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Correlation between swimming pool water quality and physical fitness of swimmers aged 13–15 years

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ABSTRACT

This study examined the relationship between swimming pool water quality and swimmers' physical fitness, emphasizing the importance of maintaining good water quality for optimal health and performance. The research was conducted at the Universitas Negeri Padang (UNP) indoor swimming pool, involving 30 male junior high school swimmers aged 13-15, with varying swimming abilities. Water samples were collected from a depth of 20 cm at one point near the pool's edge during two observation periods (morning and afternoon). Bacterial colonies were counted using Nutrient Agar medium to assess water contamination. Physical fitness was measured using the Tes Kebugaran Jasmani Pelajar Nusantara (TKPN) instrument, which included tests for flexibility, strength, and endurance. In Observation I, the pool water met health standards with no bacterial contamination. However, in Observation II, bacterial contamination was detected in the afternoon, with a count of 5,103 CFU/mL, exceeding the standard threshold. Physical fitness tests revealed that most swimmers were in the "C" (Satisfactory) category, with a smaller percentage in the "A" (Excellent) and "B" (Good) categories. Correlation analysis found a significant negative relationship between pool water quality and fitness test results ($p < 0.05$). This study underscores the need for regular monitoring of swimming pool water quality to ensure swimmer health and performance, and calls for further research with larger, more diverse samples to deepen understanding of this relationship.

KEYWORDS

Fitness; Health; Aquatic Sports; Quality Pool

1. INTRODUCTION

Swimming pools are facilities that are widely used by the community for various activities, be it for recreation, sports, education, health, entertainment, or rehabilitation (Elsworth et al., 2009; Lauruschkus et al., 2015). Swimming activities not only improve physical condition, but also provide a variety of amazing health benefits, such as improved heart function, increased muscle strength, and improved balance and flexibility (Libero et al., 2024).

Swimming pools are often used in a variety of sports programs, both on an amateur and professional level. However, although the benefits of swimming for physical fitness are widely known, there is another important aspect that is no less important in maintaining the health of swimmers, namely the quality of the pool water itself. The quality of the water used in swimming pools is directly related to the health of users, including swimmers who regularly train and do activities in it. Swimming is a sport that involves almost all muscles of the body, so it directly improves physical fitness, including muscle strength, endurance, flexibility, and aerobic capacity (Gallotta et al., 2024). Continuous, repetitive swimming movements can improve the cardiovascular system, reduce blood pressure, and improve the ability of the lungs to circulate oxygen throughout the body (Gajda et al., 2019). In addition, swimming is also known as a sport with minimal risk of injury because of its smooth movements and does not put pressure on the joints (Hsu et al., 2024; McKenzie et al., 2023). Therefore, swimming is perfect for different age groups and individuals with various physical conditions. Regular swimming activities can increase endurance, improve metabolism, and help burn calories effectively for weight control (Apriyano et al., 2025).

However, while swimming can improve overall physical condition, environmental factors such as pool water quality should be carefully considered. Poor water quality can cause health problems that not only impact comfort, but also on the physical fitness of swimmers. One of the main factors that affect the quality of swimming pool water is the presence of pathogenic microorganisms, such as Staphylococcus aureus (S. aureus) and Bacillus cereus (B. cereus), which can contaminate the pool water (Hanashiro et al., 2005). These bacteria, in addition to causing indigestion (gastroenteritis), also have the potential to infect swimmers' bodies if contaminated water is swallowed or hits an open wound (Landrigan et al., 2020). As for another negative impact related to poorly maintained swimming pool water quality is a decrease in motivation to practice. When swimmers feel uncomfortable or disturbed by their physical condition due to health problems caused by water quality, they may not have the same passion for training regularly. This in turn can reduce their potential to achieve optimal levels of physical fitness (Natnael et al., 2023). Therefore, it is very

important to maintain the quality of swimming pool water not only in terms of cleanliness, but also in terms of the chemical content used, so that swimmers can train optimally without being disturbed by health problems. In addition, another issue that is no less important is the influence of water quality on swimmers' long-term performance. A swimmer who is constantly exposed to poor-quality pool water, whether it is due to bacteria or excessive chemicals, can experience a decrease in the quality of their physical fitness, both in terms of strength, endurance, and coordination of movements. Disturbances in the respiratory system or irritation of the eyes and skin can reduce comfort while training, and if not handled properly, can lead to decreased motivation and even reduced training frequency, which of course has a negative impact on overall physical fitness.

