Journal of Sports Sciences

ISSN: 0264-0414 (Print) 1466-447X (Online) Journal homepage: www.tandfonline.com/journals/rjsp20

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To cite this article: Marco Pernigoni, Davide Ferioli, Julio Calleja-González, Pierpaolo Sansone, Antonio Tessitore, Aaron T. Scanlan & Daniele Conte (2024) Match-related fatigue in basketball: A systematic review, Journal of Sports Sciences, 42:18, 1727-1758, DOI: 10.1080/02640414.2024.2409555

To link to this article: https://doi.org/10.1080/02640414.2024.2409555

JOURNAL OF SPORTS SCIENCES
2024, VOL. 42, NO. 18, 1727–1758
https://doi.org/10.1080/02640414.2024.2409555

Routledge
Taylor & Francis Group

SPORTS PERFORMANCE

Match-related fatigue in basketball: A systematic review

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ABSTRACT
This study aimed to systematically review fatigue responses following basketball match-play and during congested match schedules, considering performance, physiological, athlete-reported, and sleep-related outcomes. Relevant articles published until 23 January 2024 were searched using Scopus, Web of Science, and SPORTDiscus. After screening, 44 studies were included in the systematic review. The main findings indicate that, in most cases, vertical jumping and linear sprinting showed significant decrements at match-end (<1 hour post-match) compared to pre-match [*small-to-very large* effect sizes (ES)], with persistent (≥1 hour post-match) impairments lasting 24–48 hours in jumping (only in males, *small-to-very large* ES) and linear sprinting (*moderate-to-very large* ES). Physiological changes generally included significant increases (*moderate-to-very large* ES) in cortisol and nutrient metabolism markers at match-end, alongside persistent increases in muscle damage (mainly at 13–72 hours post-match) and inflammation (13–48 hours). Finally, match-play generally increased muscle soreness (mainly at 24–48 hours, *moderate-to-very large* ES) and perceived fatigue (mainly at match-end), with unclear effects on mood, and no apparent impact on sleep-related outcomes. Research assessing congested match schedules is limited, although possible worsening in muscle damage, inflammation, perceived fatigue and well-being were observed in male players. Overall, these findings indicate an impairment in some of the reviewed performance, physiological, and athlete-reported outcomes.

ARTICLE HISTORY
Received 5 February 2024
Accepted 21 September 2024

KEYWORDS
Performance; physiological stress; well-being; recovery; team sports

Introduction

In sports science settings, fatigue has been widely accepted to negatively affect athletic performance (Enoka & Duchateau, 2016; Skorski et al., 2019; Thorpe et al., 2017). Traditionally, studies on the physiology of fatigue have focused on identifying changes in central (i.e., related to muscle activation) and peripheral (i.e., related to contractile function) factors that may limit performance (Enoka & Duchateau, 2016). This aspect is essential to understand the aetiology of fatigue and identify appropriate mitigation strategies (Rampinini et al., 2016). Additionally, identifying the effect of fatigue on real-world performance is also crucial in competitive sport (Edwards et al., 2018). Accordingly, contemporary reports (Edwards et al., 2018; Enoka & Duchateau, 2016) have provided a more comprehensive characterisation of this phenomenon. Specifically, fatigue has been defined in terms of "fatigability to normalise the level of fatigue reported by an individual relative to the demands of the task that produces it" (Enoka & Duchateau, 2016). Accordingly, two main attributes of fatigue have been proposed, namely perceived fatigability and performance fatigability (Edwards et al., 2018; Enoka & Duchateau, 2016). Perceived fatigability concerns "the maintenance of homoeostasis and subjective psychological state of the athlete" (Edwards et al., 2018; Enoka & Duchateau, 2016), which includes changes in physiological (e.g., hormonal and muscle damage markers) and athlete-reported (e.g., muscle soreness, mood) outcome measures following exercise. On the other hand, performance fatigability refers to "the decline in objective performance measures (e.g., voluntary force production) derived from the capacity of the nervous system and contractile properties of muscles over time" (Edwards et al., 2018; Enoka & Duchateau, 2016). Hence, fatigue may be best identified where cognitive and/or physical function are diminished due to interactions between perceived fatigability and performance fatigability (Edwards et al., 2018; Enoka & Duchateau, 2016).

During basketball competition, players complete repeated, short bouts of high-intensity activity (e.g., accelerations, decelerations, jumps, and changes-of-direction) interspersed throughout longer periods moving at lower intensities (Ferioli, Rampinini, et al., 2020; Ferioli, Schelling, et al., 2020; Pernigoni et al., 2021; Qarouach et al., 2024), resulting in an average match intensity above lactate threshold and 85% of maximum heart rate (Edwards et al., 2018; Stojanović et al., 2018). As a consequence of these demands, basketball matches can negatively affect performance (e.g., vertical jumping, sprinting, and strength) (Chatzinikolaou et al., 2014; Delextrat et al., 2014; Delextrat, Calleja-González, et al., 2013; Pliauga et al., 2015), physiological status (e.g., muscle damage, inflammation, and

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Supplemental data for this article can be accessed online https://doi.org/10.1080/02640414.2024.2409555

oxidative stress markers) (Chatzinikolaou et al., 2014; Moreira et al., 2014; Souglis et al., 2015), and athlete-reported outcomes (e.g., muscle soreness, perceived fatigue, and mood states) (Chatzinikolaou et al., 2014; Conte et al., 2021; Gonzalez-Bono et al., 1999), with such alterations often persisting for hours or days following match-play (Chatzinikolaou et al., 2014; Moreira et al., 2014; Souglis et al., 2015). Therefore, identifying and combating fatigue is of interest to basketball practitioners (i.e., coaches, strength and conditioning specialists, sport scientists), who seek specific evidence concerning post-match fatigue to implement adequate training periodisation strategies (Edwards et al., 2018) and recovery interventions (Calleja-González et al., 2016; Davis et al., 2022; Pernigoni et al., 2022) following matches.

Furthermore, many modern basketball leagues require teams to complete matches in close succession (Conte et al., 2021; Fox, O'Grady, et al., 2020), such as during the playoffs (Ferioli et al., 2021). This regular and often congested match schedule represents an additional challenge for basketball practitioners striving to manage player fatigue, which could potentially hamper their health and readiness for subsequent training sessions or matches (Montgomery, Pyne, Hopkins, et al., 2008). Accordingly, recent research has suggested that match congestion may influence team outcome (i.e., winning or losing) (Esteves et al., 2021), weekly loads (Clemente et al., 2019; Conte et al., 2018; Fox, O'Grady, et al., 2020), hormonal responses (Kamarauskas et al., 2022), and injury risk (Doeven et al., 2021) among basketball teams.

Although previous review articles focused on basketball have provided interesting insight into the physical and physiological demands encountered during match-play (Stojanović et al., 2018), the effects of mental fatigue on performance (i.e., physical, technical, tactical, and cognitive outcomes) (Cao et al., 2022), the use of fatigue monitoring tools (Edwards et al., 2018), and the effectiveness of post-exercise recovery strategies (Davis et al., 2022; Mihajlovic et al., 2023), no previous study has systematically reviewed available research examining typical fatigue responses surrounding basketball match-play. A summary of evidence on this topic may inform better player management surrounding single and congested matches to enhance the recovery process, reduce injury risk, and optimise loading schemes. Therefore, the aim of this study is to systematically review fatigue responses following single basketball matches and congested match schedules, in terms of performance, physiological, athlete-reported, and sleep-related outcomes. Additionally, this review will inherently identify which outcome measures are most frequently adopted to assess fatigue in basketball, which is important given the increased research interest in this area (Edwards et al., 2018), and establish trends to show how players typically respond to match-play using these outcome measures.

Methods

This review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021). The protocol for this systematic review was pre-registered on the International Prospective Register of Systematic Reviews (PROSPERO Registration #CRD42022342939, 9 July 2022).

Data sources and search strategy

The Scopus, Web of Science, and SPORTDiscus databases were initially searched from inception until 4 July 2022, to identify relevant studies published online or in-print. Subsequently, an updated literature search was conducted on 23 January 2024. Search terms included a mix of medical subject headings (MeSH) and free-text words for key concepts related to basketball, performance, and fatigue. The following search terms were combined using suitable Boolean operators: (basketball) AND (game OR match OR competition OR competitive OR congested OR congestion OR condense OR double-header OR triple-header OR back-to-back) AND (fatigue OR decrement OR technical OR neuromuscular OR muscular power OR muscle power OR jump OR sprint OR agility OR change of direction OR speed OR repeated sprint OR intermittent OR hormones OR hormonal OR muscle damage OR inflammation OR inflammatory OR immunology OR immunological OR reactive oxygen species OR stress OR doms OR soreness OR recovery OR readiness OR time course).

Inclusion and exclusion criteria

Studies involving single or congested matches were considered eligible for inclusion if they satisfied the following criteria: 1) the intervention consisted of official or simulated (i.e., unofficial matches, including friendly matches) 5 × 5 basketball matches following rules from credible world basketball organisations [e.g., International Basketball Federation (FIBA), National Basketball Association (NBA), National Collegiate Athletic Association (NCAA)]; 2) official and simulated matches were included if they consisted of 4 quarters (10 or 12 min each) or 2 halves (20 min each) of match-play, regardless of halftime and inter-quarter break duration; 3) if examining single matches, all outcome measures must have been measured prior to and at some point following the match; 4) if examining congested matches, all outcome measures must have been measured prior to the first match and either following each match or at the end of the congested period; 5) published in a peer-reviewed journal; and 6) written in English.

Studies were excluded from this review if: 1) the intervention consisted of a standardised basketball protocol or training session (e.g., small-sided games, game-based drills, scrimmages). In the case of 5 × 5 scrimmages, studies were excluded if they did not consist of 4 quarters (10 or 12 min each) or 2 halves (20 min each); 2) 3 × 3 or wheelchair basketball matches were examined; 3) basketball players above the age of 50 years were included; or 4) they were studies other than original investigations (e.g., literature reviews, conference proceedings).

Study selection and quality assessment

Search results were uploaded to Endnote 20® software (Clarivate, Philadelphia, PA, USA), where duplicates were removed via an in-built function. Subsequently, two researchers (MP and DC) independently screened the titles and abstracts of retrieved studies according to the eligibility criteria. All disagreements were discussed until consensus was reached between the two researchers. After screening titles and abstracts, full-text versions of all relevant studies were retrieved and independently reviewed by the same two researchers. For any disagreements, the inclusion and exclusion reasons were presented and discussed until consensus was reached among the two researchers. Additionally, the same two researchers consulted the reference list of each included full-text article to identify additional studies for potential inclusion.

The methodological quality and risk of bias from the included studies were determined using a previously designed qualitative assessment tool (lexically adapted for better clarity) consisting of 12 questions, with a maximal attainable score of 24 (Table S1, supplementary material) (Silva et al., 2018).

