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CHANGES IN MUSCLE DAMAGE MARKERS IN FEMALE BASKETBALL PLAYERS

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ABSTRACT: The aim of the present study was to investigate changes in muscle soreness, blood muscle damage markers, muscle strength and agility following an official basketball match. Eleven elite female professional basketball players (27.4 ± 4.8 years, 179.5 ± 5.5 cm, 72.0 ± 7.8 kg) of a team participated in this study. The official match was the seventh match of the season in the first phase of the Brazilian National Female Basketball Championship. Muscle soreness, plasma creatine kinase activity (CK), and myoglobin concentration (Mb) were determined before and after the match (post-match, 24 and 48 hours after the match). The 1RM strength for bench press and leg press, and the agility T test were assessed before and at 24 and 48 hours after the match. Significant increases in muscle soreness, CK and Mb were observed at 24 and 48 hours post-match ($p<0.05$). No significant changes in the 1RM strength and T test were detected during recovery (24 and 48 hours after the match). These results suggest that a basketball match induced limited muscle damage with minimal effect on performance during recovery. The small increase in muscle damage markers following a basketball match did not affect strength and agility performance.

KEY WORDS: creatine kinase, myoglobin, muscle soreness, muscle strength, basketball

INTRODUCTION

Basketball is one of the most popular sports in the world. In the last decades, the number of matches performed during a season increased. For instance, the Women's National Basketball Association (WNBA) began in 1997 with 28 matches in a regular season but increased to 34 matches during a 4-month season, and 43 matches including the play-offs. Since 2006, the National Basketball Association (NBA) teams in the USA have played 82 matches in a regular season, and the number of matches that a team could possibly play in a season, including the play-offs, is 110 matches. This means that professional basketball players have an official match every 3 days, resulting in a short recovery time between matches. Furthermore, the physical demands of a match also increased in the past decades [2]. Even though it is important to understand the effect of an official match on physiological parameters indicating muscle damage and recovery, the information available at present is scarce.

It is well documented that eccentric muscle contractions induce muscle damage, especially when performed in an unconditioned state [3,13]. A basketball match consists of repetitive high-intensity actions and changes of direction, and repetitive jumps such as blocking and rebounding [2,9,21]. It seems reasonable to assume that these basketball manoeuvres impose an eccentric load on the lower limb muscles, inducing muscle damage.

A previous study reported muscle damage in basketball [6]. In this study, untrained individuals reporting elevated anterior compartment pressure (n=24) and healthy individuals who recreationally played basketball (n=24) performed a 10-minute session consisting of passes, shorts sprints, dribbles and jump shots. Both groups showed significant increase in plasma creatine kinase (CK) activity and myoglobin (Mb) concentration, decrease in squat strength assessed by one repetition maximal (1RM) test, and increase in muscle soreness 24-96 hours after the exercise. These changes were significantly greater for the chronic anterior compartment syndrome group compared with healthy individuals. However, no previous study has investigated professional basketball players for their muscle damage profile and recovery from a basketball official match.

As highlighted before, professional basketball players have at least two matches a week during a regular season with some training sessions in between. It is possible that the frequent exposure of lower limb muscles to eccentric loads has provided a protective effect on muscle damage, since it has been well documented that muscles become more resilient to exercise induced muscle damage with repeated exposure to eccentric contractions [8,12]. Therefore, the aim of the present study was to investigate the effect of an official basketball match on muscle damage parameters and performance of professional female basketball players. It was hypothesized that a match would not cause severe muscle damage and the players could recover from the match in a couple of days.

MATERIALS AND METHODS

Subjects. Eleven elite female professional basketball players (27.4 ± 4.8 years, 179.5 ± 5.5 cm, and 72.0 ± 7.8 kg) who were in the same professional team that won the 2009 Sao Paulo State Championship and 2009 Brazilian National Championship and 2009 South American Championship volunteered for this study. All players had at least 5 years of experience in the level of their play and had been performing 10-12 training sessions per week, consisting of strength and power training, as well as skill, speed and anaerobic fitness training. Five healthy physically active females volunteered to compose the control group (21.4 ± 2.5 years, 165.2 ± 4.5 cm, and 53.0 ± 5.8 kg). The control group was instructed to avoid all exercise practices during the study. Each participant was screened for musculoskeletal, neurological, and shoulder and elbow joint problems, and was informed of the experimental risks and purpose of the study, and signed an informed consent form prior to the investigation. The investigation was approved by an Institutional Ethical Review Board.

