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EFFECTS OF ACUTE FATIGUE ON THE FUNCTIONAL PERFORMANCE OF BASKETBALL PLAYERS

Dissertação elaborada com vista à obtenção do Grau de Mestre em Treino de Alto Rendimento

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Preview note

The preliminary results of this study were presented and discussed at the 7th Iberian Congress / 5th Ibero-American Congress of Basketball. This study was also submitted to the *E-Balonmano* journal in early January and is currently under review.

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Abstract

The study evaluated the impact of acute fatigue on basketball players' functional performance. A sample of 34 players was tested before and after a fatigue protocol. The 20-meter sprint, the agility t-test and the 505 test were analyzed. The induction of fatigue was accomplished through the Repeated Sprint Protocol, a method validated for its specificity with regard to basketball exertion (Castagna et al., 2007, 2008). The players' functional performance compared in pre and post-RSP demonstrated significant differences in the 20-meter sprint test (t (33) = -3.961; $p < 0.001$) and in the agility t-test ($S^+ = 454.5$; $S^- = 140.5$; $z = -2.685$; $p \leq 0.01$). Based on the fatigue level, players were divided into two groups: high-fatigue and low-fatigue. Significant differences were observed between pre and post-RSP for 20-meter sprint test for both groups. However, only the high-fatigue group demonstrated significant variations in the 505 agility test (t (9) = -3.101; $p \leq 0.01$). These findings suggest that acute fatigue can influence basketball players' performance in tasks requiring acceleration speed and ability to change direction. When the level of fatigue is taken into account, players with a higher level of fatigue also show differences in change of direction performance that involve changes in direction of the displacements. Basketball coaches and physical trainers should consider ways in which acute fatigue can be managed and how it may affect the functional players' performance.

Keywords: Basketball; Acute fatigue; Functional performance; Repeated sprints.

Resumo

O presente estudo avaliou o impacto da fadiga aguda no desempenho funcional em jogadores de basquetebol. Para o efeito, uma amostra de 34 sujeitos foi testada antes e depois da execução de um protocolo de fadiga. O desempenho funcional foi avaliado através dos testes do sprint de 20 metros, do teste-t de agilidade e do teste 505 de agilidade. A indução de fadiga foi concretizada através de um protocolo de sprints repetidos, um método validado pela sua especificidade face às exigências do basquetebol (Castagna et al., 2007, 2008). O desempenho funcional dos jogadores comparado no pré e pós-PSR demonstrou diferenças significativas no teste de velocidade de 20 metros (t (33) = -3.961; $p < 0.001$) e no teste t de agilidade ($S^{+} = 454.5$; $S^{-} = 140.5$; $z = -2.685$; $p \leq 0.01$). Com base na magnitude da fadiga, os sujeitos foram divididos em dois grupos: fadiga elevada e fadiga baixa. Diferenças significativas foram observadas entre o pré e pós-PSR para o sprint dos 20m nos dois grupos. Contudo, apenas o grupo de fadiga elevada apresentou diferenças significativas no teste 505 de agilidade (t (9) = -3.101; $p \leq 0.01$). Estes resultados sugerem que a fadiga aguda pode influenciar o desempenho de jogadores de basquetebol em tarefas que dependam da capacidade de aceleração e de agilidade. Quando a magnitude da fadiga é tida em conta, jogadores com níveis de fadiga mais elevados também apresentam diferenças na capacidade de execução de mudanças de direção. Os treinadores e preparadores físicos de equipas de basquetebol devem considerar formas de gerir o impacto da fadiga aguda e como esta pode influenciar a performance funcional dos jogadores.

Palavras-chave: Basquetebol; Fadiga aguda; Desempenho funcional; Sprints repetidos.

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Abbreviations

ANOVA Analysis of Variance

CMJ Countermovement Jump

HF High-Fatigue

LF Low-Fatigue

NBA National Basketball League

PM Performance Maintained

RPE Rate of Perceived Exertion

RSP Repeated Sprint Protocol

1. Introduction

Basketball is a team sport created at the end of the 19th century, 133 years ago. Throughout its history, the game has undergone significant changes, either due to modifications to some of its rules or due to the evolution of the technical-tactical tendencies put into practice. Currently, basketball is characterized by high intermittency and pace, visible by the high number of movement patterns performed by players during the game (Stojanović et al., 2018).

These new physical and physiological characteristics of basketball can lead to a greater accumulation of acute fatigue during practices and games, which can have an impact on a functional, but also technical and mental level, as will be discussed below. Therefore, it seems relevant to study the effects of acute fatigue on players' performance. The present study will focus on the effects on functional performance, namely on acceleration and change of direction abilities.

