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The influence of a badminton competition with two matches in a day on muscle damage and physical performance in elite junior badminton players

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ABSTRACT: To investigate the effects of a badminton competition with 2 matches in a day on hip strength and range of motion (ROM) and exercise-induced muscle damage in elite junior badminton players. Twenty players (age: 17±0.8 years; body mass: 62.9±6.5 kg, height: 173.8±8.9 cm) participated in this study. Passive hip internal (IR) and external rotation (ER), abduction (ABD) and adduction (ADD) hip ROM, isometric hip ADD and ABD muscle strength, countermovement vertical jump (CMJ) height and blood creatine kinase concentration (CK) were measured before and after a badminton competition during an international tournament. Blood samples were collected 24 h after the end of the last match. Compared to baseline values, hip IR and ER ROM were significantly decreased at post-competition in the dominant (IR=-9.0%; p=0.007 and ER=-15.2%; p=0.002) and non-dominant limbs (IR=-9.08%; p=0.004 and ER=-19.4%; p<0.001). In contrast, hip ADD (13.5%; p<0.001) and ABD (14.6%; p<0.001) strength increased significantly after the competition in the dominant limb and ABD strength increased significantly in the non-dominant limb (9.2%; p=0.001). From baseline values, CK increased after the competition (430.1%) and values remained elevated over baseline values 24 h later (160.4%). Although hip muscle strength increased, a badminton competition with two consecutive matches reduced hip ROM and increased blood CK concentration. This study suggests the necessity of investigating recovery strategies after a badminton competition to return hip ROM to basal values before the next day of the competition.

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INTRODUCTION

Badminton is an intermittent sport which places high physical neuromuscular demands on the lower limbs [1], represented by the continuous repetitions of short bursts of high intensity, including jumps and changes of direction, interspersed with recovery periods between rallies [2]. As a result of the demands induced by the continuous practice and play of badminton, players might be susceptible to a range of injuries [3]. In this regard, previous research has shown an injury incidence of 0.9 to 5.04 injuries per 1000 h of play [4,5]. Interestingly, 63 to 69% of the injuries reported in badminton players were located in the lower limbs [2,6]. Among lower limb injuries, groin injuries (defined as groin or hip adductor muscle strain, tenderness on palpation of the hip adductor or flexor muscles, adductor bone-tendon junction or pubic symphysis and/or pain during a resisted hip adduction test [7]) are among the most problematic for badminton players because of their tendency to become recurrent [5]. Consequently, the identification of risk factors that might predispose a player to groin injury seems to be an essential task to design strengthening training programmes [7].

Some aspects related to lower limbs muscle strength deficits and decreased range of motion (ROM) have been associated with a higher likelihood of sustaining a sport injury. Among them, isometric adduction (ADD) muscle weakness [8–10], adductor/abductor (ADD/ABD) strength imbalance [8], and decreased hip abduction [8] and reduced internal rotation (IR) ROM [11,12] have been proposed as risk factors for groin injury in several sports (e.g., tennis, soccer, ice hockey, rugby or Australian football). Furthermore, it has been reported that the combination of more than one risk factor increases the probability of a groin injury [9]. Thus, assessment of muscle imbalances, compromised levels of flexibility and strength deficits, and anatomic abnormalities seem to be essential to evaluate the probability of injury in this sport [5].

Exercise-induced muscle damage is a common occurrence following activities with a high eccentric component [13]. In badminton, several game-specific actions contain a muscle eccentric component, such as smashes, repetitive lunges and intense shuttle runs during badminton play [14]. Specifically, decelerations and stoppages after sprints, or during landing after a smash, might induce damage to leg muscles [15]. Different symptoms accompany muscle damage, including muscle soreness, increased plasma levels of muscle proteins, swelling, inflammation, and impairment of muscle function [16,17]. Moreover, an important performance-related factor for racket sports is the reported negative effect of exercise-induced muscle damage on the ability to generate rapid force [18,19]. In this regard, a progressive reduction in maximal voluntary force together with an increase in indirect markers of muscle damage such as serum creatine kinase (CK) concentration [20] has been previously reported in other racket sports (e.g., throughout prolonged or consecutive tennis matches) [21–23]. In badminton, a previous study revealed moderate-to-high levels of exercise-muscle damage after a 45-min simulated badminton match, but this event was not associated with decreased muscle performance (measured by means of a specific footwork test, a maximal isometric force test, and the agility T-test [1]). In contrast, a 60-min simulated badminton match reduced the capacity to jump and the maximum hand- and finger-grip strength [24], although no muscle damage variable was obtained in this investigation [24]. These studies investigated the outcomes of only one badminton match and, taken together, they suggest that the duration of the badminton play might have an impact on muscle performance. This is particularly interesting because badminton competitions are composed of multiple draws (singles, doubles and mixed doubles) and training demands require elite badminton players to often complete numerous competitive matches on the same day [25,26].

