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Original Scientific Article

Analyzing Muscle Damage (CK-MM) and Recovery of Muscle Strength between Non-Professional and Professional Basketball Athletes

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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Abstract

Background. Basketball is considered to be one of the most popular sports. Besides recreational training sessions, basketball lovers as non-professional athletes often perform competitions like basketball athletes, characterized by high intensity. However, the biological changing is limited.

Objectives. This study aimed to analyze the differences between basketball lovers as non-professional athletes and professional athletes regarding their blood CK-MM levels and their recovery of muscle strength.

Materials and methods. The present study was an analytical observation, involving adult males subjects (19-29 years old) divided into 2 groups: non-professional athletes (NP, n=9) and professional athletes (PA, n = 9). The blood CK-MM levels were measured using the ELISA method. The push, pull, leg, and back muscle strength were assessed with a dynamometer. The data were obtained 3 times: before (pre), 1 hour after the game (post1), and 1 day after the game (post2).

Results. The results showed that there was a higher muscle strength in the PA group compared with the NP group ($p < 0.05$). However, in both groups, the recovery of all muscle strength, except push muscle, did not occur after 1 day of the game. This was linear with the level of blood CK-MM in both groups, with a higher level of CK-MM in NP. Nevertheless, there was insignificance between groups ($p > 0.05$).

Conclusions. The findings indicate that non-professional athletes have lower strength and a higher trend of blood CK-MM level compared to professional athletes. However, the recovery of muscle strength and the changing pattern of CK-MM are similar between the two groups, which reveals that active people, such as non-professional athletes, have a good adaptation as athletes.

Keywords: muscle strength, CK-MM, basketball, athletes, healthy lifestyle.

Introduction

Basketball is a dynamic sport played by two opposing teams that continuously attack and defend to achieve victory (Salafi et al., 2023). According to Gottlieb et al. (2014), basketball involves horizontal movements such as sprinting and changing direction, as well as vertical movements such as jump shots, rebounds, and dunks.These characteristics require players to possess optimal physical capacities, particularly muscular strength, endurance, and reaction speed. To improve performance in basketball, it is essential to focus on physical fitness, both in terms of health-related and skill-related components. Physical fitness in basketball is critical in supporting performance and preventing injury. It is influenced by various factors such as physiological conditions, physical demands during the game, and recovery after the game (Putera et al., 2023; As'ad et al., 2022; Ayubi et al., 2022). According to Yewen et al. (2024), basketball players need to have high levels of muscular strength, particularly in the arms, legs, and back, to support movement efficiency during games.

A tight competition schedule and the high intensity of the game increase the risk of fatigue and decreased

performance. Muscle fatigue can impair the effectiveness of muscle contractions and increase the risk of injury (Goud et al., 2023). Athletes with well-trained muscles tend to be more resistant to fatigue due to better neuromuscular and metabolic adaptations (Schoenfeld et al., 2017). Basketball movements generally involve dynamic muscle contractions, including both concentric and eccentric contractions. Muscular strength plays a key role in various movements during the game, such as jumping, landing, sprinting, shooting, dribbling, throwing, and passing (Ferraz et al., 2021). These movements involve isotonic contractions, consisting of both concentric and eccentric phases. Eccentric contractions, which occur when a muscle lengthens while generating force, contribute significantly to mechanical stress and microtrauma in muscle tissue. This activity can lead to skeletal muscle damage and delayed onset muscle soreness (DOMS) (Hedayatpour et al., 2018). Acutely, eccentric-induced muscle damage is estimated to account for 10–55% of all sports-related injuries. The proportion varies by sport, with approximately 11% in rugby, 16% in running, and 18% in basketball (Maffulli et al., 2015). Martinez et al. (2022) also state that sports involving dominant eccentric contractions carry a high risk of muscle damage. Such microscopic injuries trigger the release of biochemical markers such as creatine kinase (CK), particularly the CK-MM isoform derived from skeletal muscle. Creatine kinase (CK-MM) is a commonly used biomarker to detect muscle damage following physical activity. CK-MM levels increase significantly after high-intensity exercise, especially activities involving eccentric contractions (Baird et al., 2012). Lieber (2018) reports that CK-MM levels increase within 45 minutes after ergometer testing and return to baseline within 24 hours in trained athletes, whereas in untrained individuals, elevated CK-MM levels may persist for up to six days. This demonstrates differences in muscle recovery capacity and adaptation between trained and untrained individuals.