Data extraction strategy

Two researchers (MP and DC) independently extracted all data and transferred it into a standardised spreadsheet. Specifically, outcome measures were pooled into three subgroups: 1) performance; 2) physiological; and 3) athlete-reported and sleep-related outcomes. Additionally, based on previous research (Goulart et al., 2022), outcome measures for single matches were categorised according to timeframe, including measurements taken at match-end (<1 hour following the end of match-play) and in the hours and days following match-play (persistent fatigue: ≥1 hour after match-play), while outcome measures throughout congested match schedules were not categorised according to timeframe.

The following information was extracted from each study: author names and year of publication, participant sample size, sex, age, and competitive level, match type (i.e., official or simulated), investigated outcome measure(s), timepoints at which the measurements were taken, and statistical changes in outcomes between timepoints. Specifically, competitive level was categorised according to previous research (Russell et al., 2021) as follows: Level 1) untrained or sedentary participants; Level 2) habitually active, physically fit, or recreationally-trained participants; Level 3) trained and competitive players; Level 4) highly-trained and competitive players; or Level 5) professional players. For intervention studies in which different post-match interventions (e.g., recovery strategies) were used, only data from control groups were extracted. If descriptive information (i.e., mean and standard deviation) were presented in figures rather than in text or tables within studies, these data were extracted from graphs using Webplotdigitizer® (version 4.6, Ankit Rohatgi, Pacifica, CA, USA), which has shown acceptable validity and reliability in extracting graph data (Drevon et al., 2017). Furthermore, percentage change was calculated to provide descriptive comparisons between pre- and post-match measurements. Specifically, percentage increase was calculated as [(final value – starting value)/(starting value)] * 100, while percentage decrease was calculated as [(starting value – final value)/(starting value)] * 100. According to previous research (Silva et al., 2018), effect sizes (ES) within individual studies were calculated by dividing the raw ES (i.e., difference in means) by the pooled standard deviations (for each pairwise comparison), and subsequently applying a correction factor (to account for possible overestimation of the true population ES, based on the sample size of each study). According to previous research (Hopkins et al., 2009), ES were interpreted as follows: *trivial* (<0.20), *small* (0.20–0.59), *moderate* (0.60–1.19), *large* (1.20–1.99) and *very large* (≥2.00). When needed, corresponding authors were contacted by email, and all necessary data [which were missing and/or unclearly reported in four studies (Chatzinikolaou et al., 2014; Izquierdo et al., 2024; Kostopoulos et al., 2017; Staunton et al., 2017)] were successfully acquired.

Results

Search findings, study selection and qualitative assessment

The flow chart showing the search and selection process is illustrated in Figure 1. The systematic search identified 3502 relevant studies across all databases combined. In turn, 971 duplicate studies were excluded, while an additional 2445 studies were excluded after screening titles and abstracts, as they did not meet the inclusion criteria. Consequently, 86 studies underwent full-text examination with 44 studies eventually being included in the systematic review. No additional studies were identified through consultation of the reference list from individual full-text articles.

The characteristics of all included studies are presented in Table S2 (supplementary material). The results of quality assessment for the included studies are shown in Table S3 (supplementary material), with total scores ranging from 9 to 22 out of 24, with a mean ± standard deviation of 16.0 ± 3.0 across studies.

Fatigue following single matches

Effects on performance

A total of 19 studies assessed changes in performance at match-end ($n = 16$, Table 1) and/or during post-match days ($n = 7$, Table 2). The most common types of tests included were vertical jump tests (15 studies), linear sprints (6 studies), strength tests [i.e., one repetition maximum (1RM), isokinetic peak torque, and hand-held dynamometry, 4 studies], repeated-sprint ability (RSA) tests (4 studies), flexibility tests (2 studies), and change-of-direction ability tests (i.e., T-test, 2 studies).

Vertical jump height

. At match-end, vertical jump height [measured through the countermovement jump (CMJ) (Chatzinikolaou et al., 2014; Cortis et al., 2011; Delextrat et al., 2012; Díaz-Castro et al., 2018; Izquierdo & Redondo, 2020, 2021; Moreno-Perez et al., 2020; Pliauga et al., 2015) or squat jump (Liveris et al., 2021) tests] was negatively [$p < 0.05$; "likely-to-almost certain" in studies employing magnitude-based inferences (MBI); ES = –0.21 – –2.35, *small-to-very large*] affected from pre-to-post-match in six out of nine studies (i.e., considering studies where pre-to-post-match values were compared through statistical analysis) (Chatzinikolaou et al., 2014; Delextrat et al., 2012; Díaz-Castro et al., 2018; Izquierdo & Redondo, 2020, 2021; Liveris et al., 2021), which included

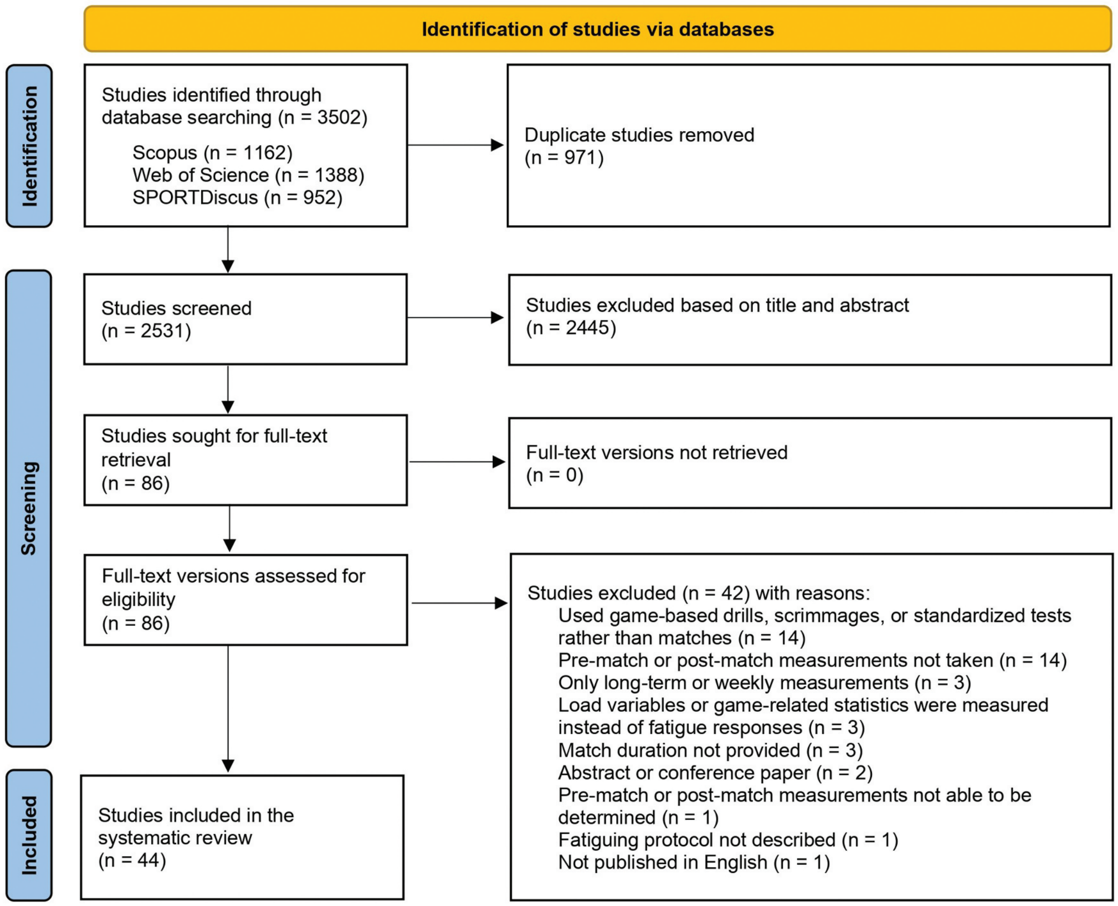

Figure 1. PRISMA flow chart displaying the identification, screening, and selection of relevant studies in this systematic review.

both male [Level 5 (Chatzinikolaou et al., 2014) and Level 2 (Díaz-Castro et al., 2018; Liveris et al., 2021)] and female players [Level 5 (Delextrat et al., 2012) and Level 3 (Izquierdo & Redondo, 2020, 2021)] across official and simulated matches. Conversely, two studies encompassing Level 3 (Pliauga et al., 2015) and Level 5 (Cortis et al., 2011) male players found no significant effects ($p > 0.05$; ES = 0.09 – −1.99, *trivial-to-large*) of match-play on CMJ performance following simulated matches, with only one study reporting an increase (MBI: very likely, ES = 0.42, *small*) in CMJ height following official matches in Level 4 male players (Moreno-Perez et al., 2020). In terms of persistent fatigue, all four studies examining CMJ performance showed jump height significantly decreased between pre-match and 24 ($p < 0.05$; ES = −0.37 – −6.38, *small-to-very large*) (Chatzinikolaou et al., 2014; Delextrat et al., 2014; Delextrat, Calleja-González, et al., 2013; Pliauga et al., 2015) to 48 hours ($p < 0.05$; ES = −0.29– −3.06, *small-to-very large*) (Chatzinikolaou et al., 2014; Pliauga et al., 2015) following official and simulated matches across Level 3 and Level 5 male players, while no significant changes ($p > 0.05$; ES = −0.96 – −0.99, *moderate*) in CMJ height were apparent 24 hours after simulated matches in Level 3 female players (Delextrat et al., 2014; Delextrat, Calleja-González, et al., 2013).

Linear sprint performance. All three studies investigating changes in 20-m linear sprint performance at match-end reported poorer performance ($p < 0.05$; MBI studies: "likely-to-very likely"; ES = 0.58–0.79, *small-to-moderate*) compared to pre-match [Level 5 (Delextrat et al., 2012) and Level 3 (Izquierdo & Redondo, 2020, 2021) female players, official matches]. In terms of changes in 10-m linear sprint performance at match-end, three out of five studies [Level 5 (Chatzinikolaou et al., 2014) and Level 3 (Cortis et al., 2011; Pliauga et al., 2015) male players, simulated matches] reported significant ($p < 0.05$; ES = 0.54–3.76, *small-to-very large*), pre-to-post-match impairments, while two studies [Level 3 females, official matches (Izquierdo & Redondo, 2020, 2021)] mostly failed to do so (MBI: "possibly"; ES = 0.12–0.32, *trivial-to-small*). Finally, two studies examining male players assessed fatigue in the days following simulated match-play, both showing persisting impairments in 10-m sprint performance up to 24 ($p < 0.05$; ES = 0.60, *moderate*; restored at 48 hours; Level 5 players) (Chatzinikolaou et al., 2014) and 48 hours ($p < 0.05$; ES = 7.31, *very large*; Level 3 players) (Pliauga et al., 2015).