The results and conclusions of the study can provide new information to coaches and technical staff about the impact of acute fatigue, contributing to better management of the training load, particularly through planning that is capable of simulating the physiological demands of the game.

1.1. Purpose

The present study purposes to evaluate the impact of acute fatigue on functional performance in basketball players. More specifically it aims (a) to compare the effects of acute fatigue in some functional capabilities for basketball performance, and (b) to understand how the level of acute fatigue may affect their performance.

1.2. Dissertation Structure

This dissertation has the following structure: firstly, a literature review is presented on the characterization of basketball and its physical and physiological demands, as well as the study of fatigue in team sports, more specifically in basketball; secondly, the research methods are explained, namely the experimental design, the characterization of the sample, the materials used, the tests performed and the statistical analysis of the data; thirdly, the results are presented and discussed; finally, the main conclusions of the dissertation are mentioned, also referring to the main limitations and recommendations.

2. Literature Review

2.1. Physical and Physiological Demands in Basketball

Basketball is an intermittent team sport, characterized by a rapid and frequent change in movements, interspersing periods of high intensity with moments of low to moderate intensity (Stojanović et al., 2018). Within the range of motor patterns that characterize the sport, shuffling, running, jumping, walking and standing stand out, with wide variations in duration, intensity and frequency (Abdelkrim et al., 2007; Hůlka et al., 2013; McInnes et al., 1995). A study evaluating elite under-19 athletes shows that there is a change in motor action every 2 seconds, in a total of 1050 motor actions in the game (Abdelkrim et al., 2007).

The assessment of the physical and physiological demands of basketball is based on data on internal load (heart rate, blood lactate concentration) and/or external load (distance covered, distance covered at high intensity, accelerations, decelerations). However, the data presented in the literature must be interpreted with caution, due to the methodological inconsistency in obtaining the data (Russell et al., 2021).

A systematic review shows that the physiological demands in basketball vary depending on the playing level, position, period of the game and sex (Stojanović et al., 2018). According to Stojanovic and colleagues, basketball players cover, on average, a distance between 5km and 6km, with low intensity actions being the predominant ones (Abdelkrim et al., 2007; Delextrat et al., 2015; McInnes et al., 1995; Narazaki et al., 2009). These data reveals the importance of the aerobic energy pathway, through which the resynthesis of phosphocreatine takes place for the execution of high-intensity efforts (Bishop et al., 2004; Narazaki et al., 2009). The contribution of this energy pathway is more significant in the second and fourth periods, moments in which fatigue causes a decrease in the intensity of the actions performed by the basketball players (Ben Abdelkrim et al., 2007; Scanlan et al., 2015).

The literature shows significant differences in the physical and physiological demands in basketball according to the playing level. A study comparing elite and sub-elite basketball players from Australian championships shows that, although athletes at both competitive levels cover similar total distances, sub-elite basketball players spend more time performing maximal efforts and low-intensity efforts than elite basketball players and, on the contrary, elite basketball players cover more distances at a moderate-high intensity (Scanlan et al., 2011). A systematic review states that basketball players at a higher competitive level play more efficiently, recording a lower maximum heart rate, lower average heart rate and shorter total distance covered in the game (Petway et al., 2020).

When it comes to comparing physiological demands between sexes, studies indicate that there are no significant differences in the total distance covered between men and women (Stojanović et al., 2018). However, a study points to a lower frequency of actions among female basketball players (Matthew & Delextrat, 2009) and a greater amount of time spent in low-intensity activities (Stojanović et al., 2018).

Regarding the comparison between player position, frontcourt players cover a smaller total distance (Scanlan et al., 2011), perform a lower number of actions (Abdelkrim et al., 2007; McInnes et al., 1995), perform low-intensity actions, such as standing or walking, more often (Scanlan et al., 2011) and perform a greater number of jumps (Delextrat et al., 2015) than backcourt players.

In addition to the aspects mentioned, the physiological demands in basketball can also be influenced by tactical and strategic factors (Abdelkrim et al., 2010) and the literature shows that the recent change of rules has caused a change in the physiological demands of basketball (Abdelkrim et al., 2007; Matthew & Delextrat, 2009).

Given the physiological demands highlighted in the previous paragraphs, it is necessary for basketball athletes to develop a specific set of physical abilities. The complexity that characterizes the practice of this sport implies the development of several physical qualities in order to optimize performance on the court (Morrison et al., 2022). Therefore, the assessment of these physical qualities is essential to identify potential talents, as it should influence the player’s training process and their improvement can positively influence the athletes' performance (Ferioli et al., 2018). Although cardiorespiratory fitness is important, the literature shows that the ability to produce force (namely power as a form of manifestation of strength), as well as the ability to maintain, throughout the game, the execution of intermittent high-intensity efforts are important qualities in high-performance basketball (Ziv & Lidor, 2011). Therefore, the assessment of these functional capabilities can allow the distinction of competitive categories in basketball.