Thus, the aim of the current study was to investigate the impact of an actual badminton competition with two competitive matches in a day on hip strength and ROM, and on exercise-induced muscle damage in elite junior badminton players. We hypothesised that the muscle damage levels would be associated with lower limb strength and ROM reductions.

MATERIALS AND METHODS

Subjects

Twenty young elite badminton players (age: 17.0±0.8 years, body mass: 62.9±6.5 kg, height: 173.8±8.9 cm) volunteered to participate in the study. Sixteen (80%) players presented right lower-limb dominance and four (20%) had the opposite dominance. The dominant limb was determined according to the definition of Thorborg et al. [27], who defined the preferred leg for kicking a ball as the dominant limb. The players were categorised as elite because they competed in international events, were ranked between the 1st and 40th position in their respective national singles ranking (U18), trained 18.4±2.8 hours per week and had badminton experience of 6.3±1.2 years. As an inclusion criterion, participants had to be free of musculoskeletal injuries and not taking dietary supplements or medication at the time of the study. Three weeks prior to the start of the investigation, all players were fully informed about the testing protocols and the purpose of the study. Written informed consent was obtained from them or their legal guardians before data collection. The institutional ethics review committee approved the procedures in accordance with the latest version of the Declaration of Helsinki. The investigation was coordinated with the Spanish Badminton Federation.

Experimental design

An observational and descriptive analysis was carried out on two consecutive days of an international badminton tournament to observe the effects of a competition with 2 matches on the same day on muscle performance and muscle damage in elite junior players. The rationale of the investigation was to provide useful and practical information for conditioning staff when planning tournament schedules, as well as preparing match and recovery strategies. For this reason, we selected an ecologically valid approach that included a real competition.

Experimental protocol

The competitive badminton matches were conducted within the XI Spanish Junior International held in Oviedo (Spain) in 2017. Each participant took part on two experimental days: the competition day and 24 h after the competition day. In the morning of the competition day, before the beginning of the matches, a battery of physical tests was performed, and a capillary blood sample was extracted (see below). This testing and blood withdrawal were replicated as soon as the players finished their competition day. Both testing trials, pre- and post-competition, were identical and were conducted in a temperate room in the indoor facility kept at 21.0±2.4ºC and 50.6±6.3% relative humidity. Between the trials, players participated in the aforementioned junior championship, including one singles match and one doubles/mixed doubles match on the same day. Due to the constraints of carrying out the experiment during a real competition, the recovery time between the first and second match varied among players, averaging 55.9±14 min. The internal load imposed by the match was measured by the session rating of perceived exertion match load (sRPE) completed after the end of each competitive match. The day after the competition, players participated in the second experimental day that consisted of a blood draw to estimate the level of muscle damage. In all cases, participants were encouraged to maintain their diet, hydration and resting competition routines. However, to reduce the interference of uncontrolled variables, all the players were lodged in a players' residence within the training facility to control meals and resting times. The participants had been previously familiarised with the measurement protocols corresponding to the maximal effort tests.

Measurements

Assessment of internal match load and muscle soreness

Self-reported internal game load was assessed using sRPE at the end of each match. For this measurement, RPE was assessed using a 1-to-10-point scale and participants were informed that a score of 0 was equivalent to how they felt when sitting in a chair and a score of 10 was equivalent to how they felt at the end of very intense exercise activity [28]. Then, RPE was multiplied by the respective match duration, thus reporting the match load (i.e., sRPE) in arbitrary units (A.U.) [29]. After the matches, subjects were also asked to rate their feelings of overall lower limb muscle soreness using a visual analogue scale (VAS). The VAS consisted of a 100 mm line whose endpoints were labelled "no pain" and "unbearable pain". Participants had to draw a vertical line at a point on the line that best represented their pain in their lower limbs at the time of measurement. The muscle soreness score was obtained by measuring the distance in centimetres from the left border of the scale to the point marked [30,31].

