study also showed that 13 out of 19 (68.4%) cases of anemia in medical students had hypochromic microcytic morphology. Anemia that occurs in samples with good sleep quality, with the majority of hypochromic microcytic anemia, can be influenced by factors that can reduce the iron content in the body. For example, a low-iron diet, absorption problems in the gastrointestinal system, and increased iron needs such as in pregnancy or the healing process. Animal iron sources have a bioavailability of 10-20%, higher than vegetable iron sources with a bioavailability of 1-5% [29].

The low level of hemoglobin in samples with poor sleep quality can occur due to the mechanism of homeostasis. Poor sleep quality affects hemoglobin levels through oxidative stress mechanisms that can only happen when ROS molecules exceed the body's capacity to stabilize by antioxidants [24]. However, this should ideally be confirmed by checking MDA levels to ascertain whether poor sleep quality in the sample has caused oxidative stress at the cellular level. Blood cells have a unique antioxidant defense system that can prevent cell damage during oxygen transport from the lungs to the tissues. This defense system consists of small molecules such as vitamins E and C, glutathione, and antioxidant defense enzymes, such as superoxide dismutase, catalase, glutathione peroxidase, glutathione reductase, and glutathione S-transferases. Since an adult erythrocyte cannot express proteins well, its antioxidant defense system has a concentration limit of stress-oxidative inducers, after which it cannot cope with stress. Due to the different ages and individuality of cells, this limit may differ for each erythrocyte. If the homeostasis system is not overloaded, the structure and function of the cell are not affected [30].

Table 2 data shows that 6 (11.1%) anemia samples had normochromic normocytic erythrocytes, and 2 (3.7%) non-anemic had hypochromic microcytic erythrocyte features. The normochromic in anemia samples can be caused by iron deficiency, whereas in stage 3A, there is a decrease in hemoglobin levels but normochromic normocytic erythrocyte morphology [31]. A hypochromic microcytic in samples that did not have anemia, indicating the stage of erythropoiesis of iron deficiency. At this stage, the hemoglobin content in reticulocytes decreases. However, the erythrocytes that circulate are mostly produced at a time when iron availability is still adequate. Then causes hemoglobin levels to remain within normal limits, and anemia has not been seen. However, Hemoglobin will decrease, followed by an increase in Red Blood Cell Distribution Widths (RDW) because small erythrocytes begin to be removed from the bone marrow so that MCV and MCHC decrease [32]. The state of iron deficiency anemia needs to be confirmed by examination of transferrin saturation, serum ferritin, and free erythrocyte protoporphyrin (FEP) [33].

LIMITATIONS

The limitation of this study is that researchers do not control the variable of food intake, which is a role variable that can affect hemoglobin levels and erythrocyte index. This study found a significant relationship. However, the percentage of samples with poor sleep quality with hemoglobin levels that were not anemic was the highest (35.2%). This study did not measure malondialdehyde (MDA) and Reactive Oxygen Species (ROS) levels, so it could not see how much sleep quality could affect oxidative stress that affects hemoglobin levels and erythrocyte index. This study did not examine transferrin saturation, serum ferritin, and free erythrocyte protoporphyrin (FEP).

CONCLUSION

Medical students of Universitas Nusa Cendana have a majority of poor sleep quality, and the prevalence of anemia is high at 33.2%. The erythrocyte index shows that the majority have a normochromic normocytic. In addition, there was a statistically significant correlation between sleep quality and hemoglobin and erythrocyte index. The researcher recommends that other factors, such as food intake that affect hemoglobin levels and erythrocyte index, need to control. Also, to assess how much sleep quality affects hemoglobin levels, it is necessary to test the level of reactive oxygen species and malondialdehyde.

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