Malaysian Journal of Sport Science and Recreation
Vol. 21. No. 1. 1-8, 2025.
DOI: https://doi.org/10.24191/mjssr.v21i1.5664

COMPARISON OF ARM AND LEG MUSCLE FATIGUE DURING A 3X3 BASKETBALL GAME: A PRE-EXPERIMENTAL STUDY

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Published Date : 15 March 2025

ABSTRACT

This study aims to analyze the differences in fatigue that occur in the explosive power of the arm and leg muscles after a 3x3 basketball game. Muscle fatigue is an important factor that affects player performance, especially in sports that rely on explosive muscle strength, such as basketball. This study uses a pre-experimental design with a quantitative approach, involving 12 participants as the sample. The data obtained from the measurement of arm and leg muscle explosive power were analyzed using the Shapiro-Wilk test to examine data distribution normality, Levene's test for homogeneity, and paired sample t-tests to identify significant differences between pre-test and post-test data. The results show a significant decrease in arm and leg muscle explosive power after the game, with significance values of 0.047 (t = -2.235) for arm muscles and 0.046 (t = -2.247) for leg muscles. This decrease indicates that muscle fatigue from the 3x3 game significantly affects player performance. This study highlights the importance of managing muscle fatigue to improve basketball player performance, especially in competitions that rely on explosive muscle strength.

Keywords: *3x3 Basketball, Basketball Performance, Fatigue, Muscle Explosion*

INTRODUCTION

Unconsciously or consciously sports activities are often done everywhere. This activity is related to physical movement, play, and recreation. Sports at this time has become a lifestyle for some people, in various places and times often find someone or a group of people exercising. Someone doing sports activities has the aim of maintaining body fitness. Sports include human life needs that must be met by exercising someone has fulfilled physical needs, many benefits that can be obtained through sports (Zhang 2020).Sport is a powerful tool for the physical and mental formation of the nation, by often exercising, daily activities will also feel light when doing it. The target in doing an activity or activity is to achieve the highest satisfaction. Basketball is a teamwork game played by five people and led by two referees. The goal of the basketball game is to put the ball into the opponent's basket and guard the team's own basket so that the opposing team does not score (Li 2023).

Basketball games must always carry out attack and defense patterns when carrying out basketball matches, especially in 3x3 matches. When making movements of the attack and defense system, basketball players must often make many movements. Movements that are often done are carrying the ball, passing, and running. This also makes basketball players experience fatigue. The physical demands of a competitive match can cause players to suffer from fatigue, causing a decrease in sprint and jump results in the middle and during the match (Lubis et al. 2021).Fatigue is commonly linked with prolonged physical exertion and manifests as reduced performance. It can significantly impact physical abilities, particularly muscle function, where muscles lose their optimal contraction capacity due to extended or intense activity (Zhang et al. 2023). This condition can impair performance across various activities (Silva et al. 2023). Rapid carbohydrate metabolism during glycolysis, breaking down glucose into pyruvic acid and Adenosine Tri Phosphate (ATP), along with increased hydrogen ion concentration, alters muscle acidity levels and leads to decreased performance in basketball players. Additionally, fatigue is influenced by the depletion of ATP energy stores from the ATP-PCr system and calcium utilization.

From a sport science perspective, fatigue often refers to a decline in physical ability (González-frutos et al. 2022). Fatigue is the body's inability to maintain a predetermined level of function or exercise intensity. Fatigue results in a decrease in performance, termed exercise-induced diminishment of performance, and it can also be a sign of various conditions (Wang 2022). Fatigue is a reduction in the muscles' ability to exercise, a physiological phenomenon caused by intramuscular contraction or the maximum output power caused by movement (Wang 2021). There is a gap between the definition of fatigue and the reality in the field, as the elements often measured by coaches for aspects of fatigue are generally objective, such as heart rate and lactic acid (Lima et al. 2023). Theory also supports that both objective and subjective elements are needed to determine the level of fatigue in an athlete. Therefore, the best approach in monitoring fatigue is through physiological aspects.

Basketball players often feel fatigue when competing (Tokatlidou et al. 2020). Such as the fatigue problem encountered during the 3x3 basketball match is the physical condition of the player the longer he plays basketball, the more the player's performance decreases. In this 3x3 match, the field feels wider so that players have to move more to close space and guard opposing players. 3x3 basketball games usually have high intensity with fast movements, jumping, and running. This can cause the muscles of the body to work hard and repetitively, which in turn can lead to muscle fatigue. Muscle fatigue is a condition in which muscles lose the ability to contract optimally, which can reduce explosive power and muscle strength.

