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Analysis of Sleep Quality on Performance in U-17 Volleyball Athletes from Kendal Regency Dissporsa Club

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Abstract. *Sleep is a process that affects almost all body systems, such as the neurological, immune, cardiovascular, and endocrine systems. During sleep, the body produces ATP, which serves as the body's energy source. Energy is needed for muscle contraction so the body can carry out daily activities. This study was conducted to determine whether sleep quality affects performance and whether there is a relationship between the two variables. The data collection method used was filling out the PSQI questionnaire and conducting MFT. The sampling technique used was purposive sampling. Data analysis was carried out using SPSS 22, by conducting normality tests, linearity tests, and correlation tests. The subjects in this study were 15 U-17 athletes from the Dissporsa club. The results showed that 11 athletes had "good" sleep quality and 4 others had "poor" sleep quality. 6 athletes had "very good" endurance, 7 others were in the "good" category, and the remaining 2 were in the "moderate" category. Based on the results of the correlation test, it was known that the Sig. value was 0.011 (p <0.05) with a correlation coefficient value of 0.635. Therefore, it can be concluded that sleep quality and performance have a very strong, significant relationship.*

Keywords: *Sleep Quality, Performance, Volleyball*

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INTRODUCTION

In today's era, many people still consider sleep to be unproductive. In fact, sleep is a physiological and biological need of the human body that must be properly met. Sleep can be defined as a condition in which the body reduces its response and interaction with the environment in a reversible manner (Tanjung & Sekartini, 2016). Sleep plays a central role in the human body because all brain and systemic functions, such as metabolism, appetite regulation, the immune system, hormones, and the heart, depend on it (Wulansih et al. 2024).

Sleep also plays a crucial role in supporting cognitive function and human brain development (Lokhandwala & Spencer, 2022; Riggins et al., 2024; Alrousan et al., 2022). Cognitive function itself is a mental process that allows people to receive, process, and use information from the surrounding environment (Mason et al. 2021). Sleep plays a vital role in both physical and mental health (Tomaso et al., 2021). Sleep is generally classified into two main categories: Non-Rapid Eye Movement (N-REM) and Rapid Eye Movement (REM). N-REM (N-REM) is the stage characterized by slow wave activity in the brain.

Another name for N-REM sleep is deep sleep or slow-wave sleep. Abnormal motor and emotional behavior often occurs during this stage, but the person experiencing it is not fully

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aware of it and may not even remember it upon awakening. This is because it is controlled by the subconscious (Tomic et al. 2025). Next comes the REM (Rapid Eye Movement) stage, characterized by rapid eye movements and fast-wave brain activity, similar to those seen during wakefulness and intense dreaming. During this stage, motor activity increases, followed by periods of wakefulness. This stage is a smaller stage compared to N-REM sleep, but plays a role in physiological functions such as memory consolidation and brain development (Peever & Fuller, 2017).

Sleep affects nearly every system in the body, including the neurological, immune, cardiovascular, and endocrine systems. For example, cortisol and growth hormone levels have a circadian pattern (Baranwal et al., 2023). This pattern helps organisms within the body function optimally by adjusting all activities (Foster 2024). According to Patel et al. (2024), the sleep cycle is divided into five stages: wakefulness, N1, N2, N3, and REM. Each of these stages can determine whether a person's sleep is quality or not. Sleep quality can be described as the sleep process carried out by an individual, resulting in freshness and fitness upon awakening (Mendonça et al., 2019; Pan et al., 2012).

Other researchers also explain that sleep quality is a way for an individual to demonstrate their sleep character (Alfi & Yuliwar 2018). However, there is another opinion that states that sleep quality is a complex situation that is difficult to define and measure objectively (Harvey et al. 2008). In the context of research, sleep quality is often used as a tool for cognitive assessment of a person's sleep perception, such as the level of a person's sleep and perception of movement during sleep.

While the ideal sleep time for adults is 7-8 hours per day, athletes require more sleep. An athlete needs at least 8-10 hours of sleep per day, with a regular sleep pattern (sleeping before 11 pm) (Skein & Hartmann, 2026). Athletes need good quality sleep because it is crucial for maintaining physical condition (Romadlon & Pramono 2024). In addition to maintaining physical condition, sleep also significantly impacts athletes' concentration levels (Zukirman et al. 2021). Research conducted by (DJ et al., 2025) confirms that sleep influences the physical recovery process or recovery process of athletes after high-intensity training or after competition.

