Profile of oxidative stress, inflammation, and muscle damage in professional athletes and recreational basketball players

Perfil del estrés oxidativo, la inflamación y el daño muscular en atletas profesionales y jugadores de baloncesto recreativos

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Abstract

Introduction: To gain a healthy lifestyle, several physical active people do popular sports such as basketball, as their hobby. However, the different physiological responses between athletes and recreational players have not yet been understood.
Objective: This study aims to analyze differences of antioxidants, free radical, inflammation, and muscle damage markers between professional athletes and recreational basketball players.
Methodology: The subjects were professional athletes (PA, n=10) and recreational basketball players (RP, n=10). All subjects performed 5x5 basketball. The heart rate (HR) during the game was recorded. Glutathione peroxidase (GPX), F2-isoprostane, C-reactive protein (CRP), and lactate dehydrogenase (LDH) were analyzed.
Results: It showed the PA had lower HRmax compared to RP group ($p=0.001$), while blood markers level between PA and RP groups was insignificant difference ($p\geq0.05$). However, the CRP of professional athletes tended to decrease after the game, while the RP group had a small increase after 1 hour. Both groups showed a transient decrease in LDH after 1 hour. Interestingly, 1 hour after the games, RP experienced a slight decrease of F2-isoprostane level, while PA underwent a small decrease of GPX level.
Conclusions: The professional athletes have better cardiovascular endurance. However, after 1 hour of the game, LDH, CRP, F2-IsoPs, and GPX seem similar in both groups. It indicates that recreational players have a good benefit as active people. Even though, the level trend of the markers in professional athletes is superior to recreational players. Nevertheless, further investigation is still needed to figure out the physiological response mechanism with more complete markers.

Keywords

Antioxidant; basketball; inflammation; muscle damage; healthy lifestyle.

Resumen

Introducción: Para lograr un estilo de vida saludable, varias personas físicamente activas practican deportes populares como el baloncesto, como pasatiempo. Sin embargo, las diferentes respuestas fisiológicas entre los atletas y los jugadores recreativos aún no se han comprendido.
Objetivo: Este estudio tiene como objetivo analizar las diferencias de antioxidantes, radicales libres, inflamación y marcadores de daño muscular entre atletas profesionales y jugadores de baloncesto recreativos.
Metodología: Los sujetos fueron atletas profesionales (PA, n = 10) y jugadores de baloncesto recreativos (RP, n = 10). Todos los sujetos jugaron baloncesto 5x5. Se registró la frecuencia cardíaca (FC) durante el juego. Se analizaron el glutatión peroxidasa (GPX), el F2-isoprostano, la proteína C reactiva (PCR) y el lactato deshidrogenasa (LDH).
Resultados: Se mostró que el PA tenía una FCmáx más baja en comparación con el grupo RP ($p = 0{,}001$), mientras que el nivel de marcadores sanguíneos entre los grupos PA y RP fue una diferencia insignificante ($p\geq0{,}05$). Sin embargo, la PCR de los atletas profesionales tendió a disminuir después del juego, mientras que el grupo RP tuvo un pequeño aumento después de 1 hora. Ambos grupos mostraron una disminución transitoria de LDH después de 1 hora. Curiosamente, 1 hora después de los juegos, RP experimentó una ligera disminución del nivel de F2-isoprostano, mientras que PA experimentó una pequeña disminución del nivel de GPX.
Conclusiones: Los atletas profesionales tienen mejor resistencia cardiovascular. Sin embargo, después de 1 hora de juego, LDH, PCR, F2-IsoPs y GPX parecen similares en ambos grupos. Esto indica que los jugadores recreativos tienen un buen beneficio como personas activas. A pesar de que la tendencia del nivel de los marcadores en los atletas profesionales es superior a la de los jugadores recreativos. No obstante, aún se necesita más investigación para determinar el mecanismo de respuesta fisiológica con marcadores más completos.

Palabras clave

Antioxidante; baloncesto; inflamación; daño muscular; estilo de vida saludable.