Assessment of exercise-induced muscle damage

A blood sample was withdrawn from each participant at three different times (pre-competition, post-competition and 24 h after the end of the last match) to assess the blood concentration of CK. Each sample consisted of 0.20 mL of capillary blood obtained by finger prick from the non-dominant hand and subsequently introduced into an EDTA Microtainer tube. Within 15 min of blood collection, 30 μL were applied to a test strip and introduced into a CK analyser (Reflotron Plus system, Roche, Madrid, Spain) for its subsequent analysis.

Hip isometric abductor (ABD) and adductor (ADD) strength.

For the measurement of maximal isometric hip ADD and ABD strength in dominant and non-dominant limbs, a handheld dynamometer (Lafayette Instrument Company, IN, USA), which was calibrated prior to each test, was used. For this measurement, the methods previously described by Thorborg et al. [32] were followed. The highest value of two attempts, for both dominant and non-dominant sides, was used in the analysis. There was a 30-second rest period between trials. One experienced examiner performed all the tests and gave standardised verbal encouragement during the effort. The intraclass correlation coefficient (ICC) measured before the experiment ranged from 0.91 to 0.97 [33].

Hip range of motion (ROM)

The passive hip IR and ER and passive hip ABD ROMs were measured at 90° of hip flexion of the dominant and non-dominant limbs, using an inclinometer (ISOMED, Portland, Oregon) with a telescopic arm, and following methods previously described [34,35]. There was a 30-second rest period between trials, limbs and tests. Based on previous studies [34,35] one or both of the following criteria determined the endpoint for each test: (a) palpable onset of pelvic rotation, and/or (b) the participant feeling a strong but tolerable stretch, slightly before the occurrence of pain.

Countermovement bilateral and unilateral vertical jump (CMJ).

Bilateral and unilateral CMJs were performed on a contact-time platform (Ergojump, Finland) according to the protocol previously published by Nuñez et al. [36] During the jump, hands were held at the hips to remove the influence of the upper body on the jump. From a standing position with straight knees, players squatted down to ~90° before jumping as high as possible. Each player performed 2 maximal attempts interspersed with 45 s of passive recovery, and the highest jump was recorded and used for statistical analysis. The ICC for this test ranged from 0.94 to 0.96 [33].

Statistical analysis

The distribution of raw data sets was checked using the Kolmogorov–Smirnov test and demonstrated that all data had a normal distribution ($p>0.05$). Paired-samples t-tests were performed to assess pre-to-post competition differences for each dependent variable using the SPSS software package version 22.0. (SPSS, Inc., Chicago, IL). Effect sizes were calculated and interpreted according to the following ranges: <0.2, trivial; 0.2–0.6, small; 0.6–1.2, moderate; 1.2–2.0, large; 2.0–4.0, very large and; >4.0, extremely large [37].

RESULTS

Internal match load and markers of exercise muscle damage

Average match duration was 27.1±5.6 min. The pre-match and

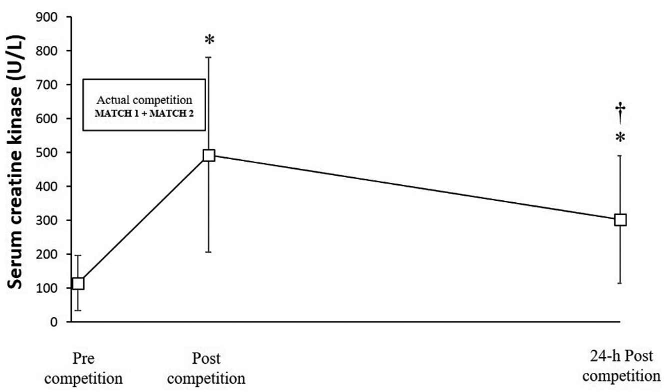

FIG. 1. Blood creatine kinase concentration pre-competition, post-competition, and 24 h after the competition in elite junior players. The badminton competition consisted of two matches in a day. Smallest significant standardised effect threshold is set as 0.2 multiplied by the pooled SD.
* Significantly different from pre-competition values ($p<0.001$)
† Significantly different from post-competition values ($p<0.001$)

post-match results are reported for descriptive purposes in Table 1. No significant differences were observed between the first and second match for the internal match load in sRPE (148.6±66.0 vs. 156.6±74.8 A.U.; p=0.60; ES=0.10) or for muscle soreness (2.8±2.4 vs 3.2±2.1 cm; p=0.63; ES=0.17). However, post-competition concentration of blood CK (493.3±287.1 U/L) was significantly higher than baseline (114.7±81.3 U/L; p<0.001; E=1.72) although it was then reduced 24 hours after the competition (302.1±188.4 U/L; p<0.001; ES=1.24 Figure 1).

