

Effects of acute fatigue on the functional performance of basketball players

Efectos de la fatiga aguda sobre el rendimiento funcional en jugadores de baloncesto

Efeitos da fadiga aguda no desempenho funcional em jogadores de basquetebol

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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 (RSP). The players' functional performance compared in pre and post-RSP demonstrated significant differences in the 20-meter sprint test (and in the agility t-test). 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. These findings suggest that acute fatigue can influence basketball players' performance in tasks requiring acceleration speed and agility. Players with a higher level of fatigue also show differences in agility 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.

Resumen

El estudio evaluó el impacto de la fatiga aguda en el rendimiento funcional de jugadores de baloncesto. Se evaluó una muestra de 34 jugadores antes y después de un protocolo de fatiga. Se analizaron el sprint de 20 metros, la prueba de agilidad t-test y la prueba 505. La inducción de fatiga se llevó a cabo mediante el Protocolo de Sprint Repetido (PSR). El rendimiento funcional de los jugadores comparado mostró diferencias significativas en la prueba de sprint de 20 metros y en la prueba de agilidad t-test. Según el nivel de fatiga, los jugadores fueron divididos en dos grupos: alta fatiga y baja fatiga. Se observaron diferencias significativas entre las pruebas en el sprint de 20 metros para ambos grupos. Solo el grupo de alta fatiga mostró variaciones significativas en la prueba de agilidad 505. Estos resultados sugieren que la fatiga aguda puede influir en el rendimiento funcional de los jugadores de baloncesto. Los jugadores con un mayor nivel de fatiga también muestran diferencias en el rendimiento en cambios en la dirección. Los entrenadores de baloncesto y preparadores físicos deben considerar formas de gestionar la fatiga aguda y cómo esta puede afectar el rendimiento funcional de los jugadores.

Palabras clave: Baloncesto; Fatiga aguda; Rendimiento funcional.

Introduction

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. Regarding the effects of acute fatigue on technical aspects, a study conducted by Romero et al. (2022) demonstrated the effects of acute fatigue on the biomechanical pattern of sprinting in football players were identified. In addition to this study, and 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, 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.

In terms of functional aspects, Silva and colleagues (2018) highlighted the impact of fatigue on a range of parameters, including metabolic, biochemical, functional and technical aspects of performance. 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 this systematic review, the authors show that acute fatigue has a negative impact on the ability to perform sprints and on the distance covered at high speeds.

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, revealing the negative impact that acute fatigue has on the kinematic patterns and efficacy of shooting (Erčulj & Supej, 2009; Bourdas et al., 2024) and passing (Li et al., 2021)). Regarding passing, acute fatigue affected shoulder and elbow joint positions and angular velocities, ball velocity, and passing effectiveness. As for shooting, fatigue negatively affected shooting effectiveness, specifically due to changes in ball entry angle and release velocity. Palmer et al. (2022) also found that acute fatigue, in both training and game contexts, leads to a reduction in the number of supramaximal activities performed.

One of the emerging topics in the study of fatigue in basketball concerns the effects of mental fatigue. A systematic review (Cao et al., 2022) highlighted that mental fatigue negatively impacts the execution of various technical aspects, such as free throw and three-point shooting performance, as well as the decision-making process.

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 intends 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.

Therefore, 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.

Materials and Methods

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.

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.

Instruments

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).

Procedures

Agility and change of direction evaluation

In order to assess agility and 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).

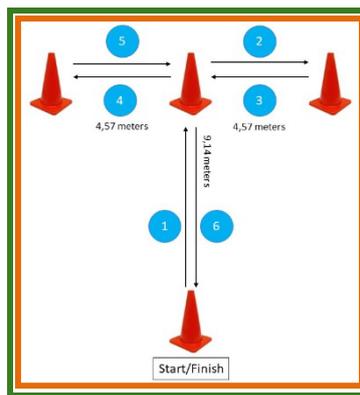


Figure 1. Agility t-test design. Figure created by the authors.

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.

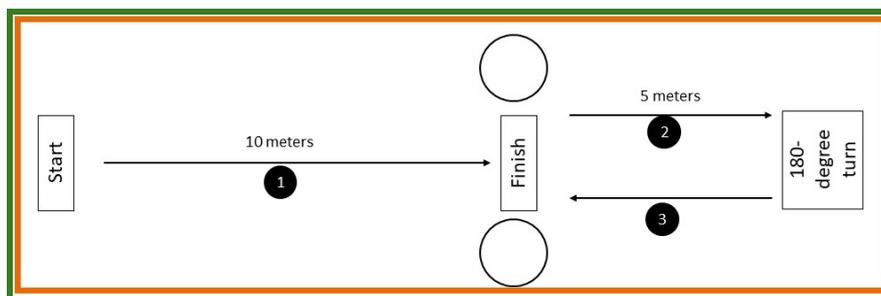


Figure 2. 505 agility test design. Figure created by the authors.

Acceleration assessment

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).