The recovery process is part of a series of training sessions that needs to be considered because this process can restore performance capabilities to the previous level or even exceed them (Amar et al. 2023). Previously, coaches and athletes only focused on training methods believed to improve abilities. In reality, training without a proper recovery process will not produce optimal results. The recovery process has a significant impact on the body's physiology, as this phase is the time for the body to regenerate muscles damaged by exercise. This restores muscle strength and can even lead to the formation of new, better-quality muscle (Yamaguchi & Rochmania, 2022).

The recovery process restores energy reserves (ATP) through metabolic processes. ATP (adenosine triphosphate) is the only energy source used directly during muscle contraction. The limited amount of ATP in muscles means it cannot be stored and must be continuously produced (Parwata 2015). ATP (adenosine triphosphate) is the primary energy source used by cells for muscle contraction during physical activity (Putra et al. 2017). ATP is produced through aerobic metabolism. Oxygen is transported by hemoglobin to the muscles, which is then used by the mitochondria through oxidative phosphorylation. This process is crucial for maintaining intense and sustained physical activity (Irawati & Hammado, 2025).

ATP can sustain muscle performance for 15-20 seconds during anaerobic activity without the use of oxygen. If an athlete depletes ATP reserves, the body's energy system automatically uses lactic acid to maintain muscle performance and function. Therefore, ATP availability and resistance significantly influence an athlete's ability to perform high-intensity physical activity (training), which directly impacts athlete performance. Sufficient ATP production will increase muscle contractions for longer durations, thereby improving endurance and athlete performance

(Dinata et al. 2022). Conversely, athletes can experience decreased performance if they experience muscle fatigue due to ATP deficiency (Windriyani 2019).

The physical components of performance include strength, speed, endurance, agility, and coordination. In this study, the researchers focused on endurance, which can be assessed by VO2 max (maximal oxygen consumption) or maximum oxygen volume. Volleyball is a sport of choice for research because it has no fixed duration, making endurance a crucial aspect for athletes to complete matches without experiencing significant fatigue (Marcelino, Imanudin, and Umaran 2023). Research conducted by (Apriyanto et al., 2021) clarifies the fact that volleyball matches have no fixed duration. This can be seen in the 2019 Proliga final four matches, where the shortest lasted 70 minutes, or 1 hour and 10 minutes. Meanwhile, the longest match lasted 151 minutes, or 2 hours and 31 minutes. With the shortest set duration being 20 minutes and the longest set duration being 41 minutes.

METHODS

This study employed a quantitative approach with correlational analysis and a descriptive research design. A quantitative approach utilizes measurement, calculations, formulas, and numerical data throughout the process (Musianto 2002). This approach was chosen because it allows for objective and standardized measurement of the variables studied. Furthermore, this approach is superior to qualitative methods because it produces stable parametric/non-parametric data, reducing subjective bias in interviews with the sample. Correlational analysis is a method used to identify and measure the relationship or correlation between two or more variables. This method was chosen because it accurately captures the non-causal associative relationship between subjective sleep quality (PSQI) and cardiovascular endurance, without requiring experimental manipulations that are not feasible in a natural field setting with a small sample size. Furthermore, this method can avoid threats to internal validity such as ordering effects (morning PSQI, afternoon MFT) or contamination by confounding factors (exercise 3x/week, dry season). A descriptive research design systematically describes or explains a particular phenomenon, event, or characteristic without intervening or manipulating the variables (Solheim et al., 2017). This research design was chosen because it is appropriate and effectively maps the characteristics of the phenomenon to the results obtained without risky interventions.

The population of this study was all 60 Dissporsa volleyball club athletes. A sample size of 15 individuals was selected based on specific requirements. Therefore, in this study, the researchers used a purposive sampling technique, or independent sampling based on certain predetermined criteria (Tajik et al., 2025). The requirements to be included in the sample are: being an active volleyball athlete of the Dissporsa club, aged 12-16 years (born 2010-2014) as of 2026, participating in regular training at least 3x/week for the past 3 months, not participating in training other than at the Dissporsa club, not experiencing any injuries or illnesses in the week prior to data collection, willing to fill out the PSQI questionnaire and participate in the Multistage Fitness Stage (MFT) voluntarily. After being selected based on these requirements, 15 athletes were selected who met all requirements. This study was based on club permission (a letter of cooperation or IA was already available), and all samples who participated in a series of tests had filled out a consent form to be included in this study. Prior to the study, the researcher distributed a statement letter to the coach which was then given or conveyed to the parents. Therefore, the implementation of this study was entirely based on parental consent considering that the samples were minors.