Introduction

One component of healthy lifestyle is physical activity. To gain a healthy lifestyle, several physical active people do popular sports such as basketball, as their hobby. Basketball is one of the most favorite sports in the world. However, Indonesia's basketball achievements are still far from the top of the world rankings. The Indonesian women's basketball team is still ranked 51st, and the men's team is still ranked 74th. To improve basketball achievement, it is necessary to pay attention to markers that can increase physical fitness both in terms of health and skills. Physical fitness in athletes is generally influenced by factors before the match, during the match, after the match, and recovery (As'ad et al., 2022; Ayubi, Purwanto, et al., 2022). The markers that play a role in this situation can be related to oxidative stress, inflammation, and muscle damage (Ayubi, Yuniarti, et al., 2022; Darmawan et al., 2024; Vigriawan et al., 2022).

Intensive and regular training in athletes can affect various biochemical parameters in the body, including antioxidant enzymes such as superoxide dismutase (SOD), glutathione peroxidase (GPX), and glutathione reductase (GR), as well as oxidative stress markers such as F-2 isoprostane. In addition, inflammatory parameters such as interleukin-1 (IL-1), C-reactive protein (CRP), and markers of muscle damage such as creatine kinase (CK) and lactate dehydrogenase (LDH) can also be affected by intense physical activity (Cerqueira et al., 2020; García-Cardona et al., 2022; Kurniawati et al., 2024; Llinás & Caballero, 2024) . Moderate to high intensity physical activity was shown to increase the activity of the endogenous antioxidant GPX in protecting against muscle damage and the influence of free radicals (Awang Daud et al., 2022). While in non-athletes, training at a certain intensity will increase reactive oxygen species (ROS) production followed by an increase in antioxidant enzymes such as SOD, CAT, GPX. These enzymes will help neutralize ROS and protect cells from muscle damage (Kawamura & Muraoka, 2018).

Basketball athletes are often involved in physically demanding workouts and competitions of greater intensity, which may affect the blood levels of these biomarkers. On the other hand, individuals who are not athletes but have a hobby of basketball may experience different changes in their biochemical parameters due to lower or irregular training intensity. This study aimed to analyze the differences in the balance of antioxidant-free radicals (glutathione peroxidas or GPX and F2-isoprostane), inflammatory markers (C-reactive protein or CRP), and anaerobic metabolism lead to muscle damage (lactate dehydrogenase/ LDH) between professional athletes and recreational basketball players. The study is expected to provide information about the profiles of athletes and non-athletes who are active people and sports enthusiasts, which it is hoped will not differ much.

Method

Study design

This study was an analytical observational study. The subjects consisted of 2 groups: professional athletes (PA) and recreational basketball player (RP) groups. The sample was determined by purposive sampling in each group. All subjects signed the research informed consent and were willing to participate in the study. This study received ethical approval from the Research Ethics Commission of the Faculty of Medicine, Airlangga University with certificate number 62/EC/KEPK/FKUA/2024.

Subjects

The subjects of this study were professional basketball athletes and recreational basketball player, male, and aged between 18-30 years. The professional athletes were recruited from professional basketball clubs. The inclusion criteria of the athletes were to have regular exercise training between 3-4 times a week with a duration of 2 hours/ session and their training experience was more than 3 years. Meanwhile, the recreational basketball players have the inclusion criteria of being recreationally active, engaging in at least 30 minutes of moderate intensity physical activity for at least 3 days per week for the past 3 months. The exclusion criteria in this study were subjects who had high blood pressure, had a history of cardiorespiratory problems, had a history of fracture/ traumatic injury, and had surgery for less than 6 months. The total sample size was 20 subjects (n PA = 10; n RP = 10). At the first meeting, participants were asked to fill out a form that contained the required data for pre or baseline, and screening data, which were age, frequency and duration of basketball training in a week, frequency and duration of physical training in a week, years of training experience, medical history and medication, and healthy lifestyle (not smoking, no alcohol consumption, no insomnia, and supplement consumption).

Basketball

Prior to the basketball game, all subjects were not allowed to perform moderate or high-intensity exercise since the previous 24 hours. This was done to avoid any bias in the results of blood biomarker examination. A basketball game or match 5 x 5 was conducted according to FIBA standards (PA vs PA; RP vs RP). Subjects warmed up for 5 minutes under the instructor's guidance before the game started. The basketball match was played for 4 quarters (4 x 10) for 40 minutes. Between quarters there was a rest period of about 1 minute. Basketball matches were guided by 3 referees, i.e. the main referee, the second referee or umpire, and the score referee. The field used for the game was standardized for basketball matches and had a room temperature between 20–22ºC. During the basketball match, each of the subject's heart rate was monitored using a Polar H10 Heart Rate Sensor to determine the intensity of each subject during the match.