2.2. Fatigue in Basketball

The concept of fatigue is widely discussed in the sports science literature. Fatigue is a multidimensional concept that can be understood in terms of multiple meanings and interactions. The present study focuses on the topic of so-called acute fatigue. Meeusen and colleagues (2021) define this phenomenon as "an acute impairment of exercise performance that includes both an increase in the perceived effort required to produce a desired force or power output and the eventual inability to produce that force or power output" (Meeusen et al., 2021). Fatigue is considered in this study as a transient inability to sustain work production at a given intensity over time (Wilmore et al., 2019).

The available literature has documented the impact of acute fatigue on various dimensions of players' performance in team sports. In a study conducted by Romero et al. (2022), the effects of acute fatigue on the biomechanical pattern of sprinting in football players were identified. Silva and colleagues (2018) highlighted the impact of fatigue on a range of parameters, including metabolic, biochemical, functional and technical aspects of performance. In terms of functional aspects, the authors emphasize the impact on neuromuscular performance, repeated sprint ability and linear speed as demonstrated by football players. More recently, Dambroz et al. (2022) have provided further evidence to support the assertion that acute fatigue has a similar impact on the performance of football players. In an open field team sport like football, Davidow et al. (2020) investigated the impact of fatigue on the players' tackling technique in rugby union and reported a significant effect. Furthermore, evidence suggests that acute fatigue affects the neuromuscular actions typical of team sport techniques. Nuño et al. (2016) demonstrated that fatigue onset influences ball release velocity and throwing accuracy in handball, concluding that performance in this specific task is negatively affected.

Regarding neuromuscular performance, a study conducted by Póvoas et al. (2014) highlighted the impact of match-induced fatigue of handball players in field tests such as the countermovement jump (CMJ) and the 20-meter sprint ability, showing statistical differences between the baseline and post-match performances. On the contrary, in volleyball (an imminently neuromuscular activity), the fatigue induced by a regular training sessions was not enough to cause statistical significant differences in CMJ force-time metrics (Cabarkapa et al., 2023). These discrepancies highlighted in the literature between different sports may be related to different physiological demands.

The study of the acute fatigue effects on performance in basketball has been focused on two distinct issues. On the one hand, the issue of monitoring and managing fatigue and training load has been approached as a fundamental aspect of the planning and periodisation process, as well as the various strategies identified for this purpose (Edwards et al., 2018). On the other hand, the issue of the fatigue impact on the technical actions of basketball players has been investigated (Bourdas et al., 2024; Erčulj & Supej, 2009; Li et al., 2021), as well as the number of supramaximal activities undertaken during training sessions or games (Palmer et al., 2022). Additionally, the influence of mental fatigue on decision-making performance has been also examined (Cao et al., 2022).

Nevertheless, few studies have focused on how acute fatigue affects the functional performance of basketball players. A systematic review of the physical and physiological characteristics of basketball players identifies the lack of assessment of the impact of fatigue on the functional performance of basketball players as a significant limitation (Ziv & Lidor, 2009). In a study by Scanlan et al. (2018), the force production in knee flexion and extension was evaluated as a functional test on an isokinetic dynamometer. However, the authors employed an instrument that is not readily accessible to the majority of sports clubs and the ecological validity of this acute fatigue assessment is highly questionable. Philipp et al. (2023) induced a repeated sprints protocol to investigate the jumping performance of basketball players. The authors demonstrated a decrease in jumping height following the fatigue protocol (after 2 minutes and after 15 minutes), yet the players were able to jump with greater efficiency, translated by less contraction time, higher eccentric peak power and higher eccentric mean deceleration force when performing the CMJ. The available literature on the impact of acute fatigue in basketball is both limited and questionable in the ecological validity of the assessment forms to fatigue induction. Furthermore, the results appear to be contradictory.

Fatigue management is vital for sports performance in basketball. The quality of decision-making may also be influenced by the acute fatigue (Li et al., 2021). As reported by Scanlan et al. (2015), there is a notable reduction in the intensity of players' actions in the final moments of both halves of a basketball game. This is a crucial factor in determining the performance of basketball players. Assessing its influence helps to predict how players will perform in situations when they will be most fatigued and informs how training programmes could enhance their ability to resist fatigue.