Strength-related outcomes. Significant, pre-to-post-match decreases were observed at match-end for 1RM chest-press ($p < 0.05$; ES = −0.28, *small*) and leg-press ($p < 0.05$; ES = −0.68, *moderate*) performance (Level 5 male players, simulated match) (Chatzinikolaou et al., 2014) as well as isokinetic hamstrings ($p < 0.05$; ES = −0.63, *moderate*) – but not quadriceps ($p > 0.05$; ES = −0.28, *small*) – peak torque and isokinetic hamstrings:quadriceps peak torque ratio ($p < 0.01$; ES = −0.75, *moderate*) (Level 5 female players, official match) (Delextrat et al., 2012), while

Table 1. Changes in performance outcomes at match-end (<1 hour post-match) following single matches.

Study	Outcome measure	Pre-match	Post-match	Statistical change	% change	ES (interpretation)
Caprino et al., (2012)	RSA total time (s)	58.81 ± 2.04	60.50 ± 1.71	**P <0.05**	2.87%	0.82 *(moderate)*
	RSA ideal time (s)	57.50 ± 2.04	58.79 ± 1.72	**P <0.05**	2.24%	0.63 *(moderate)*
	RSA performance decrement (%)	2.28 ± 1.04	2.91 ± 1.68	*p* > 0.05	27.63%	0.41 *(small)*
Chatzinikolaou et al., (2014)	CMJ height (cm)	41.20 ± 7.41	39.64 ± 6.79	**P <0.05**	−3.79%	−0.21 *(small)*
	10-m sprint time (s)	1.81 ± 0.08	1.92 ± 0.10	**P <0.05**	6.08%	1.17 *(moderate)*
	1RM leg press (kg)	322.42 ± 78.26	271.95 ± 63.94	**P <0.05**	−15.65%	−0.68 *(moderate)*
	1RM chest press (kg)	84.38 ± 16.48	79.76 ± 15.22	**P <0.05**	−5.48%	−0.28 *(small)*
	Line Drill Test time (s)	28.87 ± 1.66	30.44 ± 1.81	**P <0.05**	5.44%	0.87 *(moderate)*
	T-test time (s)	9.57 ± 0.50	9.91 ± 0.35	**P <0.05**	3.55%	0.76 *(moderate)*
	Knee range of motion (°)	DL: 146.57 ± 9.25	DL: 144.50 ± 7.87	*p* > 0.05	−1.41%	−0.23 *(small)*
		NDL: 144.03 ± 10.54	NDL: 142.72 ± 11.74	*p* > 0.05	−0.91%	−0.11 *(trivial)*
Cortis et al., (2011)	CMJ height (cm)	35.20 ± 5.20	35.70 ± 5.20	*p* > 0.05	1.42%	0.09 *(trivial)*
	Handgrip strength (N)	436.90 ± 73.30	426.50 ± 54.90	*p* > 0.05	−2.38%	−0.15 *(trivial)*
	10-m sprint time (s)	1.79 ± 0.09	1.84 ± 0.08	**P = 0.02**	2.79%	0.54 *(small)*
	10-m dribble time (s)	1.81 ± 0.11	1.96 ± 0.08	**P = 0.003**	8.29%	1.43 *(large)*
	10-m dribble/sprint ratio	1.01 ± 0.06	1.06 ± 0.06	**P = 0.049**	4.95%	0.76 *(moderate)*
	Interlimb coordination (s)	80 bpm: 60.00 ± 1.18	80 bpm: 60.00 ± 0.00	*p* > 0.05	0.00%	0.00 *(trivial)*
		120 bpm: 55.06 ± 11.92	120 bpm: 56.96 ± 7.03	*p* > 0.05	3.45%	0.18 *(trivial)*
		180 bpm: 33.30 ± 20.20	180 bpm: 43.90 ± 19.80	**P = 0.015**	31.83%	0.48 *(small)*
Delextrat et al., (2012)	Quadriceps peak torque (N·m)	108.80 ± 8.64	103.50 ± 8.09	*p* > 0.05	−4.87%	−0.57 *(small)*
	Hamstrings peak torque (N·m)	77.80 ± 9.04	71.60 ± 8.65	**P <0.05**	−7.97%	−0.63 *(moderate)*
	Hamstrings:quadriceps torque ratio	0.73 ± 0.06	0.68 ± 0.06	**P <0.01**	−6.85%	−0.75 *(moderate)*
	CMJ height (cm)	33.80 ± 0.84	29.20 ± 2.36	**P <0.05**	−13.61%	−2.35 *(very large)*
	20-m sprint time (s)	3.85 ± 0.33	4.13 ± 0.31	**P <0.05**	7.27%	0.79 *(moderate)*
Delextrat, Baliqi, et al., (2013)	RSA average speed (m/s)	Peak: 4.41 ± 0.48	Peak: 4.21 ± 0.49	*p* = 0.112	−4.54%	−0.37 *(small)*
		Mean: 3.95 ± 0.46	Mean: 3.82 ± 0.50	**P = 0.027**	−3.29%	−0.24 *(small)*
		PD (%): 11.60 ± 6.10	PD (%): 10.10 ± 4.00	*p* = 0.615	−12.93%	−0.26 *(small)*
	RSA maximal speed (m/s)	Peak: 5.36 ± 0.38	Peak: 5.26 ± 0.49	*p* = 0.245	−1.87%	−0.21 *(small)*
		Mean: 5.07 ± 0.51	Mean: 4.96 ± 0.60	*p* = 0.501	−2.17%	−0.18 *(trivial)*
		PD (%): 5.40 ± 0.20	PD (%): 5.70 ± 4.20	*p* = 0.865	5.56%	0.09 *(trivial)*
	RSA acceleration (m/s^2)	Peak: 1.89 ± 0.31	Peak: 1.74 ± 0.26	*p* = 0.123	−7.94%	−0.47 *(small)*
		Mean: 1.44 ± 0.24	Mean: 1.44 ± 0.17	*p* = 0.973	0.00%	0.00 *(trivial)*
		PD (%): 23.90 ± 5.60	PD (%): 16.70 ± 5.40	**P = 0.016**	−30.13%	−1.18 *(moderate)*
	RSA average horizontal force (N)	Peak: 215 ± 19	Peak: 210 ± 22	*p* = 0.341	−2.33%	−0.22 *(small)*
		Mean: 187 ± 26	Mean: 179 ± 22	**P = 0.032**	−4.28%	−0.30 *(small)*
		PD (%): 13.00 ± 6.30	PD (%): 14.60 ± 6.70	*p* = 0.552	12.31%	0.22 *(small)*
	RSA maximal horizontal force (N)	Peak: 790 ± 113	Peak: 608 ± 113	**P = 0.016**	−23.04%	−1.45 *(large)*
		Mean: 652 ± 98	Mean: 538 ± 85	**P = 0.037**	−17.48%	−1.12 *(moderate)*
		PD (%): 17.30 ± 5.70	PD (%): 10.80 ± 5.10	*p* = 0.121	−37.57%	−1.09 *(moderate)*
	RSA average vertical force (N)	Peak: 890 ± 110	Peak: 858 ± 122	**P = 0.032**	−3.60%	−0.25 *(small)*
		Mean: 871 ± 108	Mean: 839 ± 118	**P = 0.034**	−3.67%	−0.26 *(small)*
		PD (%): 2.10 ± 0.70	PD (%): 2.20 ± 1.00	*p* = 0.805	4.76%	0.10 *(trivial)*
	RSA maximal vertical force (N)	Peak: 2474 ± 335	Peak: 2390 ± 265	**P = 0.035**	−3.40%	−0.25 *(small)*
		Mean: 2337 ± 278	Mean: 2269 ± 253	*p* = 0.064	−2.91%	−0.23 *(small)*
		PD (%): 5.30 ± 2.40	PD (%): 5.10 ± 0.70	*p* = 0.808	−3.77%	−0.10 *(trivial)*
	RSA average power (W)	Peak: 892 ± 134	Peak: 851 ± 136	*p* = 0.215	−4.60%	−0.27 *(small)*
		Mean: 731 ± 141	Mean: 699 ± 131	*p* = 0.266	−4.38%	−0.21 *(small)*
		PD (%): 17.40 ± 10.30	PD (%): 15.40 ± 4.50	*p* = 0.589	−11.49%	−0.23 *(small)*
	RSA maximal power (W)	Peak: 2843 ± 763	Peak: 2682 ± 560	*p* = 0.169	−5.66%	−0.22 *(small)*
		Mean: 2433 ± 588	Mean: 2343 ± 561	*p* = 0.407	−3.70%	−0.14 *(trivial)*
		PD (%): 12.00 ± 6.40	PD (%): 14.90 ± 5.60	*p* = 0.429	24.17%	0.44 *(small)*
	RSA contact time (ms)	165 ± 14	177 ± 22	**P = 0.027**	7.27%	0.59 *(small)*

(Continued)

Table 1. (Continued).