Research by Damas et al. (2016) also reports that repeated resistance training-induced muscle damage can acutely reduce muscular strength, although it may promote hypertrophic adaptation in the long term. Similarly, Subagio et al. (2025) find that the high-load low-repetition (HLLR) group experiences greater microtrauma compared to the low-load high-repetition (LLHR) group, as the HLLR protocol involves lifting heavier loads. In the context of competitive sports, it is important to understand how muscle strength and muscle damage biomarkers change before and after competition. To date, the differences in muscle damage levels and muscular strength before and after basketball matches between non-professional (NP) and professional athletes (PA) remain unclear.

Based on the above background, this study aims to analyze the differences in muscle damage markers (CK-MM), as well as the muscle strength of the arms, legs, and back, between non-professional athletes and professional athletes.

Materials and Methods

Participants

The subjects recruited for this study were males aged 19 to 29 years old. This study received ethical approval from the Research Ethics Committee of the Faculty of Medicine, Universitas Airlangga, with certificate number 138/EC/KEPK/FKUA/2025.

This study was an analytical observational study. The subjects consisted of two groups: the non-professional athlete group (NP) and the professional athlete group (PA). All subjects signed informed consent forms and agreed to participate in the study. Each group initially included 10 participants. However, after conducting an outlier analysis using SPSS based on CK-MM levels, one participant from the professional group was identified as an outlier, likely due to non-compliance, and was therefore dropped from the study. Consequently, one participant from the NP group was removed through a random draw. Thus, each group consisted of 9 participants.

Procedure and Protocol Test

Before the matches began, all subjects were not allowed to perform moderate- or high-intensity exercise from 24 hours before the match until the study was completed. This restriction was implemented to avoid bias in blood biomarker results. The basketball matches were played 5 vs. 5 according to FIBA standards (PA vs. PA; NP vs. NP). Subjects performed a 5-minute warm-up under the supervision of an instructor before the match started. Each basketball game consisted of four quarters (4 x 10 minutes), lasting a total of 40 minutes. There was a 1-minute break between quarters. The matches were officiated by three referees: the head referee, the second referee, and the scorekeeper. The court used for the games was standardized for basketball competitions and maintained at a room temperature between 20 and 22°C.

Anthropometric measurements were taken before the match to assess body weight and height, which were subsequently used to calculate body mass index (BMI). Height was measured using a SECA 213 portable stadiometer, while body weight was measured using a TANITA Bc545n. BMI was calculated by dividing weight by height squared (kg/m^2). Arm muscle strength was measured using a shoulder and arm dynamometer (Dynamometer, TTM, Tokyo, Japan), while leg and back muscle strength was assessed using a back and leg dynamometer (Takei 5002 BACK-D, Type 3, Takei, Japan). All muscle strength measurements were recorded in kilograms (kg). Venous blood samples (3 cc) were collected from the cubital vein to measure CK-MM levels and analyzed using the Human CKM Enzyme-Linked Immunosorbent Assay (ELISA) Kit from BT LAB, reported in U/L. Blood sample analysis was conducted at the research laboratory of Universitas Airlangga Hospital. Muscle strength measurements and blood sampling were conducted at three time points: before (pre), 1 hour after the game (post1), and 1 day after the game (post2).

Statistical Analysis

Data analysis was performed using SPSS software. The data analysis included descriptive statistics to determine characteristics consisting of means and standard deviations before the match, one hour after, and one day after the match. Normality was tested using the Shapiro-Wilk test; homogeneity was tested using Levene's test. Differences between the NP and PA groups were analyzed using the

independent t-test or Mann-Whitney test. Differences across time within groups were analyzed using repeated measures ANOVA.