Procedures

The official match took place in the regular season of the Brazilian National Female Basketball Championship, and was the seventh match of the first season that consisted of 21 matches including playoffs. Session rating of perceived effort (RPE) was assessed at 30 minutes following the match, and the players were asked to rate their perceived exertion for the entire match answering the question "How was your workout?" using Borg's CR-10 scale [6]. Heart rate (HR) was monitored and recorded at 5 s intervals during the match using a HR monitor (Polar Team System©, Polar Electro, Kempele, Finland). Maximum HR (HR_{max}) was determined prior to the match during a laboratory-based maximal oxygen consumption test. The HR data were categorised into five HR zones – zone 1 = 50-59% HR_{max}, zone 2 = 60-69% HR_{max}, zone 3 = 70-79% HR_{max} , zone 4 = 80- 89% HR_{max}, zone 5 = 90-100% HR_{max} – using the Polar Team System software© (Polar Electro, Kempele, Finland). The match playing time of each player was provided by the Brazilian Basketball Federation.

Muscle soreness upon palpation and stretching of the hamstring muscles were assessed using a visual analogue scale (VAS) of a 100 mm line with "no pain" on one side and "extremely sore" on the other [19]. The players were asked to mark the level of pain on the scale when the investigator applied pressure to the medial part of the hamstrings with the tips of 3 fingers (2nd, 3rd, and 4th) for approximately 3 seconds (palpation). For the hamstring stretching, the players sat on the floor with both legs straight with their toes pointing straight up, and leaned forward from their hips as much as possible for 3 seconds. They were asked to record the maximal pain that they felt during the stretching.

Blood samples were obtained from the antecubital vein before (pre), immediately after (post), 24 and 48 hours after the match. using 5-mL vacutainer tubes (Becton Dickinson©, USA), one containing EDTA for plasma and another for serum. The blood samples were centrifuged at 2500 rpm for 15 min at 4°C. Plasma and serum samples were frozen and stored at -80°C until analyses. Plasma CK activity was measured by a spectrophotometric assay using a test kit (CK, Labtest©, Brazil). Serum Mb concentration was determined by enzyme-linked immunosorbent assay using a commercially available kit (Myoglobin, MP Biomedicals©, USA). The normal reference ranges were 25-140 $IU \cdot L^{-1}$ for CK and 12-100 $ng \cdot mL^{-1}$ for Mb according to the manufacturer's guidelines.

The performance tests (1RM and T test) were conducted before, 24 and 48 hours after the match. After a warm-up exercise consisting of 10 repetitions using a light weight (40%-1RM), 5 repetitions using a moderate weight (60%-1RM), and 2 repetitions using a heavy weight (80%-1RM) based on the previous 1RM test records, the players were tested for the 1RM strength for bench press followed 2 days later by leg press. The 1RM was determined by a protocol of single repetition to failure, in which the load was gradually increased in the subsequent attempts by 5-10% for the bench press and 10-20% for the leg press separated by a 3-minute rest [1]. Using the values of the two baseline measures taken one week apart, the intra-class correlation coefficient (R) and coefficient variation (CV) were calculated; R was 0.96 and CV was 2.1%.