Antropometry and body composition

Anthropometric measured to determine body weight, height, and abdominal circumference which were then used to calculate body mass index (BMI). Body composition measurements were taken to determine body fat percentage (BFP), fat free mass (FFM), and total body water (TBW) variables. Anthropometric measurements and body composition were carried out before the subject played basketball and had fasted for at least 8 hours before (water was allowed). Height and abdominal circumference measurements were taken using a SECA 213 potable stadiometer and OneMed OD-235 waist ruler. Subjects' body composition was examined using a TANITA Bc545n Bio-electrical Impedance Analysis (BIA). Body mass index (BMI) was calculated based on body weight to height (kg/m2).

Muscle strength

Muscle strength measured in this study includes upper muscle strength and lower muscle strength. Arm and shoulder muscle strength was measured using the TTM Shoulder and Arm Dynamometer. The subject stands upright by holding both sides of the dynamometer in front of the chest. The subject performs pulling or pushing movements according to the instructions and performs according to the maximum ability for 3 seconds. Meanwhile, measurements of back and leg muscle strength were measured using the Takei 5002 BACK-D leg and back dynamometer. Each measurement was taken 3 times to obtain the best average result.

Blood biomarkers

Blood biomarkers were aimed to analyze antioxidants and free radical balance/imbalance by analyzing blood glutathione peroxidase (GPX) and blood F2-isoprostane concentrations, inflammatory marker blood C-reactive protein (CRP), and anaerobic metabolism resulted muscle damage marker blood lactate dehydrogenase (LDH). Subjects were required to fast for at least 8 hours (drinking water was allowed) for the pre-data or baseline blood collection. Blood samples were taken from the arm vein for about 3 cc in each collection. Blood was taken 3 times: before basketball (pre-data or baseline data), 60 minutes and 24 hours after basketball. Subjects were not allowed to do moderate or strenuous exercise before baseline blood collection and before blood collection of 24 hours after the basketball game. GPX concentration was analyzed using Human GPX Enzyme-Linked Immunosorbent Assay (ELISA) Kit BT LAB E3921Hu with concentration unit U/ml. F2-Isoprostane concentration was analyzed using Human 8-epi-prostaglandin F2aplha ELISA Kit BT LAB E1251Hu with concentration unit ng/L. Inflammatory markers were analyzed using Human C-Reactive Protein ELISA Kit BT LAB E1798Hu with concentration unit mg/L and muscle damage markers were analyzed using Human Lactate Dehydrogenase ELISA Kit BT LAB E0747Hu with concentration unit U/L. Biomarker analysis of blood samples was carried out at the Research Laboratory of Universitas Airlangga Hospital.

Statistical analysis

Data analysis techniques were carried out using SPSS software. Data analysis included descriptive tests to determine the characteristics, which consisted of the average and standard deviation before and after intervention (1h and 24h). The normality test used Shapiro-Wilk; homogeneity test used Lavene test. The analysis of differences between groups of athletes and non-athletes using independent t-test, Mann-Whitney test and fisher's exact test, based on the data scale and the data distribution. To analyze the differences within group and between groups in serial data, the repeated measures ANOVA analysis was applied, with 95% of significant level.

Results

As mentioned above, the subjects' recruited in this study was man 18-30 years old (yo), and the average age of both groups were 22.35±3.13 years old. Because of the limitation in study, which the groups were unrandomized, the professional athletes were recruited from professional club, whereas the recreational athletes were anyone who were a basketball hobby, and agreed to join this study, there was a significant difference in age between PA and RP (p=0.014). The subject as recreational player who willing to join were 90% college students and their average age was 20.7±2.16 year. The professional athletes whose their occupation were athletes, they had an average age of 24 ± 3.16 years. This slight difference of their age, according to IOM (Institute of Medicine) & NRC (National Research Council) (2015), was still in the range of young adulthood classification, which mean their physiology and psychology is similar. Besides that, Lauretani et al. (2003) classified the the 20-29 year in the same group, for their study about age and the changes in skeletal muscle and mobility related to sarcopenia diagnosis, which mean the skeletal muscle of the age range was alike. Therefore, the age between the 2 groups was still in a similar pattern of growth.