Research conducted by Lin et al., (2022) shows that muscle fatigue can affect athlete performance, especially when carrying out matches. Fatigue can affect a person's performance and fatigue can cause injury and basic physical damage that cannot be avoided in the training process. The decrease or temporary stoppage is due to the fatigue of muscle work by their activities (Volkova 2020). Based on these problems, researchers are interested in conducting research on whether there is fatigue in 3x3 basketball players in terms of a decrease in arm muscle explosiveness and leg muscle explosiveness in the match.

METHODOLOGY

Participants

This study uses a quantitative approach with a pre-experimental design involving a single group without a control group. The participants were 12 male students who participated in the basketball extracurricular activities at SMK Negeri 1 Semarang. The average age of the respondents was 16.08 ± 0.69 years, with an average height of 166.58 ± 0.69 cm, weight of 55.98 ± 9.87 kg, and body mass index of 20.13 ± 2.75. The sampling technique used was purposive sampling, with inclusion criteria being students who were active in the basketball extracurricular activities, in good physical health, and willing to participate in all stages of the study. No specific exclusion criteria were applied in this study.

Study design

This study used a pre-experimental design with a pre-test and post-test in a single group (without a control group). The design aimed to evaluate the effects of the 3x3 basketball match intervention on the arm and leg muscle explosiveness of the participants. A pre-experimental design was chosen due to time and resource constraints, as well as the limited availability of participants to form multiple groups. The primary variables in this study were arm muscle explosiveness and leg muscle explosiveness, while secondary variables included participants' age, height, weight, and body mass index.

Instrument

The measurement instrument for arm muscle explosiveness was the Two-Hand Medicine Ball Put, and for leg muscle explosiveness, the Standing Broad Jump was used. The Two-Hand Medicine Ball Put measures arm muscle explosiveness through the distance the ball is thrown using both hands (validity 0.77, reliability 0.81), while the Standing Broad Jump measures leg muscle explosiveness through the distance jumped from a standing position (validity 0.974, reliability 0.9477). Measurements were conducted by trained research assistants, and the instruments were calibrated according to standard procedures before data collection to ensure accuracy and consistency of the results.

Procedure

The research procedure was carried out in four stages. The first stage, the preparation stage, involved informing participants about the purpose, test phases, and providing detailed instructions for the entire study. During this stage, secondary data such as age, height, weight, and body mass index were also collected. In the second stage, the pre-test, measurements of arm and leg muscle explosiveness were taken to establish baseline data. Participants performed the Two-Hand Medicine Ball Put and Standing Broad Jump tests three times each, with the highest score from the three trials recorded as the final result. The third stage involved the intervention, where participants took part in a 3x3 basketball match for three sessions with uniform intensity. Each session lasted 10 minutes, with a 1-2 minute rest interval between sessions. This intervention aimed to apply sufficient stress on the arm and leg muscles to stimulate improvements in explosiveness. Finally, in the post-test stage, arm and leg muscle explosiveness were measured again using the same instruments as the pre-test. The collected data were then analyzed to assess any changes resulting from the intervention.

Statistical Analysis

The data analysis in this study involved descriptive statistics presented as means and standard deviations. Normality testing was conducted using the Shapiro-Wilk test, and variance homogeneity was tested using Levene’s test. To compare pre-test and post-test results, paired sample t-tests were used with a significance level of 0.05. The analysis was performed using the Statistics for Social Sciences (SPSS Inc., Chicago, IL, USA) software.

Ethical Consideration

This study received ethical approval from the Ethics Committee of SMK Negeri 1 Semarang. All participants provided written consent to participate in the study, and the research was conducted in accordance with ethical principles, including maintaining the confidentiality of participants' personal data and providing full information about their right to withdraw from the study at any time without consequences.

RESULTS AND DISCUSSION

The implementation of the research was conducted at SMK Negeri 1 Semarang, located at Jl. Dr. Cipto, RT/RW 1/9, Dusun Sarirejo, Desa/Kelurahan Sarirejo, Kecamatan Semarang Timur, Kota Semarang, Central Java Province, with postal code 50124. The quantitative data obtained during the research consists of pre-test and post-test data, as described below.