According to the protocol outlined by Semenick [14], each player started with both of her feet behind the starting point and, after a sound signal, sprinted forward for 10 m to touch the first cone, ran another 5 m to the left to touch the second cone, shuffled for 10 m to the right to touch the third cone, followed by a 5 m run to the left to the first cone, and ran 10 m backward passing the finish-line at the starting point (total distance = 40 m). Two electronic time sensors (Photo-cell system, SPEED TEST 6.0©, Cefise©, Brazil) were set at the starting line 0.75 m from the floor and 3 m apart. The clock started when a participant passed the electronic sensors after the start, and stopped when the players crossed the line at the end. Each participant performed three sprints with 3 minutes of rest between each sprint and the best time of the three was used for further analysis. The reliability of the test was determined using the two baseline values measured one week apart. The intra-class correlation coefficient R was 0.95, and CV was 2.4%.

Statistical analyses

A one-way repeated measures analysis of variance (ANOVA) was used to analyse the changes in the dependent variables over time (1RM test and T test). A two-way repeated measures analysis of variance (ANOVA) was used to analyse the changes between groups over time (muscle soreness, CK activity and Myo concentration). A Tukey post-hoc test was performed for multiple comparisons, when a significant time effect was found. Significance level was set at $p<0.05$. All of the results are reported as mean ± SD.

RESULTS

As shown in Table 1, playing time varied among the players, and so did the session RPE. The average RPE was 4.0 ± 1.4, which was a moderate effort according to the category described by Foster et al. [6]. The time spent in each heart rate zone was 27.3 ± 24.8% for zone 1 (50-59% HR_{max}), 14.7 ± 5.1% for zone 2 (60-69% HR_{max}), 17.5 ± 9.6% for zone 3 (70-79% HR_{max}), 21.2 ± 10.4% for zone 4 (80-89% HR_{max}), and 19.3 ± 9.6% for zone 5 (90-100% HR_{max}).

Figure 1A shows changes in muscle soreness of the hamstring muscles upon stretching. Muscle soreness increased at 24 and 48 hours after the match (P<0.05) when compared to the control group. A similar pattern of responses was observed for the palpation assessment. As shown in Table 1, the magnitude of increase in muscle soreness varied among the participants, but no one had moderate-severe muscle soreness.

Blood markers of muscle damage increased after the match (CK at 24hours and Mb at 24 and 48 hours; P<0.05) when compared to the control group (Figure 1B and 1C). As shown in Table 1, the magnitude of changes in plasma CK activity and Mb concentration varied among the participants, but none of them showed a large increase.

No significant changes in 1RM and T test were observed after the match. None of the player showed significant decrease in 1RM and T test (Table 1).

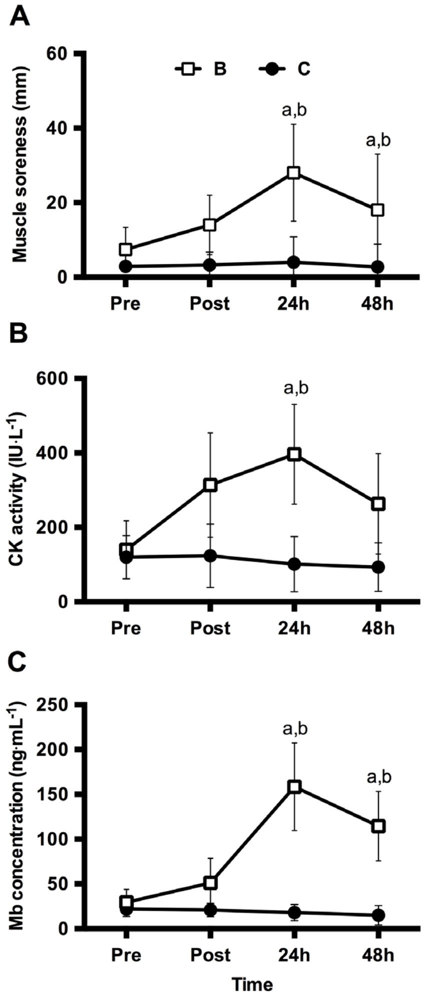

FIG. 1. CHANGES (MEAN ± SD) IN MUSCLE SORENESS OF THE HAMSTRING (1A), PLASMA CK ACTIVITY (1B), AND SERUM MYOGLOBIN CONCENTRATION (1C) BEFORE (PRE), IMMEDIATELY AFTER (POST), AND 24 AND 48 HOURS FOLLOWING THE BASKETBALL MATCH.
Note: [a] - indicates a significant (P<0.05) difference from the pre-match value. [b] - indicates a significant (P<0.05) difference from the control group [C]. White square - Basketball team [B] . Black circle - Control group [C].