Hip isometric strength and hip ROM

The pre-match and post-match results for hip isometric strength and hip ROM are reported in Table 1. The results showed a significantly higher value for both ADD (140.3±29.3 vs. 159.3±35.1 N; p<0.001; ES=0.56) and ABD (131.0±18.0 vs. 150.1±26.6 N; p<0.001; ES=0.80) strength in the dominant limb, in the post-competition compared with the pre-competition measurements. However, only isometric ABD strength in the non-dominant limb showed a significant increase post-competition (135.4±23.7 vs.

TABLE 1. Descriptive statistics and inferences across match-play for all the variables obtained in this investigation. Data are presented as mean±SD

Variables	Pre-competition (Mean±SD)	Post-competition (Mean±SD)	Mean differences	95%CI for mean differences	*p*	ES [95% CI]
Strength ADD $_{ABS}$ D (N)	140.3 ± 29.3	159.3 ± 35.1	19.0 ± 17.0	11.0 to 27.0	<0.001	0.56 [-0.1 to 1.2]
Strength ADD $_{ABS}$ ND (N)	143.2 ± 33.7	149.0 ± 43.3	5.8 ± 25.9	-6.3 to 17.9	0.329	0.14 [-0.5 to 0.8]
Strength ABD $_{ABS}$ D (N)	131.0 ± 18.0	150.1 ± 26.6	19.1 ± 20.4	9.6 to 28.7	<0.001	0.80 [0.2 to 1.5]
Strength ABD $_{ABS}$ ND (N)	135.4 ± 23.7	149.1 ± 24.5	13.6 ± 14.9	6.7 to 20.6	0.001	0.54 [-0.1 to 1.2]
Ratio ADD/ABD $_{REL}$ D (N/kg)	1.1 ± 0.2	1.1 ± 0.1	-0.01 ± 0.2	-0.1 to 0.1	0.773	-0.06 [-0.7 to 0.5]
Ratio ADD/ABD $_{REL}$ ND (N/kg)	1.0 ± 0.2	1.0 ± 0.2	-0.04 ± 0.2	-0.2 to 0.1	0.396	-0.16 [-0.8 to 0.5]
HIP IR ROM D (º)	54.3 ± 8.9	49.4 ± 6.7	-4.9 ± 7.3	-8.3 to -1.5	0.007	-0.58 [-1.3 to 0.1]
HIP IR ROM ND (º)	55.5 ± 9.7	50.0 ± 10.2	-5.4 ± 7.3	-8.9 to -2.0	0.004	-0.52 [-1.2 to 0.1]
HIP ER ROM D (º)	63.4 ± 9.4	53.8 ± 12.0	-9.6 ± 11.9	-15.2 to -4.1	0.002	-0.86 [-1.6 to -0.2]
HIP ER ROM ND (º)	64.3 ± 7.8	51.8 ± 9.2	-12.5 ± 12.4	-18.3 to -6.7	<0.001	-1.41 [-2.2 to -0.7]
HIP ABD ROM D (º)	66.1 ± 9.0	62.8 ± 9.6	-3.3 ± 8.1	-7.1 to 0.5	0.083	-0.34 [-1.0 to 0.3]
HIP ABD ROM ND (º)	63.0 ± 10.9	65.3 ± 8.6	2.3 ± 5.8	-0.4 to 5.0	0.090	0.22 [-0.4 to 0.9]
CMJ BILATERAL (cm)	29.6 ± 4.8	30.1 ± 5.0	0.5 ± 2.4	-0.6 to 1.6	0.387	0.09 [-0.5 to 0.7]
CMJ UNILATERAL D (cm)	15.2 ± 3.5	15.2 ± 3.7	-0.01 ± 2.4	-1.1 to 1.1	0.992	-0.002 [-0.6 to 0.6]
CMJ UNILATERAL ND (cm)	14.2 ± 4.2	13.8 ± 3.4	-0.3 ± 1.5	-1.0 to 0.3	0.297	-0.09 [-0.7 to 0.5]
Lower leg muscle soreness (cm)	2.8 ± 2.4	3.2 ± 2.1	0.4 ± 3.7	-1.3 to 2.1	0.632	0.17 [-0.4 to 0.8]
CK pre-post (U/L)	114.7 ± 81.3	493.3 ± 287.1	378.6 ± 241.5	265.5 to 491.6	<0.001	1.72 [0.9 to 2.6]
CK pre-post24 (U/L)	114.7 ± 81.3	302.1 ± 188.4	187.4 ± 133.0	125.2 to 249.7	<0.001	1.24 [0.5 to 2.0]
CK post-post24 (U/L)	493.3 ± 287.1	302.1 ± 188.4	-191.1 ± 179.5	-275.1 to 107.1	<0.001	-0.76 [-1.4 to -0.1]

Abbreviations: SD: standard deviation; ES: effect size; CI: Confidence intervals; IR: Internal rotation; ER: External rotation; ADD: Adduction; ABD: Abduction; D: Dominant; ND: Non-dominant; ROM: Range of motion; CMJ: Countermovement Jump.