Study	Outcome measure	Pre-match	Post-match	Statistical change	% change	ES (interpretation)
	RSA flight time (ms)	85 ± 8	85 ± 9	$p = 0.807$	0.00%	0.00 *(trivial)*
	RSA stride duration (ms)	502 ± 33	525 ± 51	**P = 0.037**	4.58%	0.48 *(small)*
	RSA swing time (ms)	337 ± 21	348 ± 33	$p = 0.089$	3.26%	0.36 *(small)*
	RSA stride frequency (Hz)	4.01 ± 0.28	3.85 ± 0.31	**P = 0.033**	−3.99%	−0.49 *(small)*
	RSA stride length (m)	1.02 ± 0.17	0.98 ± 0.17	$p = 0.208$	−3.92%	−0.21 *(small)*
Díaz-Castro et al., (2018)	CMJ height (cm)	37.30 ± 4.90	33.90 ± 4.20	**P = 0.0002**	−9.12%	−0.70 *(moderate)*
González-Devesa et al., (2023)	CMJ height (cm)	Game 1: 23.40 ± 3.50	Game 1: 24.00 ± 3.01	N/A	2.56%	0.17 *(trivial)*
		Game 2: 24.40 ± 3.70	Game 2: 25.10 ± 3.98	N/A	2.87%	0.17 *(trivial)*
Hoffman et al., (2012)	Shooting performance (shots made)	N/A	N/A	N/A	−0.49 shots made*	N/A
	Lower-body reaction time (contacts)	N/A	N/A	N/A	1.49 contacts*	N/A
	Visual reaction time (s)	N/A	N/A	N/A	0.02 s*	N/A
	Motor reaction time (s)	N/A	N/A	N/A	0.03 s*	N/A
	Peak CMJ power (W)	N/A	N/A	N/A	−14.68 W*	N/A
	Mean CMJ power (W)	N/A	N/A	N/A	−10.82 W*	N/A
Izquierdo & Redondo, (2020)	10-m sprint time (s)	Guards: 1.90 ± 0.11	Guards: 1.92 ± 0.21	50/23/27 (possibly)	1.05%	0.12 *(trivial)*
		Forwards: 1.92 ± 0.09	Forwards: 1.98 ± 0.13	85/12/3 (likely)	3.13%	0.53 *(small)*
		Centres: 1.93 ± 0.14	Centres: 1.91 ± 0.13	19/38/43 (possibly)	−1.04%	−0.14 *(trivial)*
	20-m sprint time (s)	Guards: 3.15 ± 0.14	Guards: 3.26 ± 0.22	84/11/5 (likely)	3.49%	0.58 *(small)*
		Forwards: 3.21 ± 0.14	Forwards: 3.32 ± 0.19	89/9/2 (likely)	3.43%	0.65 *(moderate)*
		Centres: 3.21 ± 0.13	Centres: 3.31 ± 0.19	83/13/5 (likely)	3.12%	0.60 *(moderate)*
	CMJ height (cm)	Guards: 31.95 ± 3.12	Guards: 27.94 ± 1.91	0/1/99 (very likely)	−12.55%	−1.52 *(large)*
		Forwards: 33.86 ± 3.71	Forwards: 29.22 ± 3.19	0/0/100 (almost certain)	−13.70%	−1.31 *(large)*
		Centres: 32.28 ± 3.00	Centres: 29.49 ± 3.46	1/6/93 (likely)	−8.64%	−0.84 *(moderate)*
Izquierdo & Redondo, (2021)	10-m sprint time (s)	U16: 2.13 ± 0.14	U16: 2.18 ± 0.17	70/28/2 (possibly)	2.35%	0.32 *(small)*
		U18: 1.91 ± 0.11	U18: 1.94 ± 0.15	55/39/6 (possibly)	1.57%	0.23 *(small)*
	20-m sprint time (s)	U16: 3.48 ± 0.19	U16: 3.60 ± 0.16	96/4/0 (very likely)	3.45%	0.68 *(moderate)*
		U18: 3.20 ± 0.13	U18: 3.30 ± 0.19	97/3/0 (very likely)	3.12%	0.61 *(moderate)*
	CMJ height (cm)	U16: 30.06 ± 3.19	U16: 26.49 ± 3.30	0/0/100 (almost certain)	−11.88%	−1.09 *(moderate)*
		U18: 32.84 ± 3.37	U18:28.94 ± 2.97	0/0/100 (almost certain)	−11.88%	−1.21 *(large)*
Izquierdo et al., (2024)	CMJ height (cm)	CT: 44.41 ± 6.75	CT: 42.21 ± 4.28	N/A	−4.72%	−0.36 *(small)*
		NCT: 44.02 ± 7.03	NCT: 42.14 ± 4.53	N/A	−4.31%	−0.30 *(small)*
Liveris et al., (2021)	Squat jump height (cm)	36.70 ± 4.20	34.60 ± 4.10	**P = 0.002**	−5.72%	−0.48 *(small)*
	Landing Error Scoring System (AU)	7.10 ± 1.30	7.70 ± 1.40	**P = 0.034**	8.45%	0.42 *(small)*
Moreno-Perez et al., (2020)	CMJ height (m)	0.48 ± 0.07	0.51 ± 0.07	99/1/0 (very likely)	6.25%	0.42 *(small)*
	Ankle dorsiflexion (cm)	DL: 8.09 ± 2.43	DL: 9.43 ± 2.51	100/0/0 (most likely)	16.56%	0.53 *(small)*
		NDL: 8.08 ± 2.25	NDL: 9.40 ± 2.52	100/0/0 (most likely)	16.34%	0.54 *(small)*
Pernigoni et al., (2023)	CMJ height (cm)	29.00 ± 4.80	Post-match: 27.29 ± 3.86	Pre – post-match: N/A	−5.90%	−0.38 *(small)*
			40-min post-match: 29.21 ± 4.49	Pre – 40-min post-match: N/A	0.72%	0.04 *(trivial)*
Pliauga et al., (2015)	10-m sprint time (s)	1.70 ± 0.01	Post-match: 1.73 ± 0.02	Pre – post-match: **P <0.05**	1.76%	1.78 *(large)*
			20-min post-match: 1.74 ± 0.01	Pre – 20 min post-match: **P <0.05**	2.35%	3.76 *(very large)*
	CMJ height (cm)	49.60 ± 0.66	Post-match: 48.90 ± 0.82	Pre – post-match: $p > 0.05$	−1.41%	−0.88 *(moderate)*
			20 min post-match: 48.20 ± 0.66	Pre – 20 min post-match: $p > 0.05$	−2.82%	−1.99 *(large)*
Shibata et al., (2023)	Symbol Digit Modalities Test score (correct answers)	67.50 ± 8.42	83.92 ± 10.84	**P <0.001**	24.33%	1.57 *(large)*
	Centre of gravity sway – total locus length (cm)	SO: 37.96 ± 10.59	SO: 36.90 ± 13.61	$p = 0.833$	−2.79%	−0.08 *(trivial)*
		SC: 76.83 ± 20.53	SC: 67.35 ± 16.45	$p = 0.225$	−12.34%	−0.47 *(small)*
		DO: 41.71 ± 13.12	DO: 41.85 ± 20.79	$p = 0.984$	0.34%	0.01 *(trivial)*
		DC: 72.40 ± 19.43	DC: 70.66 ± 17.99	$p = 0.822$	−2.40%	−0.09 *(trivial)*
	Centre of gravity sway – locus length per unit area (cm)	SO: 24.54 ± 10.53	SO: 22.57 ± 12.23	$p = 0.677$	8.03%	−0.16 *(trivial)*
		SC: 13.00 ± 2.78	SC: 9.87 ± 3.66	**P = 0.028**	−24.08%	−0.90 *(moderate)*
		DO: 20.64 ± 7.97	DO: 23.37 ± 14.32	$p = 0.570$	13.23%	0.22 *(small)*
		DC: 12.63 ± 7.75	DC: 13.26 ± 3.24	$p = 0.707$	4.99%	0.10 *(trivial)*

(*Continued*)

Table 1. (Continued).

Study	Outcome measure	Pre-match	Post-match	Statistical change	% change	ES (interpretation)
	Centre of gravity sway – peripheral area (cm)	SO: 1.83 ± 0.95	SO: 2.04 ± 1.08	$p = 0.620$	11.48%	0.19 *(trivial)*
		SC: 6.18 ± 2.05	SC: 7.50 ± 2.57	$p = 0.178$	21.36%	0.53 *(small)*
		DO: 2.31 ± 1.14	DO: 2.81 ± 2.09	$p = 0.469$	21.65%	0.28 *(small)*
		DC: 6.51 ± 3.20	DC: 5.66 ± 2.10	$p = 0.450$	−13.06%	−0.29 *(small)*
	Star Excursion Balance Test reach (cm)	AR: 65.47 ± 5.68	AR: 65.56 ± 6.40	$p = 0.714$	0.14%	0.01 *(trivial)*
		PMR: 88.20 ± 6.04	PMR: 89.58 ± 7.27	$p = 0.912$	1.56%	0.19 *(trivial)*
		PLR: 93.92 ± 6.51	PLR: 93.95 ± 7.87	$p = 0.992$	0.03%	0.00 *(trivial)*

Data presented as mean ± standard deviation. Bolded *p* values indicate a significant difference; * percentage change not computable. *Abbreviations*: ES, effect size; RSA, repeated sprint ability; CMJ, countermovement jump; 1RM, one-repetition maximum; DL, dominant leg; NDL, non-dominant leg; bpm, beats per minute; PD, performance decrement; N/A, data not available; U16, under 16 years; U18, under 18 years; CT, matches with a close score margin at match-end (clutch time); NCT, matches with a wide score margin at match-end (non-clutch time); SO, static balance ability measured with open eyes; SC, static balance ability measured with closed eyes; DO, static balance ability measured with open eyes, during the execution of a concurrent cognitive task; DC, static balance ability measured with closed eyes, during the execution of a concurrent cognitive task; AR, anterior reach; PMR, postero-medial reach; PLR, postero-lateral reach.

Table 2. Persistent (≥1 hour post-match) changes in performance outcomes following single matches.