For the reason mentioned above, the present study intents to add new data to the existing literature. Also, the knowledge of how fatigue can influence players’ performance can guide the coach in planning the training process, managing the team during the game and, in addition, it can be useful for the strength and conditioning trainer to adapt the assessment of athletes' physical qualities to the effects that acute fatigue may have on them.

3. Methods

3.1. Experimental Design

This study required each subject to attend a session at the Hermínio Barreto Gym (Faculdade de Motricidade Humana). Prior to data collection, the subjects were familiarised with the battery of functional tests and the fatigue protocol to be used during the assessment session. The participants were asked to perform three functional performance tests: the 20-meter linear sprint, the 505 change of direction test and the agility t-test. Three trials were performed for each of test, with a 30-second rest period between each trial. Participants were instructed to complete the tests as quickly as possible with strong verbal encouragement. In order to perform at their optimal level, the subjects completed a standardised warm-up protocol prior to the functional assessment, which consisted of the following steps: (1) ten minutes running at a moderate intensity, (2) active stretching exercises, (3) two laps of a circuit consisting of strength exercises, namely: ten squats, ten lunges (performed with each lower limb) and five countermovement jumps. Subsequently, the subjects were required to perform three sets of 15-meter sprints, interspersed with a two-minute interval of rest (Castagna et al., 2008). Following the functional assessment, the subjects were permitted a five-minute interval before the beginning of the fatigue protocol. This comprised 10 30-meter shuttle sprints, with an 180-degree turn (15 meters + 15 meters), separated by a 30-second period of passive recovery. Subjects were instructed to perform all trials in the most expeditious manner possible. Upon completion of the fatigue protocol, subjects were permitted a one-minute interval before repeating the functional assessment tests. The sequence of functional tests was identical for all subjects and consistent with the sequence established prior to the execution of the fatigue protocol.

3.2. Participants

A total of 34 male basketball players, aged between 18 and 40 years old (mean age 21.44 ± 4.6 years old; mean body mass 79.6 ± 9.5 kg; mean height 1.84 ± 0.09 cm; mean body mass index 23.4 ± 1.5 kg/m²) were recruited to participate in this study. The subjects are athletes registered with the Portuguese Basketball Federation, participating in the fourth (n = 27) and third (n = 7) Portuguese competitive divisions. All athletes had a minimum of four years of organised and recent experience in basketball, as well as systematic training. They all reported the absence of previous musculoskeletal injuries in the lower limbs, specifically hamstring injuries. Each subject attended one data collection session and signed a written informed consent form approved by the Ethics Committee of Faculdade de Motricidade Humana. The subjects were supervised and informed about all procedures, and were permitted to interrupt their participation at any time.

3.3. Materials

The times recorded in each of the functional tests were obtained through the use of photoelectric cells. In the case of the agility t-test and the 505 test, a single gate was employed, serving both as the input and output for the test. In the 20-meter test, a gate was used to start the trial and another to terminate it at the 20-meter mark. The photoelectric cells employed to evaluate participants' performance were sourced from Microgate (Witty Timing System, minimum resolution of 0.125 m/s and 12-meter range, Mahopac, NY, USA).

3.4. Procedures

3.4.1. Change of direction evaluation

In order to assess the ability to change of direction capacity, the agility t-test was performed (Figure 1), which is one of the most frequently used tests in the evaluation of basketball athletes (Morrison et al., 2022). The test was administered in accordance with the procedures established by Semenick (1990).

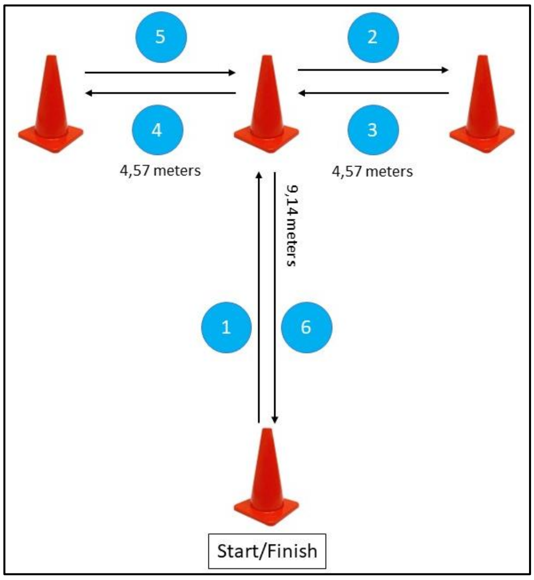

Figure 1. *Agility t-test design*

In addition to the agility t-test, the subjects' ability to change direction was also evaluated throughout the 505 test. In this test, participants are required to perform a 15-meter sprint upon receiving a signal. At the 15-meter mark, they must change direction by 180 degrees in order to complete a new 5-meter sprint. In this test, the performance is quantified in terms of the time taken for the participants to complete a 10-meter sprint with a 180-degree change of direction at 5 meters (Spiteri et al., 2014, 2015). The following figure (Figure 2) illustrates the 505 test.