149.1±24.5 N; p=0.001; ES=0.54). No differences were found in the relative ratio of ADD/ABD strength in the dominant limb or in the non-dominant limb.

Comparing pre- to post-competition results, significant reductions were found in lower hip IR ROM, in both the dominant (54.3±8.9 vs. 49.4±6.7º; $p<0.05$; ES=-0.58) and non-dominant (55.5±9.8 vs. 50.1±10.2º; $p<0.05$; ES=-0.52) limbs. Similarly, hip ER ROM was reduced in the dominant (63.4±9.4 vs. 53.8±12.0º; $p<0.05$; ES=-0.86) and non-dominant (64.3±7.8 vs. 51.9±9.2º; $p<0.001$; ES=-1.41) limbs. However, no significant changes were observed in ABD ROM from pre- to post-competition.

Countermovement jump (CMJ)

Table 1 shows the comparison between pre- vs. post-competition values of vertical jump height. No significant differences were observed for dominant (15.2±3.5 vs 15.2±3.7; p=0.992; ES=-0.002), non-dominant (14.2±4.2 vs 13.8±3.4; p=0.297; ES=-0.09) or bilateral jumps (29.6±4.79 vs 30.1±5.0; p=0.387; ES=0.09).

DISCUSSION

The aim of this study was to investigate the effects of an actual badminton competition with two competitive matches in a day on hip strength and ROM, and on exercise-induced muscle damage in elite junior badminton players. The main findings were that two badminton matches performed on a competition day of an international tournament produced a transient increase in CK and a decrease in IR and ER hip ROM on both dominant and non-dominant sides. However, hip ADD and ABD muscle strength was higher in the dominant limb after the competition and there was no change in unilateral and bilateral vertical jumps when comparing pre-post-competition values. Together, this information suggests that lower limbs muscle performance was well maintained after competing in two badminton matches but increased joint stiffness and signs of muscle damage were identified. Despite the absence of muscle fatigue, strategies aimed at recovery of joint mobility and muscle fibre damage might be useful to prepare elite badminton players for the next competitive round.

In the present study we found serum CK concentrations similar to previous research that reported moderate-to-high levels of exercise-induced muscle damage after a simulated 45-min badminton match in elite adult badminton players [1]. These similarities in CK levels could be related to the comparable match time in both studies (e.g., 45 min vs. 2 matches ×~27 min). However, it should be noted that our study sample was composed of elite under-18 badminton players while the sample of Abian et al. [1] was composed of elite adult badminton players. In this regard, it is likely that the external load demands of adult players was higher than those of under-18 players, which might have affected the overall level of muscle damage [38]. In other words, junior badminton players underwent similar levels of muscle damage to adult players despite the probable difference in the physical demands of the game between these two types of players. A novelty of the present investigation is that CK decreased 24 h after the end of the competition although the values were still higher than at baseline (Figure 1). This would suggest that exercise-induced muscle damage, as a result of a badminton competition, is a transitory phenomenon under these circumstances, but it might progress over a tournament when the competition takes place on consecutive days with less than 24 h of recovery. Interestingly, muscle performance, measured by jumps and maximal strength tests, was maintained after the competition, which is also in line with the previously mentioned research [1]. This means that, despite the development of muscle damage during a badminton match, this damage does not negatively affect muscle performance, at least in these highly trained players. In fact, a well-maintained ability to jump has been found in previous research during a multiday competition [25,26], suggesting that physical conditioning in elite badminton allows the maintenance of muscle performance despite competition resulting in a measurable level of muscle damage.