Study	Outcome measure	Pre-match	24 h	48 h	Statistical changes	% change	ES (interpretation)
Chatzinikolaou et al., (2014)	CMJ height (cm)	41.20 ± 7.41	38.43 ± 7.14	39.13 ± 6.16	Pre − 24 h: **$P < 0.05$**	−6.72%	−0.37 *(small)*
					Pre − 48 h: **$P < 0.05$**	−5.02%	−0.29 *(small)*
	10-m sprint (s)	1.81 ± 0.08	1.86 ± 0.08	1.84 ± 0.10	Pre − 24 h: **$P < 0.05$**	2.76%	0.60 *(moderate)*
					Pre − 48 h: $p > 0.05$	1.66%	0.32 *(small)*
	1RM leg press (kg)	322.42 ± 78.26	273.15 ± 61.04	283.03 ± 62.74	Pre − 24 h: **$P < 0.05$**	−15.28%	−0.67 *(moderate)*
					Pre − 48 h: **$P < 0.05$**	−12.22%	−0.53 *(small)*
	1RM chest press (kg)	84.38 ± 16.48	81.18 ± 15.75	80.60 ± 15.17	Pre − 24 h: $p > 0.05$	−3.79%	−0.19 *(trivial)*
					Pre − 48 h: $p > 0.05$	−4.48%	−0.23 *(small)*
	Line Drill Test (s)	28.87 ± 1.66	30.06 ± 1.55	30.45 ± 2.41	Pre − 24 h: **$P < 0.05$**	4.12%	0.71 *(moderate)*
					Pre − 48 h: **$P < 0.05$**	5.47%	0.73 *(moderate)*
	T-test (s)	9.57 ± 0.50	9.90 ± 0.51	9.86 ± 0.50	Pre − 24 h: **$P < 0.05$**	3.45%	0.63 *(moderate)*
					Pre − 48 h: **$P < 0.05$**	3.03%	0.56 *(small)*
	Knee range of motion (°)	DL: 146.57 ± 9.25	DL: 133.13 ± 7.63	DL: 138.74 ± 7.97	Pre-24 h DL: **$P < 0.05$**	−9.17%	−1.52 *(large)*
		NDL: 144.03 ± 10.54	NDL: 138.63 ± 9.97	NDL: 142.50 ± 7.43	Pre-24 h NDL: **$P < 0.05$**	−3.75%	−0.51 *(small)*
					Pre-48 h DL: **$P < 0.05$**	−5.34%	−0.87 *(moderate)*
					Pre-48 h NDL: $p > 0.05$	−1.06%	−0.16 *(trivial)*
Delextrat, Calleja-González, et al., (2013)	CMJ height (cm)	♂: 49.56 ± 5.43	♂: 46.23 ± 4.83	-	**$P < 0.05$**	−6.72%	−0.58 *(small)*
		♀: 34.41 ± 2.54	♀: 31.58 ± 2.69		$p > 0.05$	−8.22%	−0.96 *(moderate)*
	RSA total time (s)	♂: 58.40 ± 2.95	♂: 57.75 ± 1.85	-	$p > 0.05$	−1.11%	−0.23 *(small)*
		♀: 63.49 ± 2.37	♀: 64.49 ± 2.97		$p > 0.05$	1.58%	0.33 *(small)*
	RSA ideal time (s)	♂: 56.05 ± 3.58	♂: 55.74 ± 1.97	-	$p > 0.05$	−0.55%	−0.10 *(trivial)*
		♀: 61.33 ± 2.24	♀: 62.41 ± 3.19		$p > 0.05$	1.76%	0.35 *(small)*
	Performance decrement (%)	♂: 4.3 ± 1.5	♂: 3.6 ± 1.7	-	$p > 0.05$	−16.28%	−0.39 *(small)*
		♀: 3.6 ± 0.3	♀: 3.5 ± 0.7		$p > 0.05$	−2.78%	−0.17 *(trivial)*
Delextrat et al., (2014)	CMJ height (cm)	♂: 49.50 ± 5.53	♂: 46.21 ± 4.88	-	**$P \leq 0.001$**	−6.65%	−0.57 *(small)*
		♀: 34.38 ± 2.45	♀: 31.49 ± 2.73		$p > 0.05$	−8.41%	−0.99 *(moderate)*
	RSA total time (s)	♂: 58.40 ± 2.80	♂: 56.30 ± 4.4	-	$p > 0.05$	−3.60%	−0.51 *(small)*
		♀: 63.50 ± 2.20	♀: 64.50 ± 2.8		$p > 0.05$	1.57%	0.35 *(small)*
	RSA ideal time (s)	♂: 56.00 ± 3.40	♂: 55.70 ± 1.8	-	$p > 0.05$	−0.54%	−0.10 *(trivial)*
		♀: 61.30 ± 2.10	♀: 62.40 ± 3.0		$p > 0.05$	1.79%	0.38 *(small)*
	Performance decrement (%)	♂: 4.34 ± 1.58	♂: 3.64 ± 1.82	-	$p > 0.05$	−16.13%	−0.37 *(small)*
		♀: 3.61 ± 0.37	♀: 3.49 ± 0.73		$p > 0.05$	−3.32%	−0.18 *(trivial)*
Moreira et al., (2014)	1RM leg press (kg)	N/A	N/A	N/A	All $p > 0.05$	N/A	N/A
	1RM bench press (kg)	N/A	N/A	N/A	All $p > 0.05$	N/A	N/A
	T-test (s)	N/A	N/A	N/A	All $p > 0.05$	N/A	N/A
Moreno-Perez et al., (2020)	Ankle dorsiflexion (cm)	DL: 8.09 ± 2.43	-	DL: 7.54 ± 2.52	0/42/58 (possibly)	−6.80%	−0.22 *(small)*
		NDL: 8.08 ± 2.25		NDL: 7.43 ± 2.53	0/25/75 (possibly)	−8.04%	−0.26 *(small)*
Pernigoni et al., (2023)	CMJ height (cm)	29.00 ± 4.80	29.41 ± 4.26	-	N/A	1.41%	0.08 *(trivial)*
Pliauga et al., (2015)	10-m sprint (s)	1.70 ± 0.01	1.82 ± 0.01	1.78 ± 0.01	Pre − 24 h: **$P < 0.05$**	7.06%	10.97 *(very large)*
					Pre − 48 h: **$P < 0.05$**	4.71%	7.31 *(very large)*
	CMJ height (cm)	49.6 ± 0.66	45.2 ± 0.60	46.9 ± 0.93	Pre − 24 h: **$P < 0.05$**	−8.87%	−6.38 *(very large)*
					Pre − 48 h: **$P < 0.05$**	−5.44%	−3.06 *(very large)*

Data presented as mean ± standard deviation. Bolded p values indicate a significant difference. *Abbreviations*: ES, effect size; CMJ, countermovement jump; 1RM, one-repetition maximum; DL, dominant leg; NDL, non-dominant leg; RSA, repeated sprint ability; ♂, male participants; ♀, female participants; N/A, data not available.

handgrip strength was preserved ($p > 0.05$; ES = −0.15, *trivial*) in one study (Level 3 male players, simulated match) (Cortis et al., 2011). On post-match days, persistent impairments (compared to pre-match) in 1RM leg-press were significant ($p < 0.05$; ES = −0.53 – −0.67, *small-to-moderate*) only in Level 5 male players up to 48 hours following a simulated match (restored at 72 hours) (Chatzinikolaou et al., 2014), with no significant changes ($p > 0.05$) up to 48 hours in Level 5 female players (official match) (Moreira et al., 2014), alongside no impairments in 1RM chest-press for both Level 5 males [$p > 0.05$; ES = −0.09 – −0.23, *trivial-to-small*; up to 144 hours (Chatzinikolaou et al., 2014)] and females [$p > 0.05$; up to 48 hours (Moreira et al., 2014)] following simulated and official matches, respectively.

Repeated-sprint ability. Pre-to-post-match changes in RSA outcomes at match-end were investigated in two studies, both indicating poorer performance. In the first study, Caprino et al (2012) found significantly slower RSA total time and ideal time ($p < 0.05$; ES = 0.63–0.82, *small*) after official match-play in youth, Level 2 male players, with no significant changes ($p > 0.05$; ES = 0.41, *small*) in performance decrement. The second study analysed several kinetic and kinematic RSA outcomes in Level 3 male players (Delextrat, Baliqi, et al., 2013), reporting significant impairments in most of the analysed outcomes following official matches (see Table 1 for a detailed description). Furthermore, two studies assessed the persistent effect of official match-play on RSA total time, ideal time, and performance decrement, with no significant differences ($p > 0.05$; ES = −0.10 – −0.51, *trivial-to-small*) reported for either Level 3 males or females (Delextrat et al., 2014; Delextrat, Calleja-González, et al., 2013) at 24 hours post-match compared to pre-match measurements.

Joint range of motion. Increased (MBI: "most likely"; ES = 0.53–0.54, *small*) ankle dorsiflexion (official match) (Moreno-Perez et al., 2020), but unaltered ($p > 0.05$; ES = −0.11 – −0.23, *trivial-to-small*) knee range of motion (simulated match) (Chatzinikolaou et al., 2014) were found at match-end, compared to pre-match, in Level 4 and 5 male players, respectively. The persistent effects of official match-play – compared with pre-match measurements – revealed no substantial decreases (MBI: "possibly"; ES = −0.22 – −0.26, *small*) in ankle dorsiflexion at 48 hours post-match in Level 4 males (Moreno-Perez et al., 2020), while knee range of motion was significantly decreased up to 48 hours in the dominant leg ($p < 0.05$; ES = −0.87 – −1.52, *moderate-to-large*) and 24 hours in the non-dominant leg ($p < 0.05$; ES = −0.51, *small*) (normalising at 72 and 48 hours, respectively) after a simulated match in Level 5 males (Chatzinikolaou et al., 2014).

Change-of-direction ability. Simulated match-play induced a significant decline in T-test performance at match-end ($p < 0.05$; ES = 0.76, *moderate*), and up to 48 hours ($p < 0.05$; ES = 0.56–0.63, *small-to-moderate*; normalising at 72 hours) in Level 5 male players (Chatzinikolaou et al., 2014), while no significant changes ($p > 0.05$) were apparent at 24 hours post-match in Level 5 female players following an official match (Moreira et al., 2014).

Effects on physiological responses

Post-match changes in physiological indicators of fatigue were assessed at match-end ($n = 19$ studies, Table 3) and/or in the hours and days following match-play ($n = 8$ studies, Table 4) in 22 studies, mainly including blood and salivary markers. In turn, various markers were analysed, mainly assessing hormonal status (12 studies), muscle damage (7 studies), inflammation and immune function (5 studies), metabolic processes (4 studies), and oxidative stress (3 studies).

Hormonal status. All studies investigating changes in hormonal outcomes following match-play were conducted among male players. Significant ($p < 0.05$; ES = 0.63–5.76, *moderate-to-very large*), pre-to-post-match increases in cortisol levels were reported at match-end in all 10 studies that investigated this marker in blood (Abdelkrim et al., 2009; Chatzinikolaou et al., 2014; Souglis et al., 2015) and saliva (Arruda et al., 2014, 2017; Gonzalez-Bono et al., 1999; Moreira et al., 2013, 2018; Moreira, Crewther, et al., 2012; Moreira, McGuigan, et al., 2012) across official and simulated match-play in different player samples [except for salivary cortisol following simulated matches in Level 4 (Moreira, Crewther, et al., 2012) and 5 (Moreira, McGuigan, et al., 2012) players; $p > 0.05$; ES = 0.21–0.50; *small*], with descriptive findings from a further study also reporting ~23–25% increases (ES = 1.44–1.63, *large*) following official competition (Izquierdo et al., 2024). Salivary testosterone concentrations increased from pre-to-post-match in three studies [significant increases ($p \leq 0.005$; ES = 0.63–1.15, *moderate*) following official matches in Level 3 (Arruda et al., 2019) and Level 4 (Arruda et al., 2014) players, in addition to descriptively reported, ~25–28% increases (ES = 1.92–1.98, *large*) in Level 3 players (Izquierdo et al., 2024)], while blood ($p > 0.05$; ES = −0.25, *small*; simulated match, Level 5 players) (Chatzinikolaou et al., 2014) and salivary ($p > 0.05$; official matches, Level 5 players) (Gonzalez-Bono et al., 1999, 2000) testosterone concentrations were unaffected following matches in three other studies. In terms of persistent effects, pre-match blood cortisol concentration was unaffected at 13–37 hours ($p > 0.05$; ES = 0.34–0.36, *small*) (Souglis et al., 2015) and 24–144 hours ($p > 0.05$; ES = 1.69–2.68, *large-to-very large*; together with testosterone, $p > 0.05$; ES = 0.07 – −0.56, trivial-to-small) (Chatzinikolaou et al., 2014) following official and simulated match-play, respectively, in Level 5 players.