Based on the training pattern between PA and RP who were hobbies of basketball, it showed that there was a significant difference in both the frequency and the duration of basketball training in each week (p = 0.017). PA group had a higher frequency and duration than RP group. In addition, the frequency of physical exercise per week between PA and RP group also showed a significant difference (p = 0.022), but not significantly different for the exercise duration (Table 1).

Table 1. Respondent characteristics

Variable	Professional Athlete (Mean ± SD)	Recreational Player (Mean ± SD)	P
Frequency of basketball training (times/week)	9.5 ± 2.16	2.10 ± 1.10	<0.001*
Duration of basketball training (minute)	138 ± 28.98	102 ± 28.98	0.017*
Physical exercise frequency (times/week)	4 ± 1.33	2.3 ± 2.05	0.022*
Physical exercise duration (minutes)	80 ± 29.43	74 ± 41.15	0.754
Years of training (years)	11.10 ± 4.95	6.6 ± 2.31	0.068
Height (cm)	182.02 ± 7.48	168.41 ± 7.62	0.001#
Body weight (kg)	80.60 ± 6.73	70.33 ± 12.79	0.037#
BMI (kg/m^2)	24.38 ± 2.50	24.61 ± 2.73	0.847
Waist circumference (cm)	82.66 ± 5.74	82.55 ± 8.62	0.973
BFP (%)	13.17 ± 4.02	19.59 ± 4.55	0.004#
TBW (%)	57.51 ± 4.89	52.32 ± 4.22	0.138
FFM (%)	66.07 ± 4.22	53.25 ± 7.27	<0.001#
Medical history and medication, n (%)	0 (0)	0 (0)	1.000
History of bone or joint problems	5 (50)	0 (0)	0.033^
Smoking, n (%)	0 (0)	1 (10)	1.000
Alcohol consumption, n (%)	0 (0)	1 (10)	1.000
Poor sleep quality, n (%)	1 (10)	5 (50)	0.474
Supplements consumption, n (%)	6 (60)	3 (30)	0.370

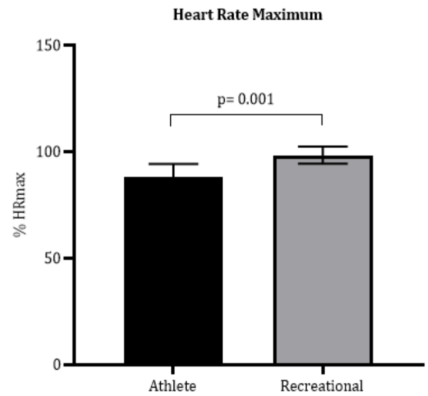
Note: BFP (body fat percentage); TBW (total body water); FFM (fat free mass). *Significant based on Mann-Whitney test (p<0.05); SD (standard deviation); #significant based on independent t-test (p<0.05); ^significant based on fisher's exact test

Body composition presented significant differences in body fat percentage and FFM between PA and RP group. Professional athletes had a lower body fat of 13.17±4.02%, while RP group had a body fat of 19.59±4.55%. The results of the independent-T test showed that there was a significant difference in body fat percentage between groups (p =0.004). Meanwhile, FFM (fat free mass) which represents lean body mass, PA group had a larger composition than RP group with a significant difference (p<0.001).

The results showed that no one respondents had medical history and medication. Half of PA group had a significant (p=0.033) history of the problem of bone, joint, or soft tissue (muscle, ligament, or tendon). However, there was no limitation when the game started, because it occurred last year and had healed. Meanwhile, the quality of sleep and supplements consumption (such as whey protein, BCAAs and caffeine) were not significantly different. All of these variables were needed to ensure that the subjects' condition was safe to be included in this study, and also to reduce confounding variables.

Intensity during basketball in this study was observed using Polar Heart Rate. The results showed that the average±SD of the %HRmax was significantly different between groups. The %HRmax in PA group was 88.5 ± 5.99% while in RP group it was 98.6 ± 4.08% (p=0.001) (Figure 1).