TABLE 1. PLAYING TIME (TIME), SESSION RATING OF PERCEIVED EXERTION (RPE), CHANGES (PEAK VALUES – PRE-MATCH VALUE) IN PLASMA CK ACTIVITY (ΔCK), SERUM MYOGLOBIN CONCENTRATION (ΔMb), MUSCLE SORENESS OF THE HAMSTRINGS (ΔHS) AND PECTORALIS MAJOR (ΔPM), AND RELATIVE CHANGES (24 H POST MATCH / PRE-MATCH X 100) IN 1RM STRENGTH OF LEG PRESS (LP) BENCH PRESS, AND T TEST TIME FOR THE 11 PLAYERS WITH THE INFORMATION ABOUT THEIR POSITIONS.

	Time (min)	RPE (0-10)	ΔCK $IU \cdot L^{-1}$	ΔMb $ng \cdot mL^{-1}$	ΔHS (mm)	ΔPM (mm)	1RM-LP (%)	1RM-BP (%)	T test (%)
1-Guard	18	3	82.5	25.1	22	16	-4.5	5.3	-0.2
2-Guard	20	3	160.3	166.3	33	6	-3.8	0.0	0.7
3-Centre	4	3	205.7	75.8	13	7	8.0	0.0	-4.3
4-Centre	18	6	297.6	46.1	17	10	0.0	0.0	-1.9
5-Centre	20	4	548.4	230.2	29	20	0.0	-13.0	-0.5
6-Centre	25	7	587.7	301.6	37	6	-2.4	0.0	4.0
7-Centre	17	4	147.1	122.5	5	12	7.0	0.0	-3.8
8-Forward	6	2	10.7	39.0	9	8	2.4	0.0	-2.8
9-Forward	22	4	29.3	66.9	2	0	-4.3	0.0	-2.3
10-Forward	20	4	65.6	83.3	18	15	0.0	4.0	-2.5
11-Forward	30	4.5	211.1	127.6	43	22	-12.0	5.7	1.7
Mean	18.2	4.0	213.3	116.8	20.7	11.5	-0.9	0.2	-1.1
SD	7.5	1.5	195.1	86.2	13.4	6.4	5.6	5.0	2.5

DISCUSSION

Data from this study indicate that an official basketball match induced minor muscle soreness and small increase in muscle proteins in the blood after the match, but no significant changes in 1RM strength and agility. These results support the initial hypothesis that muscle damage would be minimal for the professional players and they would recover within 2 days after a match.

Many studies have reported that eccentric exercise especially when it is performed by untrained individuals for the first time results in muscle damage characterized by delayed onset muscle soreness, prolonged strength loss, and increased muscle proteins in the blood [3,13]. However, little is known about muscle damage in trained individuals and athletes. Newton et al. [10] reported that resistance-trained individuals showed significantly smaller changes in muscle damage markers and faster recovery of muscle function compared with untrained individuals when they were exposed to "unaccustomed" maximal eccentric exercise of the elbow flexors. The present study is the first to investigate muscle damage after an official basketball match using top-level professional female basketball players.

As shown in Table 1, muscle soreness was minor or mild for all players (the largest increase was 43 mm for Player 11). Kostopoulos et al. [7] reported a greater increase in muscle soreness (59 mm) using the same scale as that of the present study when untrained men performed a shorter (10 min) simulated basketball exercise. In the present study, muscle soreness was assessed only for the hamstrings and pectoralis major; however, the players did not indicate muscle soreness of other muscles and they reported that muscle soreness of the hamstrings was most prominent. The hamstrings perform eccentric contractions when slowing hip flexion and knee extension especially during the landing phase to decelerate the centre of mass [20]. The hamstrings are stretched maximally during the late swing phase of sprinting before foot contact [16,17]. The repeated movements consisting of these muscle contractions in the basketball match seem to be associated with the muscle soreness of the hamstrings.