Muscle damage. Regarding changes at match-end, four studies analysed the effects of match-play on muscle damage markers. Specifically, compared to pre-match values, two studies reported significant ($p < 0.01$; ES = 1.21–4.26, *large-to-very large*) increases in muscle damage markers following matches among Level 2 (i.e., CK, simulated match) (Díaz-Castro et al., 2018) and Level 5 [i.e., CK and lactate dehydrogenase (LDH), official match] (Souglis et al., 2015) male players, while two other studies showed no significant changes ($p > 0.05$; ES = 0.73–1.46, *moderate-to-large*) in Level 5 male (i.e., CK, simulated match) (Chatzinikolaou et al., 2014) and female (i.e., CK and myoglobin, official match) players (Moreira et al., 2014). Regarding persistent changes, all studies reported significant increases ($p < 0.05$; ES = 0.70–3.74, *moderate-to-very large*) in CK (Chatzinikolaou et al., 2014; Koyama et al., 2022; Moreira et al.,

Table 3. Changes in physiological outcomes at match-end (<1 hour post-match) following single matches.

Study	Outcome measure	Pre-match	Post-match	Statistical changes	% change	ES (interpretation)
Abdelkrim et al., (2007)	Lactate concentration (mmol/L)	All players: N/A	All players: 4.94 ± 1.46	N/A	N/A	N/A
		Guards: 1.46 ± N/A	Guards: 5.89 ± N/A	**P <0.01**	303.42%	N/A
		Forwards: 1.75 ± N/A	Forwards: 4.95 ± N/A	**P <0.01**	182.86%	N/A
		Centres: 1.27 ± N/A	Centres: 4.23 ± N/A	**P <0.01**	233.07%	N/A
Abdelkrim et al., (2009)	Haematocrit (%)	44.80 ± 2.30	44.40 ± 2.10	*p* > 0.05	−0.90%	−0.18 *(trivial)*
	Triglycerides concentration (mmol/L)	0.86 ± 0.35	1.68 ± 0.37	**P <0.001**	48.81%	2.23 *(very large)*
	Free fatty acids concentration (mmol/L)	0.34 ± 0.06	0.99 ± 0.14	**P <0.001**	65.66%	5.91 *(very large)*
	Glucose concentration (mmol/L)	4.05 ± 1.27	5.26 ± 0.88	**P <0.001**	23.00%	1.08 *(moderate)*
	Insulin concentration (µmol/L)	13.84 ± 3.01	10.03 ± 2.73	**P <0.001**	−37.99%	−1.30 *(large)*
	Cortisol concentration (nmol/L)	334 ± 120	615 ± 195	**P <0.001**	45.69%	1.70 *(large)*
Arruda et al., (2014)	Salivary cortisol concentration (nmol/L)	Home: 19.50 ± 5.20	Home: 31.40 ± 7.60	**P = 0.005**	61.03%	1.73 *(large)*
		Away: 19.10 ± 5.70	Away: 28.50 ± 9.50	**P = 0.005**	49.21%	1.13 *(moderate)*
	Salivary testosterone concentration (pmol/L)	Home: 701 ± 146	Home: 944 ± 243	**P = 0.005**	34.66%	1.15 *(moderate)*
		Away: 531 ± 153	Away: 770 ± 257	**P = 0.005**	45.01%	1.07 *(moderate)*
Arruda et al., (2017)	Salivary cortisol concentration (nmol/L)	Hard match: 18.90 ± 5.80	Hard match: 31.40 ± 5.30	**P <0.05**	66.14%	2.09 *(very large)*
		Medium match: 13.00 ± 7.40	Medium match: 21.50 ± 8.30	**P <0.05**	65.38%	1.01 *(moderate)*
		Easy match: 10.10 ± 4.90	Easy match: 17.30 ± 10.20	**P <0.05**	71.29%	0.84 *(moderate)*
Arruda et al., (2019)	Salivary testosterone concentration (pmol/L)	Semifinals: 525.56 ± 113.56	Semifinals: 648.04 ± 146.26	**P <0.001**	23.30%	0.91 *(moderate)*
		Finals: 507.73 ± 105.24	Finals: 613.56 ± 202.74	**(main effect of time)**	20.84%	0.63 *(moderate)*
Chatzinikolaou et al., (2014)	Lactate concentration (mM)	1.30 ± 0.10	7.90 ± 1.90	**P <0.05**	83.54%	4.71 *(very large)*
	Glucose concentration (mmol/L)	4.63 ± 0.23	5.26 ± 0.31	**P <0.05**	11.98%	2.22 *(very large)*
	Non-esterified fatty acids concentration (mM)	0.40 ± 0.07	0.65 ± 0.12	**P <0.05**	38.46%	2.44 *(very large)*
	Triglycerides concentration (mM)	0.96 ± 0.20	1.45 ± 0.40	**P <0.05**	33.79%	1.49 *(large)*
	Glycerol concentration (µM)	0.12 ± 0.01	0.19 ± 0.02	**P <0.05**	36.84%	4.25 *(very large)*
	Urea concentration (mmol/L)	12.67 ± 1.86	13.24 ± 2.07	*p* > 0.05	4.31%	0.28 *(small)*
	Ammonia concentration (µM)	47.60 ± 5.30	91.20 ± 8.00	**P <0.05**	47.81%	6.17 *(very large)*
	Leukocyte count (*10^9/L)	6.74 ± 0.66	9.05 ± 1.92	**P <0.05**	25.52%	1.54 *(large)*
	C-reactive protein concentration (nmol/L)	8.93 ± 1.95	11.87 ± 3.90	**P <0.05**	24.77%	0.92 *(moderate)*
	Creatine kinase concentration (U/L)	201.92 ± 44.44	239.08 ± 53.26	*p* > 0.05	15.54%	0.73 *(moderate)*
	$sVCAM_1$ concentration (ng/mL)	423.18 ± 99.73	790.78 ± 119.93	**P <0.05**	46.49%	3.20 *(very large)*
	Soluble platelet selectin concentration (ng/mL)	145.93 ± 21.68	165.45 ± 23.11	*p* > 0.05	11.80%	0.84 *(moderate)*
	Uric acid concentration (µmol/L)	260.37 ± 24.79	275.81 ± 20.33	*p* > 0.05	5.60%	0.65 *(moderate)*
	Cortisol concentration (nmol/L)	285.45 ± 12.07	378.68 ± 18.37	**P <0.05**	24.62%	5.76 *(very large)*
	Testosterone concentration (nmol/L)	7.10 ± 0.90	6.89 ± 0.68	*p* > 0.05	−3.05%	−0.25 *(small)*
	Endoglin concentration (ng/mL)	4.31 ± 0.50	4.22 ± 0.39	*p* > 0.05	−2.13%	−0.19 *(trivial)*
	Interleukin-1β concentration (fmol/L)	195.93 ± 32.94	396.11 ± 54.30	**P <0.05**	50.54%	4.28 *(very large)*
	Interleukin-6 concentration (fmol/L)	281.70 ± 38.39	568.75 ± 111.16	**P <0.05**	50.47%	3.31 *(very large)*
	Reduced glutathione concentration (mM)	0.39 ± 0.02	0.28 ± 0.04	**P <0.05**	−39.29%	−3.34 *(very large)*
	Oxidised glutathione concentration (mM)	0.03 ± 0.02	0.04 ± 0.01	**P <0.05**	25.00%	0.61 *(moderate)*
	Reduced:oxidised glutathione ratio	11.24 ± 1.65	7.46 ± 1.19	**P <0.05**	−50.67%	−2.52 *(very large)*
	Glutathione peroxidase activity (U/L)	4711.01 ± 300.71	5676.86 ± 415.39	**P <0.05**	17.01%	2.56 *(very large)*
	Total antioxidant capacity (mM DPPH)	0.65 ± 0.09	0.81 ± 0.14	**P <0.05**	19.75%	1.31 *(large)*
	Catalase activity (nmol/min/mg Hb)	152.35 ± 9.88	184.15 ± 13.84	**P <0.05**	17.27%	2.54 *(very large)*
	Malondialdehyde concentration (µM)	0.25 ± 0.01	0.34 ± 0.03	**P <0.05**	26.47%	3.86 *(very large)*
	Protein carbonyls concentration (nmol/mg protein)	0.45 ± 0.04	0.59 ± 0.08	**P <0.05**	23.73%	2.13 *(very large)*
Díaz-Castro et al., (2018)	Sodium concentration (mmol/L)	141.70 ± 1.10	142.80 ± 1.10	**P = 0.002**	0.77%	0.94 *(moderate)*
	Potassium concentration (mmol/L)	4.60 ± 0.40	4.60 ± 0.40	*p* = 0.9	0.00%	0.00 *(trivial)*
	Creatine kinase concentration (U/L)	223.60 ± 93.10	308.80 ± 9.70	**P <0.0001**	27.59%	1.21 *(large)*
	Body mass (kg)	72.50 ± 13.70	72.00 ± 13.50	**P <0.0001**	−0.69%	−0.03 *(trivial)*
	Urine specific gravity (g/mL)	1.021 ± 0.006	1.026 ± 0.004	**P <0.0001**	0.49%	N/A
Gonzalez-Bono et al., (1999)	Salivary cortisol concentration (nmol/L)	Win: 3.30 ± 1.09*	Win: 6.30 ± 1.53*	**P <0.02**	90.91%	N/A*
		Loss: 3.66 ± 0.28*	Loss: 5.18 ± 0.96*	**(main effect of time)**	41.53%	N/A*

(Continued)

Table 3. (Continued).