The maintenance of lower limb muscle strength is the key to producing explosive actions during competitive badminton [39]. The present results showed improvements in hip ADD (14.62%; ~150 N) and ABD (13.54%, ~159 N) strength in the dominant limb and no differences in the non-dominant limb after the competition. Since there are no previous studies in badminton analysing hip muscle strength in badminton players, comparisons are not possible. However, these results are similar to those reported by Gallo-Salazar et al. [33], analysing young tennis players after a competition with two matches on the same day, with significant improvements in isometric hip ADD (3.3%) and ABD (1.8%) strength in the dominant limb. Although speculative, the increases observed in ADD and ABD isometric hip strength in the present study could be related to the post-activation potentiation (PAP) phenomenon, acknowledged as a short-term enhancement in muscle strength and power after performing high-intensity conditioning activities [40]. Although the existence and applicability of PAP to sport performance have been related to exercises routines performed with maximal manifestations of muscle strength and power [41], more recent investigations have also found the existence of PAP in long-lasting exercise activities performed at moderate intensity, such as endurance running [42]. Further investigations are necessary to elucidate the existence of PAP in racquet sports such as badminton and to determine whether this mechanism might explain the increases in hip strength found in both badminton and tennis. Another possible explanation for these results could be related to a higher muscle temperature during the post-tests, which has been documented to increase the following power output and is likely attributable to increased muscle temperature-related factors (e.g., increases in the adenosine triphosphate turnover rate and/or increased nerve conduction velocity) [43,44]. Other factors associated to higher muscle temperature are decreased muscle stiffness and increased anaerobic energy provision, which might have contributed to the higher hip strength values after the matches [45]. Again, although speculative, muscle temperature and thus an increased metabolic response could be related to these results [40]. Although players performed a supervised warm-up protocol, it is likely that body and muscle temperatures in the post-match assessment were significantly higher than in the pre-exercise tests. However, this assumption is based on simple observations, because we did not take these measurements.

Regarding hip ROM, the present results showed that two competitive badminton matches led to an acute reduction in the IR ROM (-9.02% and -9.08% for the dominant and non-dominant hip, respectively) and the ER ROM (-15.2% and -19.4%). Due to the lack of similar research in badminton, it is difficult to ascertain the impact of this reduction in joint mobility in elite badminton players. Previous studies have suggested that a reduction in IR increases the risk of groin injuries during sport activities [11,12], but it seems unsafe to conclude that this is a risk for injury during training or competition. In addition, although IR hip ROM showed important decreases on both sides, IR values could be considered as normal, as groin pain is typically associated with a loss of IR greater than 85º [12]. In the present study, total bilateral IR ROM values (99º) were higher than previous values reported for athletes [12]. Related to this finding, it is probable that the decreased hip mobility is related to the muscle damage generated during the competition, although this speculation deserves further investigation for confirmation.

This study has some limitations that should be acknowledged. First, muscle damage was assessed via changes from baseline CK concentrations. Although this measurement is typically used in research to evaluate the level of exercise-induced muscle damage, the measurement of other indirect markers such as serum myoglobin concentration and muscle swelling would help to enhance the identification and categorisation of the muscle damage developed during a badminton competition. Second, 24 h after the competition day, only blood samples were obtained. The assessment of muscle performance and hip range of motion would also help to reveal the progression of these variables the day after a competition. Lastly, the measurement of all variables after each single match, instead of after the competition day, would improve the accuracy of the present findings. Future research in the field should examine these variables before and after every match, in order to provide further information about the real impact of every match on badminton performance.

PRACTICAL APPLICATIONS

This is the first study to investigate the impact of an actual badminton competition with two competitive matches in a day on hip strength and range of motion, and on exercise-induced muscle damage in elite junior badminton players. Briefly, the competition day produced a transient increase in blood CK concentration and a decrease in IR and ER hip ROM on both dominant and non-dominant sides. Nevertheless, hip ADD and ABD muscle strength were higher in the dominant limb after the competition and there was no change in unilateral and bilateral vertical jumps. Together, this information suggests that, although lower limb muscle performance is improved after competing in two badminton matches, muscle damage (i.e., increased joint stiffness and signs of muscle damage) induced by the numerous eccentric contractions associated with on-court movements (i.e., acceleration and decelerations, repetitive overhead motions and changes of direction) might represent an important factor underlying the fatigue observed during racket sports [18]. Given the fact that reductions in IR ROM cause an increased groin injury risk [11,12], the present study highlights the relevance of monitoring the decline of hip IR ROM in badminton players after competitive matches, to preserve hip health and performance status. Therefore, performance programmes including IR and ER stretching protocols should be included as part of badminton players' training and competition schedules with the aim of restoring normal rotation flexibility before the next match/tournament, and therefore reducing the risk of groin injury.

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Conflict of interest

The authors declare that they have no conflict of interest derived from the outcomes of this study.

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