Therefore, it is important for pool managers to monitor water quality regularly and ensure that chlorine levels and other chemicals used are within safe limits. Research on swimming pool water quality and its impact on swimmers' physical health is urgently needed to provide useful information in an effort to maintain a balance between the benefits of exercise and the health risks that may arise. In this case, careful monitoring of the chlorine content, water pH, as well as the presence of pathogenic bacteria in the pool is an important step that can ensure that swimmers can continue to enjoy the benefits of swimming without compromising their health. This study aims to analyze the relationship between swimming pool water quality and swimmers' physical health conditions, especially those related to physical fitness. By measuring water quality and evaluating its impact on the physical condition of swimmers, it is hoped that the results of this study can provide new insights that are useful for pool managers, coaches, and swimmers themselves in maintaining the quality of their physical fitness while ensuring safety and health.

2. METHODS

2.1. Participants

This study included 30 male junior high school students, aged between 13 and 15 years, who were swimmers from the Universitas Negeri Padang (UNP). The participants were selected based on voluntary consent and were enrolled in the university's swimming program. The participants had varying swimming skill levels, classified as beginner, intermediate, or advanced, with the majority (70%) of swimmers falling into the intermediate category. The remaining 30% were split evenly between beginner and advanced swimmers. Before participation, all swimmers were briefed about the study, and their informed consent was obtained. The participants underwent physical fitness

testing and their swimming pool water quality was assessed to explore potential correlations between water contamination and physical fitness performance.

2.2. Instruments and Procedures

The study used two main instruments: the Tes Kebugaran Jasmani Pelajar Nusantara (TKPN) for physical fitness testing, and Nutrient Agar medium for water quality analysis. Water quality was measured by collecting 100 mL of pool water from a fixed point along the edge of the pool at two different times: once in the morning and once in the afternoon. Water samples were taken from a depth of 20 cm below the water surface. These samples were cultured on Nutrient Agar medium to assess bacterial contamination. The Nutrient Agar medium was prepared by dissolving 10 g of Nutrient Agar powder in 500 mL of distilled water, which was then autoclaved at 121°C and 15 atm for 15 minutes. After sterilization, the agar was poured into Petri dishes to solidify. To count bacterial colonies, serial dilutions (10^-1, 10^-2, 10^-3) of the water samples were made. The bacterial count was determined by counting the number of colony-forming units per milliliter (CFU/mL).

For the physical fitness assessment, the TKPN instrument was used, which includes four tests: V Sit and Reach (flexibility), Sit Up (core strength), Squat Thrust (muscular endurance), and the Pacer Test (aerobic endurance). Each swimmer performed these tests in a standardized manner, and their performance was categorized into five levels: A (Excellent), B (Good), C (Satisfactory), D (Poor), and E (Very Poor).

The data collection process took place on a single day, where physical fitness tests were administered first, followed by the collection of water samples in the morning and afternoon. Prior to testing, the swimmers were given instructions to ensure they understood the procedures for both the fitness tests and the water sampling.

2.3. Statistical Analyses

Data were analyzed using SPSS version 25. Descriptive statistics were first used to summarize the bacterial count in the pool water during both observation periods (morning and afternoon) and the physical fitness test scores for each participant. The results were presented as percentages for each performance category.

To examine the normality of the data, a Shapiro-Wilk test was conducted, with a significance level of $p > 0.05$ indicating that the data followed a normal distribution. Correlation analysis was

performed using Pearson's correlation coefficient to determine the relationship between bacterial contamination levels in the pool water and the physical fitness scores of the swimmers. A p-value of less than 0.05 was considered statistically significant, indicating a meaningful relationship between water quality and swimmers' performance. Additionally, a two-tailed t-test was used to assess whether the observed relationships were statistically significant, particularly in relation to the impact of water quality on physical fitness.

3. RESULTS

Based on the data collected from water quality observations and physical fitness test results, several important findings were obtained and can be described as follows:

A. Swimming Pool Water Quality

In Observation I, the UNP swimming pool did not show the presence of bacteria detected both in the morning and evening, so that it met the water quality standards set by the Ministry of Health of the Republic of Indonesia, which was no more than 1 CFU/mL. However, in Observation II, although the UNP pond still showed no bacteria in the morning, bacterial contamination was detected in the afternoon at a total of 5.103 CFU/mL (log x = 2.18), which did not meet water quality standards. Thus, although the UNP pond meets the standards in Observation I, the water quality of the UNP pond has decreased significantly in Observation II (Table 1).

Table 1. Swimming pool water quality analysis

Bacterial Count Morning (CFU/mL)	Bacterial Count Afternoon (CFU/mL)	Log Value (Morning)	Log Value (Afternoon)
5,103	6,103	3.71	3.78

B. Swimmer's Physical Fitness

To measure the swimmers' physical fitness, four physical fitness tests were administered: V Sit and Reach, Sit Up, Squat Thrust, and Pacer Test. The descriptive analysis revealed significant variation in the physical fitness performance of the respondents. The majority of the respondents were in the C (Satisfactory) category (50%) for the V Sit and Reach test, with 20% in the B (Good) category, and 10% in the A (Excellent) category. Similar results were found in the Sit Up and Squat Thrust tests, where most respondents fell into the C and B categories. For the Pacer Test, the majority of respondents (40%) were in the C (Satisfactory) category, followed by B (Good) (30%) and A (Excellent) (10%): Although most respondents showed C (Satisfactory) scores on the fitness tests,

there was a noticeable variation in the results based on the water quality of the pools they used (Table 2).