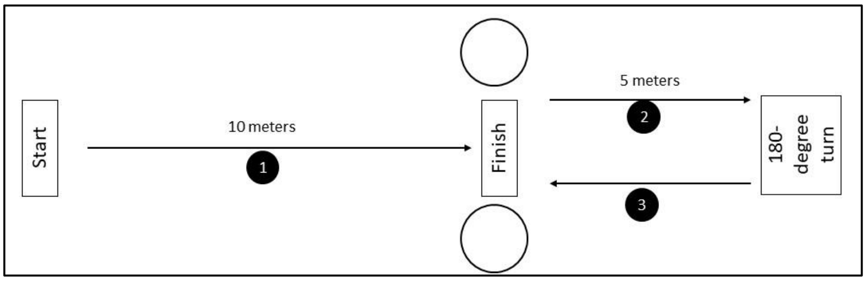

Figure 2. *505 agility test design*

3.4.2. <u>Acceleration assessment</u>

The 20-meter linear sprint was conducted to evaluate the acceleration capacity of the subjects. This test is one of the most frequently employed methods for assessing this physical quality with basketball players (Morrison et al., 2022).

3.5. Fatigue protocol

To induce fatigue, the Castagna and collaborators protocol was used (Castagna et al., 2007, 2008). The authors validated the protocol by taking into account the specificity of the tasks and the effort demanded by the basketball game. This is a Repeated Sprint Protocol (RSP), in which athletes are required to perform 10 30-meter shuttle sprints (15 metres plus 15 metres), interspersed with 30 seconds of passive recovery. This protocol has been demonstrated to induce acute fatigue, as evidenced by the analysis of blood lactate levels (Castagna et al., 2007, 2008). The subjects were instructed to start the trial with their foot on a mark placed 30 centimeters behind the timing gate of the photoelectric cell used to measure the time of the conclusion of each sprint. They were also instructed to perform each trial as rapidly as possible. To evaluate the performance and fatigue throughout the protocol, the percentage of sprint performance maintained (PM) was calculated using the following expression (Oliver, 2009):

$$\text{Performance maintained (\%)} = \left(\frac{Best\ sprint\ time\ (s)}{Mean\ sprint\ time\ (s)}\right) \times 100$$

3.6. Statistical analysis

The descriptive statistics values were calculated for each variable. The normality assumption was evaluated with the Shapiro-Wilk test. To investigate changes in functional performance metrics between baseline (pre-RSP) and post fatigue protocol (post-RSP), a paired samples t-test (two-tailed) was employed to compare the data collection in two different moments. In cases where the assumption of normality was not confirmed, a non-parametric methodology was employed, using the Wilcoxon test as the preferred option. The differences between the 30-meter shuttle sprint bouts were assessed using analysis of variance (ANOVA) for repeated measurements with Bonferroni's post-hoc test. The present study employed PM as an indicator of fitness and fatigue. The first and third quartiles of PM were calculated, and two groups with different fatigue levels were created: a group of participants below the PM first quartile (high-fatigue group) and another group of participants above the third quartile (low-fatigue group). The comparison of these two groups allows for an evaluation of the impact of fatigue and fitness level and conditioning on subjects' performance in functional tests.

The requisite sample size was calculated using the GPower software (version 3.1.9.7) (Faul et al., 2007). The input parameters for calculating the sample size were the error probability α, the power $(1 - \beta)$, and the effect size d. The reference values were established as follows: $\alpha = 0.05$, $1 - \beta = 0.80$ ($\beta = 0.20$) and $d = 0.50$. The effect size value d was defined using the Cohen reference (Cohen, 1992), with 0.50 considered as an average value. The interaction of these values yielded a sample size of n=34 subjects.

All statistical analysis were performed using SPSS software (version 29 for Windows; SPSS Inc., Chicago, IL, USA). The level of significance was set at $p \leq 0.05$.

4. Results

The descriptive statistics values of performance in the RSP are presented in the Table 1 and Figure 3.