A research instrument is a tool that meets academic requirements and can be used to measure an object or collect data on a variable (Sappaile 2007). In this study, the researchers used two instruments in the data collection process: the Pittsburgh Sleep Quality Index (PSQI) to measure athletes' sleep quality (Buysse et al. 1989). The PSQI was chosen because it measures seven components of sleep quality, providing a multidimensional picture. Furthermore, this questionnaire has undergone numerous validity and reliability tests across various populations (adolescents, the elderly, healthcare workers, etc.). The PSQI questionnaire used has been translated into Indonesian, which has been validated and has undergone a reliability assessment by (Setyowati & Chung, 2021). The PSQI measures sleep quality over the previous month to differentiate between good and poor sleep and provide an assessment. The PSQI consists of 19 questions divided into seven groups that reflect different aspects of sleep. Each question has a rating scale of 0 to 3, with 0 indicating no sleep disturbance and 3 indicating the most severe sleep disturbance. The assessment is done by adding the scores of the seven components to form a global PSQI score, with values ranging from 0 to 21, with higher scores indicating poor sleep quality. Sleep quality is considered good if the global or overall score is ≤ 5, while if the score is > 5 (6-21), sleep quality is considered poor (Sulistyani, 2021).

During the questionnaire completion process, researchers and certified trainers provided explanatory assistance. This assistance was provided to reduce research bias and help the participants understand the intended points clearly and correctly. The second instrument was the Multistage Fitness Stage (MFT), also known as the Beep test, which is a 20-meter back-and-forth run test used to assess cardiovascular endurance (Banten n.d.). The MFT was chosen as the instrument for assessing endurance because it measures cardiovascular (aerobic) endurance through VO_2 max, which can be predicted from the level and speed of running achieved. This selection also aligns with the Indonesian Student Fitness Test (TKSI) standards developed by the Ministry of Education, Culture, Research, and Technology (the previous Ministry), which has undergone validity and reliability testing (Tumangger et al., 2024). The test begins with participants standing behind a starting line. A rhythmic marker is then used, and participants can begin running upon hearing a "beep." Participants must reach (with one foot on the line) or cross the line at the designated point before the "beep" sounds for that stage to be considered valid. As the test progresses, the intervals gradually shorten, requiring participants to increase their running speed. During the test, warnings and stops are provided. Warnings are given if participants stop before reaching the line at any point or if they start running several times before the rhythmic marker is heard. Warnings are given twice; if a third error occurs, the participant is immediately stopped.

Table 1. Multi Stage Fitness Norms (MFT)

Son	Daughter	Score	Category
> L7 S7	> L4 S5	5	Very well
L4 S4 – L7 S7	L3 S3 - L4 S5	4	Good
L2 S2 – L4 S3	L2 S1 - L3 S2	3	Currently
LI S2 – L2 S1	L1 S2 - L1 S7	2	Not enough
< L1 S2	< L1 S2	1	Very little
Information: L = Level, S = Stage			

Table 2. PSQI Norms

Score	Category
≤ 5	Good
> 5	Bad

This research was conducted at the Dissporsa Pagerweru Volleyball Court, Pagerwojo, Limbangan District, Kendal Regency, Central Java 51383. The study was conducted once on Saturday, February 7, 2026 4:00-6:00 PM WIB. The weather during the data collection was light rain with a temperature of 24-28 °C and humidity between 75-94%. The study began with the completion of the PSQI questionnaire. This was done simultaneously with the assistance of explanations from the trainer and researcher to clarify the meaning of the questions. After completing the questionnaire, the participants were given 10 minutes to prepare. Once the participants were ready, a 15-minute warm-up was conducted together (light jogging, static warm-up, and dynamic warm-up) to warm up the body's muscles and reduce the risk of injury. The audio used was standard audio, with a flat field condition, and trained supervision by the

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researcher and trainer. The researcher also provided first aid to anticipate if the participants experienced injuries or other conditions requiring minor medical assistance.