Figure 1. Heart rate maximum during basketball



An analysis of oxidative stress, inflammation, and markers of muscle damage in professional athletes and recreational basketball players after basketball training was presented in table 2. The results indicated that 1 hour after basketball exercise there was a decrease in blood LDH concentration in both groups but not significantly different. However, the blood LDH of 24 hours after basketball increased (152.375±69.33 U/L) in PA group, while the blood LDH of RP group indicated a decrease (116.28 ± 44.64 U/L). The results of the overall analysis showed no significant interaction by time and group of the LDH análisis (Table 2).

Table 2. Oxidative Stress, Inflammation, and Muscle Damage

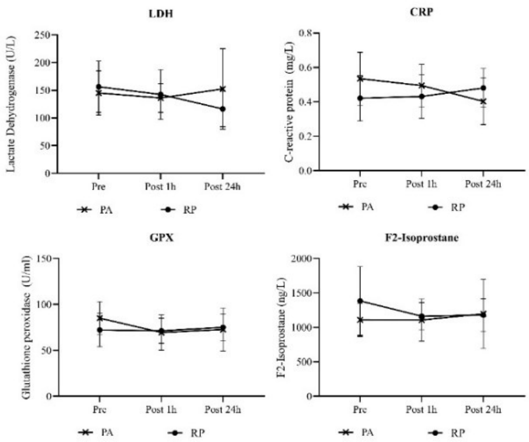
Variable	Pre Mean±SD	Post 1h Mean±SD	Post 24h Mean±SD	Within group p-value
LDH (U/L)				
Professional Athletes	145.151 ± 55.54	136.075 ± 36.16	152.375 ± 69.33	0.260
Recreational Players	156.387 ± 64.58	142.409 ± 62.66	116.28 ± 44.64	0.592
p-value between groups	0.684	0.436	0.223	0.790
CRP (mg/L)				
Professional Athletes	0.534 ± 0.21	0.494 ± 0.17	0.402 ± 0.12	0.122
Recreational Players	0.421 ± 0.18	0.430 ± 0.17	0.480 ± 0.15	0.650
p-value between groups	0.218	0.427	0.323	0.657
F2-Isoprostane (ng/L)				
Professional Athletes	1109.918 ± 335.53	1107.040 ± 428.80	1197.044 ± 477.81	0.506
Recreational Players	1383.813 ± 698	1162.052 ± 277.02	1178.425 ± 332.35	0.252
p-value between groups	0.280	0.737	0.928	0.592
GPX (U/ml)				
Professional Athletes	85.012 ± 25.128	69.451 ± 26.93	71.712 ± 22.022	0.635
Recreational Players	72.224 ± 25.39	71.333 ± 19.09	75.005 ± 20.49	0.374
p-value between groups	0.089	0.436	0.837	0.787

Note: LDH (lactate dehydrogenase); GPX (glutatthione peroxidase); CRP (C-reactive protein).

The blood CRP level before exercising showed higher in PA than RP group. However, after playing basketball and resting for about 1 hour and 24 hours, CRP levels in PA decreased. In contrast, in the RP group, CRP levels increased after physical activity and remained high up to 24 hours later.

This study used blood F2-isoprostane as a marker of oxidative stress effect and blood GPX as a marker of antioxidant capacity. The results revealed that the RP group had higher F2-isoprostane concentrations before basketball exercise, but decreased 1 hour after basketball exercise and did not differ significantly after 24 hours. Before exercise, the PA group showed higher GPX activity indicating better antioxidant capacity. After basketball, both groups experienced a significant decrease in GPX activity, especially in the PA group. This decrease indicated an increase in oxidative stress due to the intensity of exercise. Interestingly, within 24 hours after exercise, GPX activity in both groups increased again and approached baseline values, suggesting an antioxidant recovery mechanism in the body.

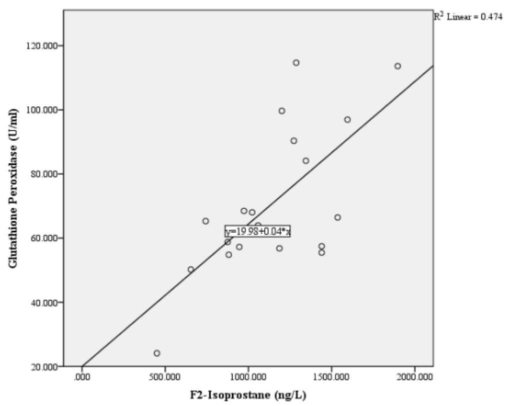
Figure 2. The level changes of blood markers of oxidative stress, inflammation, and muscle damage



There was no significant different between groups and within group (p≥0.05).