The small increase in plasma CK activity and serum Mb concentration also indicate that muscle fibre damage was minimal. The mean CK activity and Mb concentration were 213 $IU \cdot L^{-1}$ and 116 $ng \cdot mL^{-1}$, respectively, in the present study (Table 1). In contrast, Kostopoulos et al. [7] reported greater peak CK activity (720.8 ± 194.1 $IU \cdot L^{-1}$) and peak Mb concentration (970.3 ± 183.8 $ng \cdot mL^{-1}$) after a simulated basketball game performed by untrained participants [7]. The small changes in the blood markers of muscle damage (i.e. CK and Mb) and muscle soreness after the match suggest that professional basketball players are resilient to exercise-induced muscle damage. This is likely due to their previous participation in training and matches. It is known that exposure of lower limb muscles to eccentric loads attenuates the magnitude of muscle damage as a result of the repeated bout effect even for untrained individuals [11]. However, if a match is more competitive, greater muscle damage may be induced and recovery could take longer, which could affect performance in subsequent matches and training sessions.

It is also important to note that the match investigated in the present study was the seventh game of the season for the team, and the team won the match by 30 points. As indicated by the moderate session RPE and the distribution of time spent in the high intensity heart rate zones (30% in the zones 4 and 5), it does not appear that the match was very strenuous for the players. The playing time analysis also suggests that the match was not highly competitive to keep the main players most of the time in the court. It is possible that greater changes in muscle damage markers are observed if a match is more competitive and players are forced to play at higher intensity.

There were no changes in 1RM strength and agility after the match. Tofas et al. [18] reported no changes in peak torque of knee extensors and knee flexors after an intense bout of plyometric jumps performed by untrained men, and they stated that the magnitude of muscle damage was not large enough to affect muscle performance [18]. It seems that the basketball match in the present study did not induce muscle damage that impairs muscle function and performance. As shown in Table 1, the players who had a shorter playing time (e.g. Players 3 and 8) showed minimal responses in the measures, but the players who had a longer playing time (e.g. Players 6 and 11) showed decreases in 1RM strength and agility at 1-2 days after the match. Thus, it is possible that greater and longer lasting decreases in muscle strength and agility are observed if a match requires longer playing time at high intensity. Since the present study investigated only 1RM of squat and bench press and agility, it is not possible to ensure that the players were fully recovered within 48 hours after the match. However, it appears that the players could play another match without compromising their performance after two days of recovery.

Data collected in other sports such as rugby or soccer using professional players showed greater magnitude of muscle damage as compared to basketball in the present study. For instance, Fatouros et al. [5] reported that peak CK activity was close to 900 $IU \cdot L^{-1}$ at 48 hours after a soccer match, the extent of muscle soreness was severe (mean score of ~8 in the 10 VAS scale), and 20-m sprint performance and maximal jump ability decreased significantly at 24 hours after a match played by elite young soccer players [5]. It may be that the longer playing time and larger court area in the soccer match induce greater muscle damage compared with basketball. It is also possible that the level of physical contact is associated with the greater magnitude of muscle damage observed in soccer and rugby compared with basketball. Cunniffe et al. [4] have reported a large increase in plasma CK activity (1182 ± 231 $IU \cdot L^{-1}$) after a rugby match played by highly trained athletes [4]. Takarada et al. [15] also reported high peak CK activity (~1000 $IU \cdot L^{-1}$) and peak myoglobin (~1000 $ug \cdot L^{-1}$) concentration after a rugby match played by amateur rugby players, and found a positive correlation in the number of tackles during a rugby match and the increase in CK activity (r = 0.99) [15]. It appears that there is less muscle damage due to physical contact in basketball than in soccer and rugby.

CONCLUSIONS

In conclusion, the results of the present study suggest that a basketball match induced limited muscle damage with minimal effect on performance during recovery. The small magnitude of muscle damage following a basketball match did not affect strength and agility performance.

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