Study	Outcome measure	Pre-match	Post-match	Statistical changes	% change	ES (interpretation)
	Salivary testosterone concentration (nmol/L)	Win: 0.13 ± 0.03*	Win: 0.15 ± 0.03*	$p > 0.05$	15.38%	N/A*
		Loss: 0.18 ± 0.02*	Loss: 0.16 ± 0.02*	(main effect of time)	−11.11%	N/A*
Gonzalez-Bono et al., (2000)	Salivary testosterone concentration (nmol/L)	T1: 0.078 ± 0.017*	T1: 0.116 ± 0.025*	$p < 0.058$	48.72%	N/A*
		T2: 0.087 ± 0.009*	T2: 0.087 ± 0.016*	$p < 0.97$	0.00%	N/A*
Izquierdo et al., (2024)	Salivary cortisol concentration (nmol/l)	CT: 21.15 ± 3.13	CT: 26.34 ± 2.77	N/A	25.18%	1.63 *(large)*
		NCT: 21.10 ± 2.87	NCT: 25.75 ± 3.12	N/A	22.78%	1.44 *(large)*
	Salivary testosterone concentration (pmol/l)	CT: 655.23 ± 46.76	CT: 820.56 ± 102.99	N/A	24.73%	1.92 *(large)*
		NCT: 661.00 ± 61.36	NCT: 847.88 ± 107.79	N/A	28.06%	1.98 *(large)*
	Testosterone:cortisol ratio	CT: 0.032 ± 0.005**	CT: 0.031 ± 0.004**	N/A	−3.13%	−0.21 *(small)*
		NCT: 0.032 ± 0.006**	NCT: 0.034 ± 0.007**	N/A	6.25%	0.29 *(small)*
Moreira, McGuigan, et al., (2012)	Salivary cortisol concentration (nmol/L)	SM: 4.79 ± 2.02	SM: 6.04 ± 2.54	$p > 0.05$	26.10%	0.50 *(small)*
		OM: 9.13 ± 3.96	OM: 17.12 ± 7.98	**P <0.05**	87.51%	1.16 *(moderate)*
Moreira, Crewther, et al., (2012)	Salivary cortisol concentration (nmol/L)	SM: 4.20 ± 0.70	SM: 4.4 ± 1.00	$p > 0.05$	4.76%	0.21 *(small)*
		OM: 6.10 ± 0.80	OM: 12.7 ± 2.20	**P <0.05**	108.20%	3.65 *(very large)*
	Salivary immunoglobulin A concentration (μg/mL)	SM: 494 ± 99	SM: 635 ± 137	$p > 0.05$	28.54%	1.08 *(moderate)*
		OM: 457 ± 68	OM: 552 ± 59	$p > 0.05$	20.79%	1.36 *(large)*
	Salivary immunoglobulin A rate (μg/min)	SM: 118 ± 22	SM: 145 ± 31	$p > 0.05$	22.88%	0.92 *(moderate)*
		OM: 132 ± 30	OM: 156 ± 26	$p > 0.05$	18.18%	0.78 *(moderate)*
Moreira et al., (2013)	Salivary cortisol concentration (nmol/L)	4.44 ± 1.30	6.79 ± 2.41	**P <0.05**	52.93%	1.17 *(moderate)*
	Salivary interleukin-21 concentration (pg/mL)	194.92 ± 44.93	163.32 ± 36.55	**P <0.05**	−16.21%	−0.74 *(moderate)*
	Salivary immunoglobulin A concentration (μg/mL)	107.50 ± 63.81	110.59 ± 81.79	$p > 0.05$	2.87%	0.04 *(trivial)*
	Salivary immunoglobulin A rate (μg/min)	18.28 ± 8.94	18.58 ± 10.93	$p > 0.05$	1.64%	0.03 *(trivial)*
	Total protein concentration (mg/mL)	1.70 ± 0.80	1.90 ± 0.90	$p = 0.7$	11.76%	0.23 *(small)*
Moreira et al., (2014)	Creatine kinase concentration (U/L)	178.59 ± 19.77	313.41 ± 122.47	$p > 0.05$	75.49%	1.46 *(large)*
	Myoglobin concentration (ng/mL)	28.85 ± 7.36	51.08 ± 27.35	$p > 0.05$	77.05%	1.05 *(moderate)*
Moreira et al., (2018)	Salivary BDNF concentration (pg/mL)	1037.25 ± 487.11	979.94 ± 461.32	$p > 0.05$	−5.53%	−0.12 *(trivial)*
	Salivary cortisol concentration (nmol/L)	9.26 ± 3.8	17.19 ± 7.11	**P <0.05**	85.64%	1.35 *(large)*
Pernigoni et al., (2023)	Ln-rMSSD (ms)	4.00 ± 0.60	Post-match: 2.63 ± 0.51	Pre – post-match: N/A	−34.25%	−2.30 *(very large)*
			40-min post-match: 3.71 ± 0.71	Pre – 40-min post-match: N/A	−7.25%	−0.41 *(small)*
			45-min post-match: 3.75 ± 0.66	Pre – 45-min post-match: N/A	−6.25%	−0.37 *(small)*
Perrea et al., (2014)	Total serum peroxides concentration (μmol/L)	50.60 ± 95.70***	58.10 ± 66.80***	N/A	14.82%	N/A***
	Myeloperoxidase concentration (ng/mL)	54.00 ± 40.00***	52.00 ± 32.00***	N/A	−3.70%	N/A***
	Polymorphonuclear elastase concentration (ng/mL)	23.30 ± 13.00***	16.42 ± 7.00***	N/A	−29.53%	N/A***
	Fibrinogen concentration (g/L)	1.29 ± 0.18***	1.24 ± 0.18***	N/A	−3.88%	N/A***
Souglis et al., (2015)	Tumour necrosis α concentration (pg/mL)	1.73 ± 0.74	3.84 ± 1.03	**P <0.01**	121.97%	2.25 *(very large)*
	Interleukin-6 concentration (pg/L)	1.10 ± 0.19	3.95 ± 0.52	**P <0.01**	259.09%	6.95 *(very large)*
	C-reactive protein concentration (pg/mL)	1.56 ± 1.25	1.67 ± 1.31	$p > 0.05$	7.05%	0.08 *(trivial)*
	Creatine kinase concentration (U/L)	150.67 ± 30.99	293.86 ± 33.12	**P <0.01**	95.04%	4.26 *(very large)*
	Lactate dehydrogenase concentration (IU/L)	155.54 ± 37.99	228.36 ± 27.71	**P <0.01**	46.82%	2.09 *(very large)*
	Urea concentration (mg/dL)	35.58 ± 3.98	48.65 ± 4.17	**P <0.01**	36.73%	3.06 *(very large)*
	Ammonia concentration (μmol/L)	32.13 ± 3.48	44.28 ± 4.03	**P <0.01**	37.82%	3.08 *(very large)*
	Cortisol concentration (μg/dL)	12.24 ± 1.71	20.82 ± 3.60	**P <0.01**	70.10%	2.91 *(very large)*
Stålnacke et al., (2003)	S100 calcium-binding protein B concentration (μg/L)	0.22 ± 0.04	0.30 ± 0.10	**P = 0.001**	36.36%	1.00 *(moderate)*
	Neuron-specific enolase concentration (μg/L)	9.71 ± 2.93	10.26 ± 3.06	$p = 0.13$	5.66%	0.18 *(trivial)*

Data presented as mean ± standard deviation, unless otherwise specified. Bolded *p* values indicate a significant difference; * data reported as mean ± standard error of the mean; ** values erroneously reported in the original study (Izquierdo et al., 2024) were recalculated after obtaining the dataset from the corresponding author; *** data reported as median ± interquartile range. *Abbreviations*: ES, effect size; N/A, data not available; $sVCAM_1$, Circulating Vascular Cell Adhesion Molecule-1; T1, Team 1; T2, Team 2; CT, matches with a close score margin at match-end (clutch time); NCT, matches with a wide score margin at match-end (non-clutch time); SM, simulated match; OM, official match; BDNF, brain-derived neurotrophic factor; Ln-rMSSD, log-transformed squared root of the mean sum of the squared differences between R-R intervals.

Table 4. Persistent (≥1 hour post-match) changes in physiological outcomes following single matches.

Study	Outcome measure	Pre-match	2 h	4 h	13 h	15 h	24 h	37 h	39 h	48 h	Statistical changes	% change	ES (interpretation)
Chatzinikolaou et al., (2014)	Leukocyte count (*10^9/L)	6.74 ± 0.66	-	-	-	-	8.05 ± 1.51	-	-	7.40 ± 1.16	Pre – 24 h: **P <0.05** Pre – 48 h: $p > 0.05$	19.43% 9.79%	1.08 *(moderate)* 0.67 *(moderate)*
	C-reactive protein concentration (nmol/L)	8.93 ± 1.95	-	-	-	-	17.63 ± 3.00	-	-	11.29 ± 2.86	Pre – 24 h: **P <0.05** Pre – 48 h: $p > 0.05$	97.42% 26.43%	3.30 *(very large)* 0.93 *(moderate)*
	Creatine kinase concentration (U/L)	202 ± 44	-	-	-	-	298 ± 62	-	-	398 ± 80	Pre – 24 h: **P <0.05** Pre – 48 h: **P <0.05**	47.62% 96.96%	1.71 *(large)* 2.91 *(very large)*
	$sVCAM_1$ concentration (ng/mL)	423 ± 100	-	-	-	-	816 ± 122	-	-	485 ± 110	Pre – 24 h: **P <0.05** Pre – 48 h: $p > 0.05$	92.72% 14.63%	3.38 *(very large)* 0.57 *(small)*
	Soluble platelet selectin concentration (ng/mL)	146 ± 22	-	-	-	-	179 ± 25	-	-	160 ± 29	Pre – 24 h: $p > 0.05$ Pre – 48 h: $p > 0.05$	22.52% 9.35%	1.35 *(large)* 0.52 *(small)*
	Uric acid concentration (μmol/L)	260 ± 25	-	-	-	-	311 ± 38	-	-	294 ± 35	Pre – 24 h: **P <0.05** Pre – 48 h: $p > 0.05$	19.28% 12.96%	1.52 *(large)* 1.07 *(moderate)*
	Cortisol concentration (nmol/L)	285 ± 12	-	-	-	-	326 ± 17	-	-	320 ± 16	Pre – 24 h: $p > 0.05$ Pre – 48 h: $p > 0.05$	14.03% 12.05%	2.68 *(very large)* 2.38 *(very large)*
	Testosterone concentration (nmol/L)	7.10 ± 0.90	-	-	-	-	6.60 ± 0.80	-	-	6.78 ± 1.09	Pre – 24 h: $p > 0.05$ Pre – 48 h: $p > 0.05$	−7.04% −4.51%	−0.56 *(small)* −0.31 *(small)*
	Endoglin concentration (ng/mL)	4.31 ± 0.50	-	-	-	-	4.46 ± 0.59	-	-	4.52 ± 0.50	Pre – 24 h: $p > 0.05$ Pre – 48 h: $p > 0.05$	3.48% 4.87%	0.26 *(small)* 0.40 *(small)*
	Interleukin-1β concentration (fmol/L)	196 ± 33	-	-	-	-	266 ± 62	-	-	245 ± 22	Pre – 24 h: $p > 0.05$ Pre – 48 h: $p > 0.05$	35.66% 24.94%	1.35 *(large)* 1.68 *(large)*
	Interleukin-6 concentration (fmol/L)	282 ± 38	-	-	-	-	353 ± 79	-	-	363 ± 74	Pre – 24 h: $p > 0.05$ Pre – 48 h: $p > 0.05$	25.36% 29.00%	1.10 *(moderate)* 1.32 *(large)*
	Reduced glutathione concentration (mM)	0.39 ± 0.02	-	-	-	-	0.21 ± 0.02	-	-	0.36 ± 0.03	Pre – 24 h: **P <0.05** Pre – 48 h: $p > 0.05$	−46.15% −7.69%	−8.64 *(very large)* −1.13 *(moderate)*
	Oxidised glutathione concentration (mM)	0.03 ± 0.02	-	-	-	-	0.04 ± 0.01	-	-	0.03 ± 0.01	Pre – 24 h: **P <0.05** Pre – 48 h: $p > 0.05$	33.33% 0.00%	0.61 *(moderate)* 0.00 *(trivial)*
	Reduced: oxidised glutathione ratio	11.24 ± 1.65	-	-	-	-	5.25 ± 1.07	-	-	10.58 ± 1.36	Pre – 24 h: **P <0.05** Pre – 48 h: $p > 0.05$	−53.29% −5.87%	−4.14 *(very large)* −0.42 *(small)*
	Glutathione peroxidase activity (U/L)	4711 ± 301	-	-	-	-	5896 ± 456	-	-	4943 ± 359	Pre – 24 h: **P <0.05** Pre – 48 h: $p > 0.05$	25.15% 4.92%	2.94 *(very large)* 0.67 *(moderate)*
	Total antioxidant capacity (mM DPPH)	0.65 ± 0.09	-	-	-	-	0.88 ± 0.12	-	-	0.74 ± 0.13	Pre – 24 h: **P <0.05** Pre – 48 h: $p > 0.05$	35.38% 13.85%	2.08 *(very large)* 0.77 *(moderate)*
	Catalase activity (nmol/min/mg Hb)	152 ± 10	-	-	-	-	190 ± 11	-	-	164 ± 11	Pre – 24 h: **P <0.05** Pre – 48 h: $p > 0.05$	24.82% 7.73%	3.47 *(very large)* 1.10 *(moderate)*
	Malondialdehyde concentration (μM)	0.25 ± 0.01	-	-	-	-	0.39 ± 0.04	-	-	0.28 ± 0.06	Pre – 24 h: **P <0.05** Pre – 48 h: $p > 0.05$	56.00% 12.00%	4.61 *(very large)* 0.67 *(moderate)*
	Protein carbonyls concentration (nmol/mg protein)	0.45 ± 0.04	-	-	-	-	0.64 ± 0.10	-	-	0.49 ± 0.12	Pre – 24 h: **P <0.05** Pre – 48 h: $p > 0.05$	42.22% 8.89%	2.40 *(very large)* 0.43 *(small)*