Table 1. *Descriptive statistics for repeated sprint ability during the fatigue protocol*

	Mean ± SD	Minimum	Maximum
Sprint 1	5.89 ± 0.23	5.34	6.43
Sprint 2	5.85 ± 022	5.48	6.30
Sprint 3	5.88 ± 0.25	5.45	6.32
Sprint 4	5.89 ± 0.24	5.50	6.39
Sprint 5	5.92 ± 0.28	5.48	6.82
Sprint 6	5.93 ± 0.27	5.39	6.52
Sprint 7	5.97 ± 0.26	5.53	6.63
Sprint 8	6.02 ± 0.26	5.64	6.82
Sprint 9	6.00 ± 0.29	5.62	6.79
Sprint 10	6.03 ± 0.29	5.58	6.86

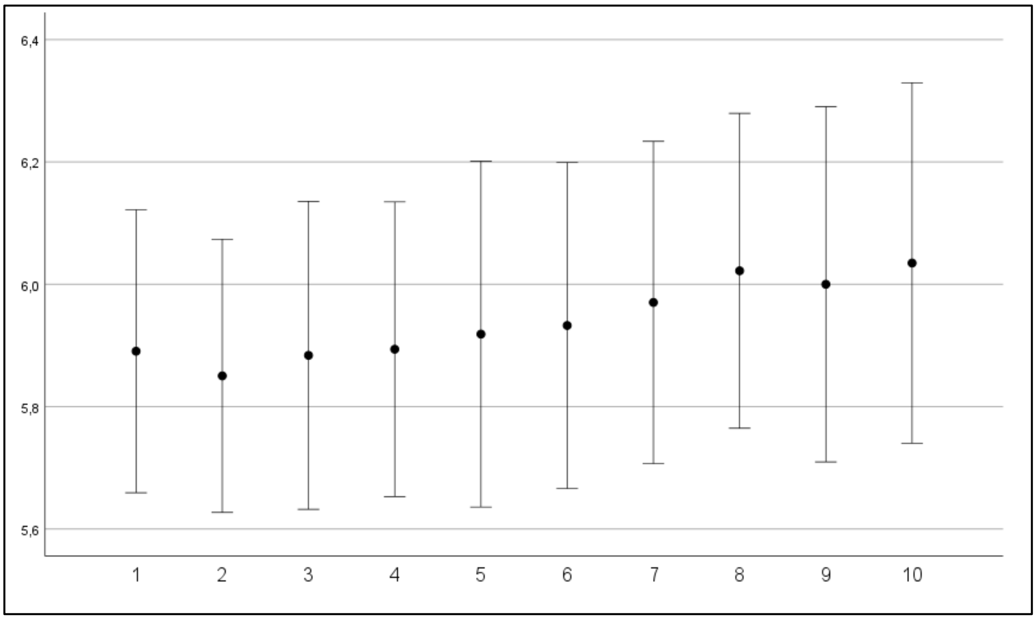

Figure 3. *Error bar graph with mean ± SD for repeated sprint ability during fatigue protocol*

Since the assumption of sphericity was not validated, the ANOVA for repeated measurements with the Greenhouse-Geisser correction was used. Significant differences were found between sprints (*F* (4.07,134.31) = 8.713; $p < 0.001$). The Bonferroni's post hoc test (Table 2) shows that performance decreases significantly from the eighth sprint onwards. The average value of the second sprint was used as a reference, since it was from there that a progressive decrease in performance was recorded. Differences are statistically significant when comparing the average values of the second sprint (best average sprint) with the eighth ($p \leq 0.01$), ninth ($p \leq 0.05$) and tenth sprint ($p \leq 0.01$).

Table 2. *Bonferroni's post-hoc test and pairwise comparison between sprints*

Best sprint	Other sprints	p-value
	1st	1.00
	3rd	1.00
	4th	1.00
	5th	1.00
2nd	6th	0.93
	7th	0.14
	8th	**< 0.01**
	9th	**0.04**
	10th	**< 0.01**

Note: Bold = significantly different from baseline (p <= 0.05)

The mean ± standard deviation of the performance values in the functional tests, in the pre and post-RSP, are reported in the Table 3. Significant differences were found between pre and post-RSP in the 20-meter linear test (t (33) = -3.961; $p < 0.001$) with Cohen effect size d = 0.14. In contrast, there were not verified statistical differences for the results obtained in the 505 test performance (t (33) = -1.859; $p = 0.072$). Since the assumption of normality was not verified for the agility t-test, the comparison between the pre and post situations was carried out using the Wilcoxon test. For this case, significant differences were shown between pre and post-RSP ($S^+ = 454.5$; $S^- = 140.5$; $z = -2.685$; $p \leq 0.01$) with Cohen effect size d = 0.08.