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):

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

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 (n=9) first quartile and another group of participants above the third quartile (n=9). 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. Similarly to the procedure used to compare the differences between pre and post-RSP protocol for the sample, differences in the HF and LF groups were calculated using a paired-samples t-test.

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.

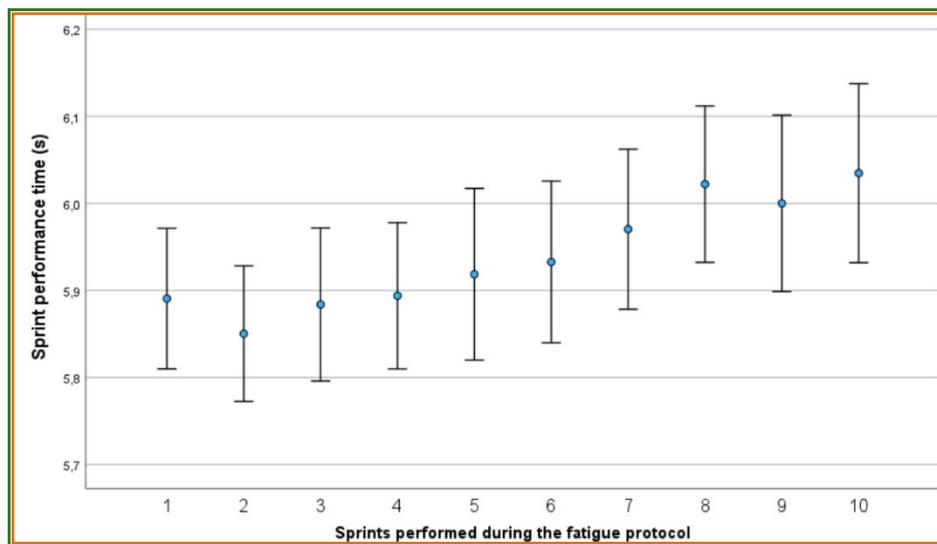
All statistical analysis were performed using SPSS software (version 29 for Windows; SPSS Inc., Chicago, IL, USA). The level of significance was set at $p \leq 0.05$.

Results

The descriptive statistics values of performance in the RSP are presented in the Table 1. 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 shows that performance decreases significantly from the eighth sprint onwards (Table 2). 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 1. Descriptive statistics for repeated sprint ability during the fatigue protocol

	Mean \pm SD	Minimum	Maximum
Sprint 1	5.89 \pm 0.23	5.34	6.43
Sprint 2	5.85 \pm 0.22	5.48	6.30
Sprint 3	5.88 \pm 0.25	5.45	6.32
Sprint 4	5.89 \pm 0.24	5.50	6.39
Sprint 5	5.92 \pm 0.28	5.48	6.82
Sprint 6	5.93 \pm 0.27	5.39	6.52
Sprint 7	5.97 \pm 0.26	5.53	6.63
Sprint 8	6.02 \pm 0.26	5.64	6.82
Sprint 9	6.00 \pm 0.29	5.62	6.79
Sprint 10	6.03 \pm 0.29	5.58	6.86

**Figure 3.** Error bar graph with mean \pm SD for repeated sprint ability during fatigue protocol**Table 2.** Bonferroni's post-hoc test and pairwise comparison between sprints

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

Note: Bold = significantly different from baseline ($p \leq 0.05$)

The mean \pm standard deviation of the performance values in the functional tests, in the pre and post-RSP, are reported in the Table 2. 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

Table 3 illustrates the performance data for participants included in the high-fatigue (HF) and low-fatigue (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 ($p \leq 0.05$)

* = small effect size

[†] = moderate effect size

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 statistically 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. More specifically, since only the subjects in the HF group showed significant differences in the 505 and T-test agility tests, it is possible that the ability to perform changes of direction is more influenced by the onset of acute fatigue than the acceleration capacity assessed by the 20-meter sprint test. This may be due to the characteristics of the fatigue protocol used, which include a 180-degree change of direction following a 15-meter sprint.

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).

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 agility 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.

Practical Applications

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.

In addition to being used as a training tool, the fatigue protocol employed may serve as a means of monitoring the development of athletes' anaerobic lactic endurance. Given that this is a particularly demanding protocol, future studies could explore adaptations that allow it to be applied more frequently throughout the season, while minimizing excessive physical strain on the athletes.

Limitations and recommendations

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). Furthermore, the study by Cobos et al. demonstrates that RPE is a simple, non-invasive, and effective method for assessing internal load and fatigue in athletes from team sports such as beach handball (Lara Cobos et al., 2024). 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.

Author Contributions:

Conceptualization, F.P. and A.P.F.; methodology, F.P. and A.P.F.; software, F.P.; validation, A.P.F.; statistical analysis, F.P.; literature review, F.P.; resources, F.P. and A.P.F.; data processing, F.P.; manuscript writing, F.P. and A.P.F.; review and editing, F.P. and A.P.F.; supervision, A.P.F. All authors have read and accepted the published version of the manuscript.

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