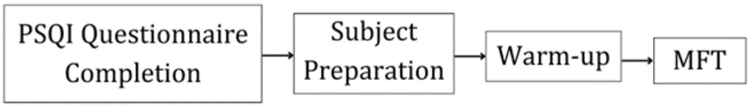

Figure 1. Data Collection Procedure

The data analysis technique used in this study was statistical. The data analysis technique utilized normality tests, linearity tests, and correlation tests. The normality test is used to determine whether the data obtained is normally distributed. This test is used as a prerequisite for systematic parametric testing. The Shapiro-Wilk normality test was chosen due to the small sample size (n=15<50). The guideline for this test is that if the significance value (Sig.) or probability value is <0.05, the data distribution is not normal. Conversely, if the significance value (Sig.) or probability value is >0.05, the data distribution is normal. The linearity test is used to determine whether two variables have a significant linear relationship. This test was chosen to confirm a linear relationship between variables to meet the correlation assumption. The linearity test is based on the following: if the Deviation from Linearity Sig. value is > 0.05, there is a linear relationship between the independent and dependent variables. Conversely, if the Deviation from Linearity Sig. value is < 0.05, there is no linear relationship between the independent and dependent variables. A correlation test is a test conducted to measure the strength, direction, and significance of a linear relationship between two or more variables. This test was chosen to determine whether the two variables have a relationship, the direction of the relationship, and how strong the relationship is. If the data meets the prerequisites (normally and linearly distributed), a parametric test is performed, namely Pearson. Conversely, if the data does not meet the prerequisites for the parametric test, a non-parametric test is performed, namely Spearman. The correlation test is guided by; if the Significance value Sig. (2-tailed) <0.05, there is a correlation between the connected variables. Conversely, if the Significance value Sig., (2-tailed) >0.05, there is no correlation. Interpretations of correlation coefficient values include; 0.00-0.25 (very weak); 0.26-0.50 (sufficient/weak); 0.51-0.75 (strong); 0.76-0.99 (very strong); 1.00 (perfect). In analyzing and summarizing the data, researchers used SPSS 22 software, Microsoft Excel 2021, and a BMI calculator.

RESULT AND DISCUSSION

The table presents data on sleep quality and endurance performance of athletes. The data consists of completed sleep quality questionnaires (PSQI) and recorded MFT results. The analysis will include normality, linearity, and correlation tests. Normality tests are conducted to ensure data validity, followed by linearity and correlation tests to determine whether sleep quality affects endurance and to determine if there is a relationship between the two.

Data Description

Table 3. Description of Socio-Demographic Statistics

Variable	N	Min	Max	Mean
Exercise Frequency	15	3	3	3
Height (cm)	15	142,3	162	152,7
Weight (kg)	15	31,6	62,9	43,45
BMI (kg/m2)	15	15,2	27,6	18,513
Age	15	12	13	12

The athletes' training frequency is 3 times per week. The average height of the athletes is 152.7 cm, with the shortest athlete being 142.3 cm and the tallest being 162 cm. The average weight is 43.45 kg, with the heaviest athlete weighing 62.9 kg and the smallest being 31.6 kg. The average Body Mass Index (BMI) of the athletes is 18.513 kg/m2, which is in the normal category.

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The lowest BMI is 15.2 kg/m2, which is in the underweight category, and the highest BMI is 27.6 kg/m2. The average age of the athletes is 12 years, with the oldest being 13 and the youngest being 12. Details of the athletes' socio-demographic descriptions can be seen in Table 4.

Table 4. Socio-Demographic Description

Respondent Characteristics	Number of Athletes N = 15	
	Total (N)	Presentation (%)
Exercise Frequency		
3 times	15	100
Height (cm)		
140-150	4	26,67
151-160	9	60
> 160	2	13,33
Body Weight (kg)		
30-40	6	40
40-50	6	40
> 50	3	20
BMI (kg/m2)		
Underweight	8	53,33
Normal	6	40
Overweight	1	6,67
Age		
13	7	46,67
12	8	53,33

The BMI of 8 athletes (53.33%) who were underweight indicates a possible lack of energy and nutrient intake. This has the potential to affect ATP production and cardiovascular endurance because poor nutritional status can reduce the intake of energy and essential nutrients needed for energy production in the body. Optimal ATP production is highly dependent on the availability of sufficient nutrients and energy. This statement is supported by research conducted by (Abdullah & Putri, 2017) which found that energy intake is significantly related to endurance, athletes with low energy intake tend to have "poor" endurance. It can also be seen that there is 1 athlete (6.67%) who is in the "overweight" category, this can occur due to several factors including calorie intake exceeding the body's needs, lack of physical activity, as well as genetic and environmental factors.