Result

The characteristics of the participants are presented in Table 1. The average age of the NP group was younger than that of the PA group; however, this difference was not statistically significant (p = 0.59). The NP group had a mean age of 20.89 ± 2.20 years, while the PA group had a mean age of 23.89 ± 3.33 years. Based on Table 1, no significant differences were found between the NP and PA groups in terms of age or body mass index (BMI). Therefore, both groups can be considered to be at equivalent stages of physiological growth.

Table 1. Participant characteristics

Variables		NP group (n = 9)	PA group (n = 9)	p*
Age (years)	mean ± SD	20.89 ± 2.20	23.89±3.33	0.59
	Median	20	25	
BMI (kg/m^2)	mean ± SD	24.30 ± 2.70	24.45±2.68	0.95
	Median	24.14	24.92	

Note: BMI = body mass index; NP = non-professional athletes; PA = professional athletes; *T-independent test or mann whitney test

The results of the CK-MM levels analysis between the NP and PA groups are presented in Figure 1. The average CK-MM level in the NP group before the match was 247.90 ± 42.90 U/L, while in the PA group it was 246.52 ± 37.12 U/L. One hour after the match, the CK-MM level in the NP group decreased to 234.45 ± 23.24 U/L, whereas in the PA group it decreased to 211.23 ± 30.56 U/L. One day after the match, the CK-MM level in the NP group slightly increased to 240.31 ± 48.55 U/L, and in the PA group it rose to 225.49 ± 31.04 U/L. The results of the repeated measures test on CK-MM levels between the NP and PA groups showed no significant difference (p = 0.148).

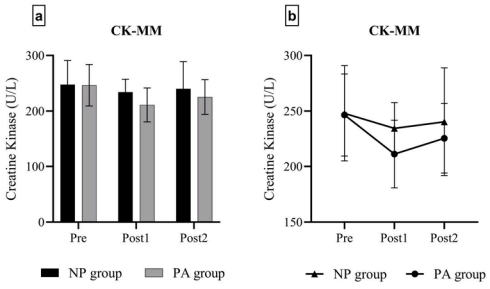

Fig. 1. The concentration of CK-MM in each group (a) and the changing of CK-MM (b). Pre = before the game; Post1= 1 hour after the game; Post2= 1 day after the game

Figure 2a presents arm muscle strength measured using a push dynamometer in the NP and PA groups. The average push muscle strength before the match was 25.38 ± 8.58 kg in the NP group and 40.55 ± 10.56 kg in the PA group. One hour after the match, the NP group showed an increase to 26.50 ± 9.94 kg, and the PA group increased to

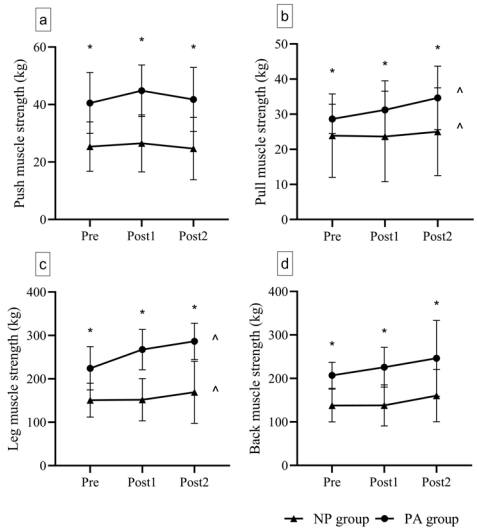

Fig. 2. The changing of muscle strength. Pre = before the game; Post1= 1 hour after the game; Post2= 1 day after the game. *sig. diff between groups at the same time (p<0.05), t independent test or mann whitney test. ^sig. diff in the same group due to different time (p<0.05), repeated measures ANOVA

44.55 ± 10.56 kg. However, one day after the match, push muscle strength decreased to 24.66 ± 10.86 kg in the NP group and to 41.77 ± 11.15 kg in the PA group. The pattern of change in push muscle strength was similar in both groups, with an increase one hour after the match followed by a decrease one day after the match. Repeated measures tests showed no significant differences over time, but there were significant differences between groups in the overall results of the push muscle strength measurements (p time = 0.150; p group = 0.002). Based on the results of post hoc analysis, there were significant differences between the two groups before the match, one hour after the match, and one day after the match (p = 0.004, p = 0.001, p = 0.005 respectively).