The relationship between antioxidants and free radicals is illustrated in Figure 3. The straight line on the graph represents a linear regression model where the changes value of blood F2-isoprostane affected the value of blood GPX level. The R-squared value of 0.474 indicates that about 47.4% of the variation in GPX can be explained by changes in F2-isoprostane. The regression line equation y=19.98 + 0.04x presumed that every one unit increase in F2-isoprostane predicted to increase GPX up to 20.02 ng/L (Figure 3).

Figure 3. Relationship between antioxidants and free radicals 1 hour after basketball exercise



Discussion

This study aims to analyze the differences of antioxidants and free radical balance/ imbalance effect, inflammatory, and muscle damage markers between professional basketball athletes and recreational basketball players.

Lactate Dehydrogenase (LDH)

The lactate dehydrogenase (LDH) is an enzyme that converts pyruvate to lactate, and nicotinamide adenine dinucleotide (NADH) to nicotinamide adenine dinucleotide (NAD). Therefore, LDH has a dominant role when there is an anaerobic metabolism condition. Normally, LDH concentration should not reach 200 U/L (Zhou et al., 2022).

Within group, the results of the overall analysis showed no significant interaction by time and group of the blood LDH test results. Pyruvate and lactate are the fuel sources for skeletal muscles, especially during anaerobic dominant exercise. Pyruvate is mainly produced from the process of glycolysis, where pyruvate is used in the mitochondrial TCA cycle to produce ATP in aerobic metabolism, or used for lactate production in aerobic metabolism. In addition, pyruvate can also be generated through lactate oxidation, where physical exercise is known to increase lactate oxidation in skeletal muscle. As mentioned above, the enzyme that regulates the interconversion between pyruvate and lactate is LDH, which plays an important role in maintaining the homeostatic balance of pyruvate and lactate in the cell (Liang et al., 2016). Therefore, LDH enzyme activity in serum is a biochemical marker for muscle damage that can lead to decreased physical performance (Martínez et al., 2022).

Studies about LDH response to exercise have shown inconsistent results. Resistance and aerobic exercise can increase LDH levels immediately post-exercise, and the response may vary between individuals (Callegari et al., 2017). Based on a study conducted by Callegari et al. (2017) resistance training increases LDH levels greater than aerobic exercise at 60% and 80% VO2max. Logically, the resistance exercise will increase LDH more than aerobic exercise, since resistance exercise may have a dominant in aerobic state.

The LDH pattern at 24 hours after the match in the PA group showed an increase insignificantly. This was because of the athletes' tight training schedule, therefore, even though they had been given previous instructions not to do physical exercise after the match, it was difficult to control them, because they were used to training more than once a day.

C-reactive protein (CRP)

C-reactive protein (CRP) is a predominantly hepatically synthesized protein and secreted in response to cytokine signaling as physiological reaction of acute proinflammatory response (Olson et al., 2023). In several cases, certain exercise can lead to inflammatory the condition (Kurniawati et al., 2024).

The results of blood CRP in this study revealed that 24 hours after basketball exercise of PA group decreased, while the CRP of RP group slightly increased, insignificantly. The study conducted by (Bazgir et al., 2015) reported that exercise caused an increase in CRP levels in non-athletes, while CRP levels decreased significantly after exercise in athlete subjects. Other meta-analysis study found that exercise training generally decreased CRP, especially when accompanied by weight loss (Fedewa et al., 2017). These findings suggest that the relationship between exercise and CRP may depend on several factors, such as fitness level, type of exercise, and individual characteristics. Higher levels of physical activity and cardiorespiratory fitness are consistently associated with a 6-35% reduction in blood CRP levels. Studies on long-term exercise showing reduced CRP concentrations range from 16% to 41% (Plaisance & Grandjean, 2006).