This condition can affect physical performance, including aerobic capacity and muscle endurance, which are related to ATP production. Athletes who are overweight are likely to experience disruptions in the efficiency of energy production and ATP utilization during physical activity. This is due to a disproportionate relationship between body weight and physical capacity, requiring muscles to work harder to move a larger body mass, which can accelerate neuromuscular fatigue and reduce effective ATP production during activity. This is in line with research conducted by (Moran et al. 2017), which found that overweight children performed less well on the shuttle run test compared to children of normal weight. Overweight children achieved fewer stages in the test, indicating decreased aerobic capacity and endurance. However, the frequency and intensity of training still need to be considered. Based on data obtained by the researchers, the club has a combined training program of 30 and 70%. On Tuesdays, training is dominated by physical training (70%) and technical training (30%). On Thursdays and Saturdays, training is dominated by technical training (70%) and physical training (30%).

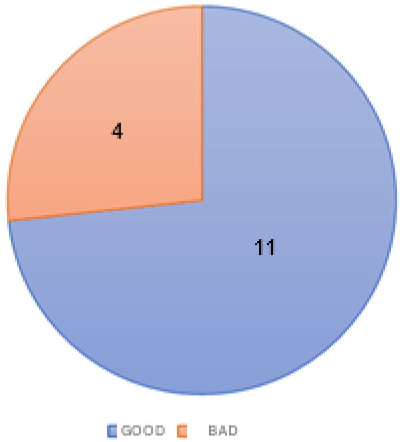

Figure 2. Pie Chart Sleep Quality

The results of the sleep quality questionnaire showed that 11 athletes (73.33%) had good sleep quality. Meanwhile, four other athletes (26.67%) had poor sleep quality. Details of sleep quality can be seen in Table 5.

Table 5. Description of Sleep Quality Data

Component	**Number of Athletes N= 15**	
	Total (N)	**Presentation (%)**
Overall sleep quality		
Good	11	73,33
Poor	4	26,67
Subjective sleep quality		
Very good	5	33,33
Fairly good	9	60
Somewhat poor	1	6,67
Very poor	0	0
Sleep latency		
Very good	7	46,67
Quite good	7	46,67
Somewhat bad	1	6,66
Very bad	0	0
Sleep duration		
> 7 jam	11	73,33
6-7 jam	4	26,67
5-6 jam	0	0
<5 jam	0	0
Sleep efficiency		
≥ 85%	15	100
75-84%	0	0
65-74%	0	0
≤ 65%	0	0
Sleep disorders		
Never	0	0
1x a week	12	80
2x a week	3	20
≥ 3x a week	0	0
Drug use		
Never	15	100

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1x a week	0	0
2x a week	0	0
≥ 3x a week	0	0
Dysfunction during the day		
Never	1	6,67
1x a week	3	20
2x a week	9	60
≥ 3x a week	2	13,33

The finding that the majority of athletes (73.33%) had sleep quality in the "good" category indicates that the current training program generally supports healthy sleep patterns. However, it should be noted that 26.67% of athletes still fell into the "poor" category, indicating the need for specific interventions for this group. A closer look reveals that 12 athletes (80%) experienced sleep disturbances once a week, while three others (20%) experienced sleep disturbances twice a week. The data shows that the majority of athletes experienced sleep disturbances due to cold, often waking up in the early hours of the morning. This is due to environmental factors in their homes, which are located near the foot of Mount Ungaran, which tends to be cold at night. It can also be seen that the majority of athletes experienced daytime dysfunction, with two athletes (13.33%) experiencing dysfunction ≥ 3 times a week, nine athletes (60%) experiencing dysfunction twice a week, three athletes (20%) experiencing it once a week, and one athlete (6.67%) never experiencing daytime dysfunction. Daytime dysfunction includes excessive sleepiness, fatigue, and difficulty maintaining alertness during daytime activities.