Table 3. *Descriptive statistics for 20-meter linear sprint test, 505 agility test and agility t-test across the two time-points*

	Pre-RSP	Post-RSP
20-meter linear sprint	3.06 ± 0.16	**3.15 ± 0.16***
505 test	2.27 ± 0.09	2.30 ± 0.13
Agility T-Test	9.36 ± 0.42	**9.54 ± 0.63***

Note: Bold = significantly different from baseline (p < 0.05)
* = small effect size

As mentioned in the previous section, the sample was divided into two groups using the PM variable. This variable provides information about the impact of acute fatigue and the subjects' level of conditioning. In the high-fatigue (HF) group, PM values range between 94% and 96%, while in the low-fatigue (LF) group the values are equal to or greater than 98%.

Table 4 illustrates the performance data for participants included in the HF and LF groups at pre and post-RSP. Significant differences were found in the 20-meter line test for both groups of fatigue: t (9) = -5.102; p <0.001; d = 0.12; for the HF group and t (9)= -2.363; $p \leq 0.05$; d = 0.12 for the LF group.

Looking at the 505 test, participants in the HF group were significantly slower (t (9) = -3.101; $p \leq 0.01$; d = 0.09). No significant differences were found in the LF group. With regard to the agility t-test, no significant differences were observed between the groups. Nevertheless, a notable distinction emerged among the HF group, which exhibited a quasi-significant outcome (t (9) = -2.149; p = 0.06), accompanied by a moderate effect size (d = 0.54).

Table 4. *Descriptive statistics for 20-meter linear sprint, 505 agility test and agility t-test across the two time-points and by fatigue-related group classification*

	Group	Pre-RSP	Post-RSP
20-meter linear sprint	High	3.05 ± 0.16	**3.24 ± 0.22***
	Low	3.06 ± 0.16	**3.15 ± 0.13***
505 agility test	High	2.29 ± 0.09	**2.38 ± 0.14***
	Low	2.24 ± 0.09	2.25 ± 0.13
Agility T-Test	High	9.48 ± 0.42	9.87 ± 0.87†
	Low	9.35 ± 0.43	9.46 ± 0.44

Note: Bold = significantly different from baseline (p <= 0.05)
* = small effect size
† = moderate effect size

5. Discussion

The primary aim of the present study was to evaluate the effects of acute fatigue on the functional performance of basketball players. As previously mentioned, the selected protocol has been validated in the literature as being specific to basketball, with physiological demands that are analogous to those experienced during the activity of real game, and which also induce fatigue (Castagna et al., 2007, 2008). Upon consideration of the entire sample, the impact of acute fatigue became evident in the 20-meter sprint and in the agility t-test, with statistically significant differences observed between the pre and post-protocol performances. Nevertheless, it is important to acknowledge that these variations are accompanied by small effect sizes ($d = 0.14$ and $d = 0.08$, respectively).

The findings are consistent with those reported by Silva et al. (2018), who examined the effects of acute fatigue on linear sprint and change of direction tests in football. These results are further substantiated by the research conducted by Dambroz et al. (2022). Regarding the 20-meter sprint, the findings align with those reported by Póvoas et al. (2014), which indicated substantial variations in the 20-meter sprint performance of handball players following a match. In the context of basketball, Cortis et al. (2011) had registered a decline in the performance of young Italian players in executing a 10-meter sprint following a friendly match. Additionally, Delextrat et al. (2012) had also documented a significant decrease in the 20-meter sprint performance of female players from English Basketball National League after an official match. However, the same impact of the acute fatigue was not registered after a practice session (Delextrat et al., 2012).

The comparison of the two groups – the HF and the LF groups – using the maintained performance variable allowed a more precise evaluation of the data. While both groups showed significant differences between pre and post-RSP in the 20-meter sprint test, only the HF group presented significant differences between the two moments in the 505 agility test ($p \leq 0.01$). For the agility t-test the differences in the HF group, although not statistical significant ($p = 0.06$), have a moderate effect size ($d = 0.54$). This findings suggest that athletes with a higher level of conditioning, as reflected by a better ability to maintain their performance in the fatigue protocol, are less vulnerable to the effects of acute fatigue and able to maintain their performance in the functional tests.