Intense exercise increases the inflammatory response characterized by leukocyte mobilization and an increase in circulating inflammatory mediators produced by immune cells and directly from active muscle tissue. CRP levels were reported to increase 30 minutes after exercise with a significant increase at 24 hours after exercise (Cerqueira et al., 2020). This condition is similar with our result, which the RP group who had a maximum intensity based on their HRmax during basketball games, small increased in blood CRP level in 1 hour and 24 hours after exercise. However, it differed with PA group who might have a better physiological response. Similar to LDH, the 24 hours after the game, CRP level in PA group also increase insignificantly.

F2-isoprostane (F2-IsoPs) and Glutathione Peroxidase (GPX)

Oxidative stress is an imbalance of oxidant (free radical)-antioxidant or redox system imbalance, leading to molecular damage. The primary target of it is polyunsaturated fatty acids (PUFAs), and it causes lipid peroxidation. Several early markers for lipid peroxidation are thiobarbituric acid-reactive substance

(TBARS), malondialdehyde (MDA), and lipid hydroperoxides (LOOHs, which are said to be ineffective because of relatively instable. In 1991, F2-isoprostanes (F2-IsoPs) were discovered and it has better quality as a lipid peroxidation compared to TBARS, MDA, and LOOHs (Milne, 2017).

Glutathione peroxidase (GPX) is the most prominent family of proteins which act as antioxidant enzymes that affect cellular signaling. GPX, superoxide dismutase, and catalase work as an enzymatic antioxidant system. They reduce reactive oxygen species (ROS) which trigger oxidative stress (Pei et al., 2023).

In this study, the effect of oxidative stress on lipid peroxidation was analyzed through blood F2-IsoPs levels, and antioxidants were analyzed through glutathione peroxidase (GPX) levels. However, the limitation of this study, superoxide dismutase, and catalase were not measured. The study conducted by Zare et al., (2023) also showed that athletes have low F2-IsoPs compared to non-athletes. In addition, it is known that maximal exercise induces a large variability in oxidative stress biomarkers such as F2-IsoPs, protein carbonyls, and GPX between individuals. In contrast to the study handled by Hajizadeh Maleki et al. (2013) where active men had low levels of free radicals and high antioxidants compared to elite athletes and inactive men.

Professional athletes appeared characteristic changes in pro- and antioxidant systems, indicating heterogeneous shifts in oxidative metabolism (Karuzin et al., 2018). During intense exercise, super oxide and other free radicals are formed, leading to muscle damage. Muscle mitochondria release super oxide during metabolism to produce ATP, which triggers oxidative stress. Increasing endogenous antioxidants during physical activity can prevent oxidative stress and cell damage. Physical activity can cause muscle damage and increased oxidative stress due to the production of free radicals that are out of balance with endogenous antioxidants enzymes, which consist of SOD, CAT, GPX, GSSH. GPX provides defense against ROS produced during high-intensity physical activity and it is known that GPX activity increases in response to physical activity in studies conducted in humans and animals (Leeuwenburgh & Heinecke, 2012).

Antioxidant markers-free radicals, inflammation, and muscle damage in athletes and recreational basketball players can be influenced by the exercise performed routinely. In the same type of exercise, when compared between athletes and non-athletes have different biochemical responses. Future research needs to analyze other biomarkers that mediate muscle damage, inflammation, antioxidant balance and free radicals. Further research also needs to analyze the differences in physiological responses according to the position of players in basketball matches. Training protocols using a treadmill or ergocycle with a certain intensity may be carried out in future studies on professional basketball athletes and recreational basketball players.

The limitations of study

Some imperfections of the study include unrandomized subjects due to the category of subjects, professional athletes and recreational players were recruited. Several subjects, especially athletes related to this study's procedure, because of their tight schedule, were hard to control which may lead to inconsistent pattern of blood markers level 24 hours after the game. The blood markers for muscle damage, inflammatory response, and stress oxidative effect also need to be explored with different markers.

Conclusions

This study concluded, based on heart rate, professional athletes have better cardiovascular endurance compared to recreational players. However, after 1 hour of the game, LDH, CRP, and F2-IsoPs and GPX seem similar in both groups. The changes of the blood markers time by time for professional athletes and recreational players also present similar patterns. It indicates that recreational players have a good benefit as active people. Even though, the level trend of the markers in professional athletes is superior to recreational players. Nevertheless, the level trend of 24 hours after the game has been inconsistent especially among athletes. Therefore, further investigation is still needed to figure out the physiological response mechanism with more complete markers and the effect of prolong training.

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