Many factors can contribute to this dysfunction, including impaired sleep quality due to sleep disorders. This aligns with the findings of this study, which found that the majority of athletes experience sleep disorders, as previously described. Furthermore, other undiagnosed medical factors should also be considered as reasons why athletes frequently experience daytime dysfunction. Athletes with poor sleep quality are at risk of experiencing recovery deficits, which can accumulate over time and impact long-term performance decline. Coaches need to identify the factors contributing to the 26.67% of athletes experiencing poor sleep quality. This should include consideration of factors such as differing academic loads among athletes, differences in distance from home to training, differences in activity patterns outside of school, or differences in stress levels. By identifying these factors, coaches can adjust training schedules or provide flexibility for certain athletes. Although the majority of athletes experience "good" sleep quality, regular monitoring is necessary to prevent sleep deterioration. Recovery programs should include a sleep hygiene education component, considering that sleep is the most fundamental yet often overlooked recovery modality.

Figure 3. Pie Chart of Endurance

The high levels of endurance in the sample indicate that the current training program is effective in developing cardiovascular capacity. However, it is important to consider that this good endurance capacity must be maintained and progressively developed as age and

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competition level increase. The age period of 12-13 is a golden period for cardiovascular development, so training programs should be designed to maximize the athlete's developmental potential. Furthermore, the principle of periodization should be considered to prevent overtraining; increasing intensity should be done gradually, taking into account adequate recovery. The results of this study demonstrate that the explanation previously stated (related to BMI and ATP production) confirms that BMI influences athletes' MFT results. Athletes with an underweight and overweight BMI achieved "Moderate" to "Good" results, while athletes with a "Normal" BMI achieved "Excellent" MFT results. This demonstrates that, in addition to sleep quality, many external factors can influence athlete endurance.

Table 6. Description of Endurance Data

Description	**Number of Athletes N = 15**		
	Return Level	**Total (N)**	**Presentation (%)**
Very Good	> L4 B5	6	40
Good	L3 B3 – L4 B5	7	46,67
Fair	L2 B1 – L3 B2	2	13,33

Normality Test

Table 7. Normality Test

	N	**Statistic**	**Sig.**	**Description**
Sleep Quality	15	0,923	0,	Abnormal
Endurance	15	0,887	0,061	Normal

Based on the results of the Shapiro-Wilk normality test, it can be seen that the sleep quality data is not normally distributed (Sig. = 0.004 < 0.05). Meanwhile, the endurance data is normally distributed (Sig. = 0.061 > 0.05). The abnormal distribution of sleep quality data is caused by the homogeneous characteristics of the sample (the majority of athletes have good sleep quality (73.33%)), so that the data is concentrated in one category. This condition actually reflects a valid phenomenon in the context of trained athletes who follow a structured training program.

Linearity Test

Table 8. Linearity Test

	N	**Sig.**	**Description**
Sleep Quality	15	0,572	Linear
Endurance	15	0,572	Linear

Based on the linearity test data above, the significance value is 0.572, indicating a linear relationship between the independent and dependent variables. Although the data indicated a linear relationship, the non-normal distribution of sleep quality data made parametric testing impossible. Therefore, a non-parametric Spearman test was conducted to strengthen the credibility of the findings. This step was taken to strengthen the validity of the conclusions, despite the relatively small sample size (n=15). It is important to critically acknowledge that this limited sample size may impact the statistical power and generalizability of the findings to the broader athlete population.

Correlation Test

Table 9. Correlation Test (Spearman)

Variable	**N = 15**			
	Sleep quality		**Durability**	
	Correlation coefficient	Sig.	Correlation coefficient	Sig.
Sleep Quality	1	-	- 0,635	0,011
Endurance	- 0,635	0,011	1	-

Based on the results of the Spearman correlation test, it can be concluded that sleep quality and endurance are related, as the significance value is 0.011, meaning <0.05. The correlation coefficient is 0.635, indicating a strong relationship between sleep quality and endurance. The direction of the relationship between the two variables is negative, meaning they are inversely related (as sleep quality decreases, endurance increases). However, this interpretation needs to be understood proportionally, taking into account several methodological limitations and potential confounding variables. First, correlational tests do not allow for causal inference (it cannot be determined whether sleep quality affects endurance, or whether a third factor influences both). Second, there are external variables that were not controlled in this study and could provide alternative explanations for the relationship found, such as nutritional status and daily calorie consumption.

Academic load and psychological stress, as athletes face academic demands that potentially affect sleep quality and recovery, were not measured in this study. Training intensity and duration, training frequency of three times a week accompanied by a training program in which each training session includes physical exercise, and training duration between 2:00 PM and 6:00 PM and often continuing until 7:00 PM (data obtained based on researcher observations). The entire training program can cause fatigue that affects both sleep quality and endurance. Environmental factors, such as the geographical location of the highland environment and the weather conditions during data collection, are situational variables that cannot be controlled and have the potential to influence test performance. Based on these considerations, the relationship is interpreted as a "significant associative relationship" without assuming a deterministic causal relationship. This finding suggests an association that warrants further exploration with research designs that can control for confounding variables, such as longitudinal or experimental studies with more stringent controls.