The characteristics of protocol-induced fatigue are due to a variety of factors. In general terms, they may have neural foundations or muscular reasons. The failure of motor unit recruitment and neural drive can have neural causes to induce the acute fatigue provoked by the protocol. But the accumulation of metabolites and availability of intramuscular phosphocreatine can also be on the basis of the alterations of the athletes performance after the RSP (Girard et al., 2011). It is possible to suggest that athletes who are less susceptible to the effects of acute fatigue, specifically anaerobic lactic fatigue, and better conditioned, may have, among other physiological mechanisms, a more optimized buffering capacity. Indeed, the study by Ferioli and colleagues (2018) shows that the physiological responses to high-intensity efforts are related to the competitive level of the athletes, with elite athletes having a better capacity to cope with this high-intensity exercise. More specifically, the study shows that athletes at a higher competitive level have a greater buffering capacity, a capacity that the literature suggests is fundamental to sustaining high-intensity efforts (Bishop et al., 2004). For this reason, the results suggest that anaerobic lactic endurance may play an important role in basketball, and players who have this capacity more developed will tend to be able to maintain their functional performance in the final stages of the game, where acute fatigue could have a more significant influence.

The data leads us to emphasize the importance of taking into account the inter-individual effects of fatigue, influenced by an individual's level of conditioning, when assessing the impact of acute fatigue on performance. This study shows that analyzing the sample as a whole may mask the effects of acute fatigue on less conditioned athletes. As it appears that the level of conditioning of players has an impact on the effects of acute fatigue on performance, physical training should play an important role in the preparation of a basketball team. Within the National Basketball League (NBA), strength and conditioning practices are well documented in the literature (Simenz et al., 2005) and contribute to player functioning and team success (Mexis et al., 2022). Among the physical qualities, the ability to perform repeated sprints (fatigue protocol used in this study) can be highlighted, which, as demonstrated by Stojanovic et al. (2012), shows a correlation with the production of explosive force and the height of the CMJ. Furthermore, the literature shows that the physiological response to high-intensity intermittent efforts can be a variable used to differentiate athletes competing at different levels (Ferioli et al., 2018).

6. Conclusions

In accordance with the primary objective delineated in the present study, it has been demonstrated that acute fatigue exerts a substantial influence on the functional performance of basketball players. In consideration of the RSP, a method for inducing a form of anaerobic lactic fatigue, the findings elucidate the impact of acute fatigue on the capacity to generate displacements in speed acceleration conditions and to execute change of direction tasks in basketball players. The findings further suggest that acute fatigue can disrupt players' performance in terms of skill execution and tactical behaviour. Moreover, the results indicate that players with a higher capacity to resist anaerobic lactic fatigue are better able to sustain their performance. Consequently, it is imperative for coaches and their staff to incorporate player conditioning as a pivotal element of their training regimen, with a primary focus on enhancing players' capacity to sustain high-intensity intermittent efforts and improving their anaerobic lactic endurance.

In the context of contemporary basketball, characterised by an accelerated pace of play, coaching staff are compelled to meticulously design training programmes that emulate the physiological demands of the game. The strategic integration of high-intensity, lactic anaerobic exercises into training regimens is of paramount importance, as it enables athletes to enhance their capacity for maintaining functional performance in the face of acute fatigue. This approach has been shown to enhance the athletes' anaerobic lactic endurance, as evidenced by an improvement in buffering capacity and other key factors. Additionally, it enables the training of technical and tactical elements in a manner that emulates the fatigue experienced during game play. The intensity of these efforts can be tailored to resemble the fatigue protocol employed in this study. It is crucial to note that the volume of training should be carefully considered, as significant performance declines were observed only from the eighth sprint onwards.

7. Recommendations and Limitations

The present study is subject to certain limitations that should be noted. Firstly, the participants are basketball players of a lower competitive level, playing in the fourth and third Portuguese competitive divisions. This could have an effect on the results due to their training background and level of conditioning. Future studies should include participants from clubs playing at a higher competitive level (second and/or first Portuguese divisions) to verify whether the results of elite players are similar to those of non-elite players. Secondly, the absence of an assessment of the participants' blood lactate concentration represents a significant limitation, as this could have provided important information on the acute fatigue induced. The study by Castagna et al. (2007) reported blood lactate concentrations of 13.6 ± 3.1 and 14.2 ± 3.5 mmol-L-1 immediately and 3 minutes after the protocol, respectively. However, given that the participants in the present study differ in age and competitive profile, it would have been relevant to evaluate the effect of the fatigue protocol on this variable. Another measure to assess internal load could have been used, such as rate of perceived exertion (RPE), an instrument validated in the literature to quantify internal load (Edwards et al., 2018). Thirdly, the functional performance evaluated focused on the execution of lactic anaerobic functional tests. Consequently, it is recommended that future studies assess the impact of acute fatigue on additional dimensions of functional performance, such as aerobic performance. Moreover, given that contemporary basketball is characterised by a densely scheduled competitive calendar, comprising numerous games with reduced rest periods between them, it is imperative that future studies also evaluate the impact of accumulated fatigue on players' functional performance.

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