Tabel 1. Data Description

Group		Pre-test	Post-test	Gain
Arm Muscle Explosive Power	N	12	12	12
	$\bar{X}$	5.85	5.69	-0.15
	SD	0.27	0.29	0.24
Leg Muscle Explosive Power	N	12	12	12
	$\bar{X}$	2.44	2.38	-0.06
	SD	0.19	0.20	0.09

Table 3 presents the descriptive statistics for arm and leg muscle explosive power before and after the intervention, along with the gain scores. For arm muscle explosive power, the pre-test average was 5.85 (SD = 0.27), and the post-test average decreased slightly to 5.69 (SD = 0.29), resulting in a gain of -0.15, indicating a minor reduction in performance. Similarly, for leg muscle explosive power, the pre-test average was 2.44 (SD = 0.19), and the post-test average slightly decreased to 2.38 (SD = 0.20), with a gain of -0.06. This suggests a small decrease in performance in both arm and leg muscle explosive power after the intervention, with the arm muscle showing a slightly more significant decline compared to the leg muscle.

Tabel 2 Normality Test

No	Variable	n	Normality Statistic	Sig	Conclusion
Pre Test					
1	Arm Muscle Explosive Power	12	0.924	0.321	Normal
2	Leg Muscle Explosive Power	12	0.927	0.353	Normal
Post Test					
1	Arm Muscle Explosive Power	12	0.963	0.821	Normal
2	Leg Muscle Explosive Power	12	0.935	0.432	Normal

The results of the normality test presented in the table show the results of the Shapiro-Wilk normality test for pre-test and post-test data. For the pre-test, arm muscle explosiveness has a statistical value of 0.924 with a significance of 0.321, and leg muscle explosiveness has a statistical value of 0.927 with a significance of 0.353. Meanwhile, for the post-test, arm muscle explosiveness has a statistical value of 0.963 with a significance of 0.821, and leg muscle explosiveness has a statistical value of 0.935 with a significance of 0.432. Since all significance values are greater than $\alpha = 0.05$, it can be concluded that both the pre-test and post-test data are normally distributed. = 0.05, it can be concluded that both the pre-test and post-test data are normally distributed.

Tabel 3 Homogeneity of Data Test

No	Variable	Levene Statistic	Sig	Conclusion
1	Arm Muscle Explosive Power	0.018	0.893	Homogen
2	Leg Muscle Explosive Power	0.057	0.814	Homogen

The results of the homogeneity of variance test presented in the table show that for arm muscle explosiveness, the Levene statistic is 0.018 with a significance of 0.893, and for leg muscle explosiveness, the Levene statistic is 0.057 with a significance of 0.814. Since both significance values are greater than $\alpha = 0.05$, it can be concluded that the variance between the pre-test and post-test data groups is homogeneous.

Tabel 4 Paired sample t test

No	Group	t	Sig. (2-tailed)
1	Arm Muscle Explosive Power	-2.235	0.047
2	Leg Muscle Explosive Power	-2.247	0.046

The results of the paired sample t-test presented in the table show that for arm muscle explosiveness, the t value is -2.235 with a significance of 0.047, and for leg muscle explosiveness, the t value is -2.247 with a significance of 0.046. Since both significance values are smaller than $\alpha = 0.05$, it can be concluded that there is a significant difference between the pre-test and post-test values for both arm and leg muscle explosiveness. This study aims to examine the impact of a 3x3 basketball competition on the decline in explosive power of the arm and leg muscles in players. Based on the statistical tests, two main findings were obtained, showing a significant decrease in arm and leg muscle explosive power after the competition. These findings are consistent with previous research that shows physical fatigue can affect muscle explosive power and athlete performance. The decrease in arm and leg muscle explosive power after the 3x3 basketball competition indicates that muscle fatigue due to intense physical activity affects the athletes' ability to perform the explosive movements required in the game. This study supports the importance of managing muscle fatigue to maintain optimal performance in competitions that demand high muscle explosive power, such as in basketball competitions.

The results of the study indicate a decrease in arm muscle explosive power with a significance value of 0.047. The t-value of -2.235 suggests that the mean explosive power of the arm muscles in the pre-test was higher than in the post-test. This decrease is most likely due to the fatigue caused by the intense competition. This supports the findings of Shi et al. (2022), who demonstrated that a decline in muscle explosiveness is often caused by fatigue resulting from excessive physical activity. Shi et al. (2022) also stated that fatigue can reduce muscle performance in various types of sports, including basketball, which requires high muscle strength and explosive power. Fatigue is a physiological phenomenon that occurs after intense physical activity and affects the muscles' ability to contract effectively. Muscle fatigue can reduce movement efficiency and lower an athlete's ability to perform basic techniques such as passing, dribbling, and shooting. In basketball, arm muscle explosiveness is crucial for these techniques, which are related to the quality of passing and shooting accuracy. When the arm muscles become fatigued, athletes will struggle to generate the necessary force to perform these movements (Gómez-Carmona et al. 2021).