This study used two variables: sleep quality and performance, assessed through cardiovascular endurance in U-17 volleyball athletes from the Kendal Regency Sports and Sports Department. The Pittsburgh Sleep Quality Index (PSQI) questionnaire showed that 11 of the 15 athletes had good sleep quality, while the other 4 had poor sleep quality. One factor contributing to the improved sleep quality of the Kendal Regency Sports and Sports Department athletes is fatigue. Fatigue results from the inability of muscles to contract and suboptimal muscle fiber metabolism to consistently deliver performance (Candra et al., 2016). Physical fatigue due to internal workload can be calculated using the formula (training volume × training intensity). However, in this study, the authors did not delve deeper into this workload, thus becoming a limitation of the study (Hamlin et al. 2021). However, the authors obtained data from field observations that athletes trained 4-5 hours per day after school. This tends to lead to faster sleep, thus achieving the optimal sleep duration for adolescent athletes, which is ≥7-9 hours per day for cardiovascular recovery. This also aligns with the sleep recommendations from the Indonesian Ministry of Health (RI 2022) for adolescents aged 12-18 years who require a healthy 8-9 hours of sleep per day.

Research conducted by Campbell et al. (2021) explains that measurable subjective/objective fatigue can cause muscle fatigue, reduce sleep efficiency, increase sleep disturbances, and cause daytime dysfunction (this is related to neurochemical changes in the brain due to sleep deprivation, such as increased serotonin and decreased dopamine, which affect alertness and cognitive function). This statement is consistent with the results obtained in the field, although the total PSQI score indicated good sleep quality in 11 athletes (73.33%). PSQI component data revealed that 12 athletes (80%) experienced sleep disturbances at least once a week and 3 athletes (20%) experienced them as much as twice a week. Sleep disturbances were dominated by nighttime awakenings due to cold, nightmares, or needing to use the bathroom. This resulted in reduced sleep efficiency even though the duration was sufficient. Daytime dysfunction was also significant, only 1 athlete (6.67%) never experienced it, 3 athletes (20%) experienced it once a week, 9 athletes (60%) experienced it twice a week, and 2 other athletes (13.33%) experienced it even ≥3 times a week. Daytime dysfunction includes sleepiness, fatigue,

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and decreased alertness, which can increase the risk of training injuries, reduce technical cognitive benefits, and potentially disrupt growth hormone, muscle repair, and immunity during the developmental phase of adolescent athletes. This contradiction suggests that the PSQI may be less sensitive for athletes, requiring in-depth analysis and long-term implications on cardiovascular performance.

Performance refers to an athlete's ability to perform physical activities, encompassing aspects of strength, endurance, speed, and skill. This study focused on athlete endurance. Endurance is a person's ability to perform physical activity without experiencing significant fatigue. An athlete's endurance can be assessed using the Multistage Fitness Test (MFT). The MFT is a test conducted to determine the body's maximum capacity to consume oxygen during strenuous activity. The endurance assessment norms or standards used in this study were based on the Indonesian Student Fitness Test (TKSI) phase D because the athletes who were subjects were between 12-13 years old (Banten n.d.). In this study, 6 athletes (40%) had endurance in the "very good" category, 7 others (46.67%) were in the "good" category, and the remaining 2 (13.33%) were in the "moderate" category.

Sleep is a natural physiological and biological process in the body. Sleep can be described as the body's recovery time to achieve optimal health (Vina et al. 2020). Maintaining health is essential for every individual, especially for highly active individuals such as athletes. An athlete can be defined as a professional who undergoes systematic and intensive training in a particular sport. Recovery is a crucial part of a training program. Recovery is crucial because it maintains physical fitness, ensuring stable stamina during matches or training (Chen et al. 2025). Volleyball, a large ball sport, requires good endurance because it doesn't have a fixed playing time. Good endurance is influenced by a smooth respiration process. Respiration is the process by which ATP (adenosine triphosphate) is formed, the body's energy source. ATP is a molecule commonly found in living microorganisms and functions as a molecular mediator between cells (Lau et al. 2025; Rauwers et al. 2022). ATP is an energy source typically used in muscle contraction. If an athlete runs out of ATP reserves, the body's energy system automatically uses lactic acid to maintain muscle performance and function. Therefore, ATP availability significantly impacts an athlete's ability to perform high-intensity activities, directly impacting their performance.