The mean arm muscle strength measured using a pull dynamometer (Figure 2b) in the NP and PA groups before the match was not significantly different (NP = 23.88 ± 11.88 kg; PA = 28.66 ± 4.18; p = 0.272). One hour after the match, the NP group had an average of 23.66 ± 12.93 kg, while the PA group increased to 31.22 ± 8.31 kg (p = 0.160). One day after the match, the NP group increased to 25.00 ± 12.53 kg and the PA group increased to 34.66 ± 9.04 kg (p = 0.079). The repeated measures test showed a significant difference over time in pull muscle strength between the two groups (p = 0.013).

Figure 2c shows that there was a significant difference in pre-match leg muscle strength between the NA and PA groups, where the PA group showed higher mean values than the NP group (NP= 150.88 ± 39.04 kg; PA= 224.33 ± 49.97 kg). One hour after the match, the NP group had an average of 151.88 ± 48.64 kg, whereas the PA group increased to 267.44 ± 46.54 kg. One day after the match, leg muscle strength in the NP group increased to 169.00 ± 71.37 kg, and in the PA group to 286.41 ± 41.95 kg. Repeated measures tests showed significant differences over time (p = 0.019) and between groups (p < 0.001) in the overall leg muscle strength measurement results. Based on the result of post hoc analysis, there were significant differences between the

two groups before the match, one hour after the match, and one day after the match ($p = 0.003$; $p = 0.001$); $p = 0.002$ respectively).

Figure 2d shows the back muscle strength in the NP and PA groups. The average back muscle strength was higher in the PA group than in the NP group. The back muscle strength before the match was 137.94 ± 37.66 kg, while in the PA group it was 207.11 ± 30.11 kg. One hour after the match, the NP group did not experience significant changes, with a strength of 138.11 ± 47.26 kg, while the PA group increased to 225.77 ± 45.68 kg. One day after the match, back muscle strength in the NP group increased to 160.66 ± 60.18 kg, and in the PA group to 246.35 ± 87.07 kg. The repeated measures test showed no significant difference over time, but there were significant differences between groups in the overall results of the back muscle strength (p time = 0.148; p group < 0.001). Based on the results of post hoc analysis, there were significant differences between the two groups before, one hour, and one day after the match ($p = 0.001$; $p = 0.001$; $p = 0.015$ respectively).

Discusion

This study aims to analyze the differences in muscle damage markers as well as the muscle strength of the arms, legs, and back between non-professional athletes and professional athletes.

Creatine kinase

Creatine kinase (CK-MM) serves as an indicator for detecting muscle damage caused by physical activity (Baird et al., 2012). The CK-MM levels measured before the match, one hour after, and one day after show no significant differences between the NP and PA groups. In this study, the average CK-MM level decreases one hour after the match. According to Clarkson & Hubal (2002), this decline may result from increased blood flow after the match, which accelerates the clearance of CK-MM from the bloodstream. However, this decrease is temporary, as CK-MM levels typically peak within 24–72 hours following physical activity (Brancaccio et al., 2007). In the current study, no peak in CK-MM levels is observed even 24 hours post-match. Gutenbrunner (2000) compares CK-MM responses between trained and untrained individuals using an ergometer test. The results show that the untrained group exhibits increased CK-MM levels, while the trained group does not demonstrate a significant rise. In this study, the NP group trains three times per week, while the PA group trains ten times per week. Both groups are considered trained individuals, which may explain why CK-MM levels do not significantly increase 24 hours after the match.

Arm, Leg, and Back Strength

The results of arm muscle strength during the push movement, measured before, one hour after, and one day after the match, indicate that the PA group demonstrates higher strength compared to the NP group. The push movement is essential in basketball for activities such as dribbling, shooting, passing, and rebounding. According to Murach & Bagley (2016), regular training increases muscle hypertrophy. In this study, the NP group trains three times per week, while the PA group trains ten times per week. Therefore, push strength is greater in the PA group. On average, push strength increases one hour after the match. This finding aligns with Finlay et al. (2022), who state that high-intensity activities such as dribbling, passing, and shooting enhance neuromuscular activation, leading to a temporary increase in muscle strength. Pull strength in the arm muscle also increases after the match in both the NP and PA groups. According to Lambrich & Muehlbauer (2025), this occurs because trained athletes tend to have higher fatigue tolerance after competition. Since both groups in this study consist of trained individuals, arm muscle pull strength increases after the match in both NP and PA athletes.