Arm muscle explosiveness, which plays a crucial role in fundamental basketball techniques such as passing, dribbling, and shooting, showed a decrease after the competition, leading to a reduction in performance in these technical skills. Muscle fatigue can affect the quality of passing and shooting accuracy, both of which are essential components of basketball performance (Gómez-Carmona et al. 2021).The second finding of this study shows a decrease in leg muscle explosiveness with a significance value of 0.046. Similar to arm muscle explosiveness, the t-value for leg muscles also shows a negative number (-2.247), indicating that the average leg muscle explosiveness in the pre-test was higher than in the post-test. This decrease suggests that players experienced a reduction in their ability to perform jumping and running movements after the competition.Fatigue in the leg muscles is often caused by physical activities that require strength and endurance in the lower body, such as sprinting, jumping, and pivoting in basketball. A decrease in leg muscle explosiveness directly affects the ability to perform movements such as lay-ups, rebounds, and shot blocks. The decline in leg muscle performance indicates that players are unable to execute these movements optimally after experiencing fatigue. Lin et al. (2022).

This finding is consistent with the research by Lin et al. (2022), which indicates that fatigue in the leg muscles can reduce explosive power in basketball jumps. Xu (2021) also revealed that muscle fatigue can lead to a decrease in muscle strength and impact the quality of a player’s jumps. In basketball, the ability to jump powerfully plays a crucial role in the effectiveness of the game, particularly in rebounds, blocks, and shooting. Additionally, fatigue in the leg muscles can affect balance and body coordination, both of which are essential for maintaining player stability on the court. Based on these findings, it can be concluded that fatigue caused by 3x3 basketball competitions can affect the explosive power of both arm and leg muscles. This decline shows a significant negative relationship between fatigue and basketball player performance. Muscle fatigue can reduce the quality of movements such as passing, shooting, and jumping, all of which impact the game outcome (Gómez-Carmona et al. 2021). The significant decline in performance in both components of muscle explosiveness highlights the importance of addressing fatigue in training and competition programs to prevent injury and maintain optimal performance.

Fatigue can occur in two forms: central and peripheral fatigue. Central fatigue is related to the decreased ability of the central nervous system to send signals to the muscles, while peripheral fatigue

occurs at the muscle level due to the accumulation of metabolic byproducts such as lactic acid. Both types of fatigue can contribute to a decline in athletic performance, and a deeper understanding of the mechanisms of fatigue is crucial in designing training and recovery programs for athletes. Fatigue can also increase the risk of injury by reducing coordination and the body's ability to perform precise movements (Sumartiningsih et al. 2022).

This study has several limitations that need to be considered. First, the limited sample size of only 12 participants may restrict the generalizability of the findings to a broader population, so further research with a larger sample is necessary for more representative results. Second, this study only measured the explosiveness of arm and leg muscles, without considering other components that could be affected by fatigue, such as cardiovascular endurance or body coordination. Future research should expand to include these factors for a more comprehensive understanding of the impact of fatigue. Third, external factors such as participants' initial fitness level, basketball playing experience, and the duration of rest between training sessions and matches may affect the results, so it is important to control these variables in future studies to obtain more valid outcomes. Fourth, this study focused solely on players participating in 3x3 basketball competitions, which may produce different results if applied to other basketball competition formats, such as 5v5. Future research could broaden the context by comparing the impact of fatigue across different competition formats. Nevertheless, these limitations should be taken into account when interpreting the results and recommendations of this study.

CONCLUSION

This study reveals that basketball players experience fatigue in arm and leg muscle explosive power during 3x3 basketball matches, characterized by significant differences. Effective fatigue management and proper physical care can help mitigate these negative impacts. Continued research and well-planned training programs can enhance players' muscle explosive power in basketball games. The implications of these findings underscore the importance of fatigue management in basketball, particularly in faster-paced formats like 3x3. Well-planned training not only reduces the risk of excessive fatigue but also enhances athletes' performance in crucial areas such as muscle explosive power, critical for fundamental techniques like passing, dribbling, and shooting. Thus, improving athlete performance requires not only technical and tactical aspects but also appropriate physical care and effective fatigue management.

FUNDING

This research was funded by the Indonesian Educational Fund Management Institution (LPDP).

ACKNOWLEDGEMENTS

The researchers thanked the Indonesian Educational Fund Management Agency (LPDP) who has fully funded this research. The researcher also appreciated the LPDP who has funded his studies in the Master's Studies Program in Sports Education at the State University of Semarang.

CONFLICT OF INTREST

The author(s) have no conflicts of interest relevant to this paper.

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