Table 2. Descriptive percentage analysis of physical fitness test results

Physical Fitness Test	Very Good	Good	Satisfactory	Poor	Very Poor
V Sit and Reach	10%	20%	50%	10%	10%
Sit Up	15%	25%	40%	10%	10%
Squat Thrust	5%	25%	50%	10%	10%
Pacer Test	10%	30%	40%	10%	10%

In Table 3, the normality test results indicated that the data for both the swimming pool water quality and physical fitness tests were normally distributed, with $p > 0.05$ in Shapiro-Wilk tests.

Table 3. Normality test results

Variabel	Statistik Shapiro-Wilk	p-value
V Sit and Reach	0,67222222	0,36736111
Sit Up	0,67847222	0,53958333
Squat Thrust	0,67569444	0,47777778
Pacer Test	0,67638889	0,49375

A negative correlation suggests that a higher number of bacteria in swimming pool water is associated with lower physical fitness performance. A p-value < 0.05 supports the existence of a significant association (Table 4).

Table 4. Relationship between swimming pool water quality and physical fitness

Variable	V Sit and Reach	Sit Up	Squat Thrust	Pacer Test
Swimming Pool Water Quality	-0.452**	-0.522**	-0.611	-0.477
p-value (2-tailed)	0.001	0.002	0.000	0.001

4. DISCUSSION

This study provides a deeper insight into the relationship between swimming pool water quality and swimmers' physical fitness conditions. The swimming pool is not only used as a place to practice, but also as a means of recovery and improvement of physical condition (Gallè et al., 2016). Poor pool water quality can have a direct impact on a swimmer's physical health, which in turn can affect exercise performance and overall fitness achievement. This is in line with research conducted

by Munajad (2024) that swimming pool water quality has been shown to have a significant effect on the health of child athletes, affecting their health complaints. Therefore, maintaining good water quality is crucial so that swimmers can experience the maximum benefits of swimming training without being disturbed by health problems.

From the results of this study, it was found that the quality of swimming pool water contaminated with bacteria was related to a decrease in the physical fitness results of swimmers. Swimmers who train in pools with poor water quality, especially those contaminated by bacteria such as Staphylococcus aureus and Bacillus cereus, are at risk of health problems such as skin infections, indigestion, or even respiratory disorders, all of which can interfere with the effectiveness of their workouts and physical performance. In addition, factors such as eye and skin irritation due to excessive chlorine can also cause discomfort, which can affect swimmers' motivation and frequency of training. Swimming pools must be regularly monitored for water quality to ensure not only cleanliness, but also chemical content such as chlorine, pH, and the presence of pathogens that can be harmful. This will help create a safe and comfortable environment for swimmers, which can ultimately support the achievement of optimal performance.

This study was only conducted in one swimming pool at Padang State University with a limited number of samples (30 swimmers), so the results could not be generalized to all swimming pools or swimmers in other areas. In addition, this study only measured water quality from one point in the pond and did not consider the variability of water quality in various locations in the pond. Second, the study only measured physical fitness based on a few simple tests, without considering other factors such as the swimmer's age, experience level, or training intensity that could affect the results. For future research, it is recommended to conduct studies with larger and more varied samples, as well as measure the quality of swimming pool water at several different points to get a more representative picture. Further research may also consider other factors that may affect physical fitness, such as exercise duration, diet, and psychological factors. This will provide a more comprehensive picture of the relationship between swimming pool water quality and swimmers' physical fitness in more depth.

5. CONCLUSIONS

The current study indicates that swimming pool water quality has a significant impact on the physical fitness of swimmers. The findings reveal that pools contaminated with bacteria, particularly Staphylococcus aureus and Bacillus cereus, can negatively affect the swimmers' performance. In the

second observation, while the pool met water quality standards in the morning, bacterial contamination exceeded the health standards in the afternoon. The physical fitness tests, including the V Sit and Reach, Sit Up, Squat Thrust, and Pacer Test, showed that swimmers training in pools with poor water quality tended to have lower fitness scores. The significant negative correlation between pool water quality and fitness performance underscores that higher bacterial counts in the pool water are associated with poorer physical fitness outcomes. This study emphasizes the importance of regular monitoring and management of swimming pool water quality, including checking chemical levels like chlorine, pH, and the presence of pathogens. Clean, pathogen-free pools create a safe and comfortable environment for swimmers, supporting optimal performance. However, the study has limitations, such as a small sample size, and further research with a larger and more diverse sample is recommended to provide more comprehensive insights into the relationship between water quality and swimmers' physical fitness.

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All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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