Leg muscle strength plays a crucial role in basketball, particularly for running and jumping. The results of this study show that leg and back muscle strength measured before, one hour after, and one day after the match is higher in the PA group. This finding is consistent with the study by Schoenfeld et al. (2017), which explains that intensive and well-structured strength and endurance training improves muscle strength and hypertrophy. Increases in leg and back strength after the match are observed in both groups. This improvement is likely due to the effect of regular training in enhancing intermuscular activation and coordination, which contributes to faster muscle recovery (Franchi et al., 2017; Peake et al., 2016). Monica (2015) also states that trained athletes tend to have greater fatigue tolerance after competition. Since both groups in this study consist of trained individuals, leg and back strength increases after the match in both NP and PA athletes.

Conclusions

This study concludes that professional athletes (PA) have greater muscle strength compared to non-professional athletes. The muscles recovery is not occurred after one day of competition, except push muscle. This pattern of muscles recovery is similar to the pattern of CK-MM levels, however insignificantly between groups. This indicates that the non-professional athletes obtain a good effect as active people. Nonetheless, further research is needed to better understand the physiological response mechanisms and the effects of prolonged training for safety.

Acknowledgments

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Conflict of Interest

The authors declare that they have no conflicts of interest.

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Аналіз пошкодження м'язів (КК-ММ) та відновлення м'язової сили серед непрофесійних та професійних баскетболістів

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 7 с., 1 табл., 2 рис., 25 джерел.

Історія питання. Баскетбол вважається одним із найпопулярніших видів спорту. Окрім рекреаційних тренувальних сесій, поціновувачі баскетболу, які не є професійними спортсменами, часто беруть участь у змаганнях, типових для баскетболістів, що характеризуються високою інтенсивністю. Однак біологічні зміни є обмеженими.

Мета дослідження. Це дослідження мало на меті проаналізувати відмінності між поціновувачами баскетболу як непрофесійними спортсменами та професійними спортсменами щодо рівня КК-ММ (креатинкіназа м'язового ізоферменту, що знаходиться в скелетних м'язах) в крові та відновлення м'язової сили.

Матеріали та методи. Представлене дослідження проводилося у формі аналітичного спостереження, в якому взяли участь дорослі представники чоловічої статі (віком 19–29 років), розподілені на 2 групи: непрофесійні спортсмени (НП, n = 9) та професійні спортсмени (ПС, n = 9). Визначення рівня КК-ММ у крові здійснювалося із використанням методу імуноферментного аналізу (ІФА). Оцінювання показників сили відштовхування, тяги, м'язів ніг і спини проведено за допомогою динамометра. Отримання даних здійснено тричі: безпосередньо перед грою (переддослідницький етап), через 1 годину після гри (постдослідницький етап1) та через 1 день після гри (постдослідницький етап2).

Результати. Результати показали, що в групі ПС показник м'язової сили був вищим порівняно з групою НП ($p < 0.05$). Однак в обох групах відновлення всієї м'язової сили, крім сили м'язів під час відштовхування, не спостерігалося через 1 день після гри. Це було лінійно пов'язано з рівнем КК-ММ в крові в обох групах, причому рівень КК-ММ був вищим у групі НП. Проте значущої різниці між групами не встановлено ($p > 0.05$).

Висновки. Результати дослідження свідчать про те, що непрофесійні спортсмени мають нижчі показники сили та вищий рівень КК-ММ у крові порівняно з професійними спортсменами. Однак відновлення м'язової сили та зміна патерну КК-ММ є подібними в обох групах, що вказує на належну адаптацію до занять спортом активних осіб, як-от непрофесійних спортсменів.

Ключові слова: м'язова сила, КК-ММ, баскетбол, спортсмени, здоровий спосіб життя.

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