Based on the explanation above, sleep is part of the recovery process that impacts athlete performance (endurance). The results of this study confirm that sleep quality has a linear relationship with athlete performance, with a Sig. 0.572. Linearity and normality tests are among the statistical requirements before conducting a correlation test. The sleep quality data in this study were not normally distributed, so parametric tests could not be performed. Therefore, a non-parametric test, the Spearman test, was conducted. The correlation test was conducted using SPSS 22 and yielded a Sig. 0.011, meaning <0.05. Therefore, it can be concluded that sleep quality and athlete performance (endurance) are related. The correlation coefficient value is 0.635, indicating a very strong relationship between the two variables. Research conducted by Ramadhon & Bakti, (2024) corroborates the findings of the previous study. Both studies analyzed sleep quality and VO2 max.

The results of both studies indicate a relationship between sleep quality and VO2 max. However, there are differences in the intensity of the correlation, the actual conditions of the athletes in the field, and the theoretical basis used to explain this phenomenon. Comparative analysis shows that the results between the two reference journals and the findings of this study tend to be similar, namely a relationship between sleep quality and endurance. In this study, the researchers provide a more specific theoretical contribution by linking sleep quality directly to ATP (Adenosine Triphosphate) synthesis. Unlike the two reference journals, both view sleep as supporting the cardiovascular system at a macro level and do not position sleep as a crucial phase of micro energy metabolism that determines fuel availability for muscle contraction as in this study. Methodologically, there are significant differences in participant profiles that influence the interpretation of the results. Reference journal 1, with a sample of adult pencak silat athletes, showed the strongest correlation coefficient (sig = 0.766), which may reflect that in athletes with

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physiological maturity, the impact of sleep disturbances on performance is much less. The results in this study show a lower correlation value (sig = 0.635). This invites theoretical reflection that in adolescent athletes of growth age (12-13 years), other variables such as nutritional and hormonal status may have a more overlapping role than in adult subjects. Reference journal 2 presents the most contrasting findings, where the majority of futsal athletes (66.7%) actually have poor sleep quality.

Unfortunately, reference journal 2 does not analyze "why" adolescent and adult athletes (high school) are more susceptible to sleep disorders. However, upon critical analysis, this difference in results is not merely a statistical figure, but rather a representation of differences in training load management and lifestyle control between club-based and school-based athletes. Differences in the sports studied can lead to different results. Reference journal 1 conducted research on pencak silat athletes, while reference journal 2 studied futsal teams. Volleyball, as a sport involving explosive movements, may have different energy sources than those in other sports. There is no guarantee that the sleep-performance relationship found in other sports can be directly translated to volleyball. Thus, the strength of this study lies in its biochemical depth, while Reference Journal 1 excels in correlational validity in adult subjects, in contrast to Reference Journal 2 as a case study of the real impact of sleep deficit on decreased performance in the field.

CONCLUSION

this study demonstrates that sleep quality significantly influences athletic performance, particularly endurance, as evidenced by better MFT results among athletes with good sleep quality compared to those with poor sleep quality, and supported by correlation test findings indicating a meaningful relationship between the two variables. These findings highlight the importance of integrating sleep management into athlete development programs. Practically, coaches are encouraged to routinely monitor athletes' sleep quality using simple tools such as the PSQI or sleep tracking applications, adjust training intensity especially prior to competitions and implement sleep hygiene education, including consistent sleep schedules, reduced gadget use before bedtime, and structured pre-sleep routines. Athletes themselves should develop self-awareness by maintaining sleep journals, ensuring adequate sleep duration of 8–9 hours per night, and seeking medical consultation when experiencing persistent sleep disturbances. Institutional support from clubs is also essential, including providing adequate recovery facilities, ensuring proper nutrition through collaboration with nutritionists, and offering training for coaches on recovery and sleep management. Furthermore, the implementation of a phased strategy consisting of an initial awareness phase, followed by reinforcement through monitoring and training adjustments, and culminating in a maintenance phase with comprehensive evaluation can facilitate sustainable behavioral changes in sleep practices, ultimately contributing to improved long-term athletic performance.

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