(*Continued*)

Table 4. (Continued).

Study	Outcome measure	Pre-match	2 h	4 h	13 h	15 h	24 h	37 h	39 h	48 h	Statistical changes	% change	ES (interpretation)
Kostopoulos et al., (2017)	Leukocyte count (10^3/μL)	5.10 ± 1.00	-	-	-	6.40 ± 0.80	-	-	6.40 ± 1.30	-	Pre-15 h: **P <0.05** Pre-39 h: **P <0.05**	25.49% 25.49%	1.37 *(large)* 1.07 *(moderate)*
	Neutrophils (%)	51.60 ± 8.20	-	-	-	56.30 ± 10.80	-	-	56.70 ± 8.80	-	Pre-15 h: $p > 0.05$ Pre-39 h: **P <0.05**	9.11% 9.88%	0.47 *(small)* 0.57 *(small)*
	Lymphocytes (%)	42.50 ± 8.30	-	-	-	36.90 ± 8.10	-	-	38.40 ± 9.00	-	Pre-15 h: **P <0.05** Pre-39 h: $p > 0.05$	−13.18% −9.65%	−0.65 *(moderate)* −0.45 *(small)*
	Red blood cells count (10^6/μL)	4.98 ± 0.25	-	-	-	4.98 ± 0.26	-	-	5.05 ± 0.27	-	Pre-15 h: $p > 0.05$ Pre-39 h: $p > 0.05$	0.00% 1.41%	0.00 *(trivial)* 0.26 *(small)*
	Mercury concentration (μg/L)	16.40 ± 0.65	-	-	-	16.40 ± 0.75	-	-	16.80 ± 0.71	-	Pre-15 h: $p > 0.05$ Pre-39 h: $p > 0.05$	0.00% 2.44%	0.00 *(trivial)* 0.56 *(small)*
	Haematocrit (%)	44.30 ± 1.71	-	-	-	44.00 ± 2.09	-	-	44.70 ± 2.03	-	Pre-15 h: $p > 0.05$ Pre-39 h: $p > 0.05$	−0.68% 0.90%	−0.15 *(trivial)* 0.20 *(small)*
	Platelet count (10^3/μL)	196 ± 35	-	-	-	218 ± 40	-	-	221 ± 38	-	Pre-15 h: **P <0.05** Pre-39 h: **P <0.05**	11.22% 12.76%	0.56 *(small)* 0.65 *(moderate)*
	Glucose concentration (mg/dL)	74.20 ± 4.20	-	-	-	76.50 ± 9.80	-	-	73.90 ± 11.00	-	Pre-15 h: $p > 0.05$ Pre-39 h: $p > 0.05$	3.10% −0.40%	0.29 *(small)* −0.03 *(trivial)*
	Triacylglycerols concentration (mg/dL)	93.00 ± 61.00	-	-	-	85.00 ± 58.00	-	-	93.00 ± 56.00	-	Pre-15 h: $p > 0.05$ Pre-39 h: $p > 0.05$	−8.60% 0.00%	−0.13 *(trivial)* 0.00 *(trivial)*
	Total cholesterol concentration (mg/dL)	158 ± 28	-	-	-	160 ± 29	-	-	158 ± 32	-	Pre-15 h: $p > 0.05$ Pre-39 h: $p > 0.05$	1.27% 0.00%	0.07 *(trivial)* 0.00 *(trivial)*
	LDL cholesterol concentration (mg/dL)	99.00 ± 27.00	-	-	-	102 ± 27	-	-	98.00 ± 31.00	-	Pre-15 h: $p > 0.05$ Pre-39 h: $p > 0.05$	3.03% −1.01%	0.11 *(trivial)* −0.03 *(trivial)*
	HDL cholesterol concentration (mg/dL)	41.00 ± 12.00	-	-	-	42.00 ± 11.00	-	-	41.00 ± 11.00	-	Pre-15 h: $p > 0.05$ Pre-39 h: $p > 0.05$	2.44% 0.00%	0.08 *(trivial)* 0.00 *(trivial)*
	Uric acid concentration (mg/dL)	4.80 ± 0.80	-	-	-	5.20 ± 1.10	-	-	4.80 ± 0.90	-	Pre-15 h: $p > 0.05$ Pre-39 h: $p > 0.05$	8.33% 0.00%	0.40 *(small)* 0.00 *(trivial)*
	Creatine kinase concentration (U/L)	RC: 118 ± 20 NRC: 180 ± 80	-	-	-	RC: 266 ± 54 NRC: 184 ± 78	-	-	RC: 129 ± 43 NRC: 156 ± 76	-	Pre-15 h RC: **P <0.05** Pre-15 h NRC: $p > 0.05$ Pre-39 h RC: $p > 0.05$ Pre-39 h NRC: $p > 0.05$	125.42% 2.22% 9.32% −13.33%	3.47 *(very large)* 0.05 *(trivial)* 0.31 *(small)* −0.29 *(small)*
	Lactate dehydrogenase concentration (U/L)	183 ± 31	-	-	-	187 ± 34	-	-	184 ± 38	-	Pre-15 h: $p > 0.05$ Pre-39 h: $p > 0.05$	2.19% 0.55%	0.12 *(trivial)* 0.03 *(trivial)*
	Thiobarbituric acid reactive substances concentration (μM)	1.35 ± 0.34	-	-	-	1.37 ± 0.34	-	-	1.41 ± 0.29	-	Pre-15 h: $p > 0.05$ Pre-39 h: $p > 0.05$	1.48% 4.44%	0.06 *(trivial)* 0.18 *(trivial)*
Koyama et al., (2022)	Creatine kinase concentration (U/L)	141 ± 77	-	-	-	-	215 ± 122	-	-	-	**P = 0.001**	52.77%	0.70 *(moderate)*
Moreira et al., (2014)	Creatine kinase concentration (U/L)	179 ± 20	-	-	-	-	396 ± 134	-	-	263 ± 135	Pre-24 h: **P <0.05** Pre-48 h: $p > 0.05$	121.74% 47.43%	2.15 *(very large)* 0.83 *(moderate)*
	Myoglobin concentration (ng/mL)	29.85 ± 7.36	-	-	-	-	158 ± 49	-	-	114 ± 39	Pre-24 h: **P <0.05** Pre-48 h: **P <0.05**	448.87% 295.77%	3.47 *(very large)* 2.85 *(very large)*

(*Continued*)

Table 4. (Continued).

Study	Outcome measure	Pre-match	2 h	4 h	13 h	15 h	24 h	37 h	39 h	48 h	Statistical changes	% change	ES (interpretation)
Nie et al., (2008)	Cardiac Troponin T concentration (ng/mL)	0.005 ± 0.000	0.014 ± 0.012	0.023 ± 0.029	-	-	0.005 ± 0.000	-	-	-	N/A	Pre-2 h: 180% Pre-4 h: 360% Pre-24 h: 0%	0.97 *(moderate)* 0.80 *(moderate)* N/A*
	Cardiac Troponin I concentration (ng/mL)	0.015 ± 0.013	0.029 ± 0.023	0.054 ± 0.064	-	-	0.029 ± 0.012	-	-	-	N/A	Pre-2 h: 93% Pre-4 h: 260% Pre-24 h: 93%	0.69 *(moderate)* 0.77 *(moderate)* 1.02 *(moderate)*
Pernigoni et al., (2023)	Ln-rMSSD (ms)	4.00 ± 0.60	-	-	-	-	4.05 ± 0.63	-	-	-	N/A	1.25%	0.08 *(trivial)*
Pliauga et al., (2015)	Creatine kinase concentration (U/L)	197 ± 32	-	-	-	-	409 ± 66	-	-	276 ± 38	Pre-24 h: **P <0.05** Pre-48 h: **P <0.05**	107.73% 40.52%	3.74 *(very large)* 2.06 *(very large)*
Souglis et al., (2015)	Tumour necrosis factor α concentration (pg/mL)	1.73 ± 0.74	-	-	1.94 ± 0.74	-	-	1.84 ± 0.75	-	-	Pre-13 h: $p > 0.05$ Pre-37 h: $p > 0.05$	12.14% 6.36%	0.27 *(small)* 0.14 *(trivial)*
	Interleukin-6 concentration (pg/mL)	1.10 ± 0.19	-	-	1.18 ± 0.32	-	-	1.12 ± 0.22	-	-	Pre-13 h: $p > 0.05$ Pre-37 h: $p > 0.05$	7.27% 1.82%	0.29 *(small)* 0.09 *(trivial)*
	C-reactive protein concentration (pg/mL)	1.56 ± 1.25	-	-	3.35 ± 1.39	-	-	1.61 ± 1.22	-	-	Pre-13 h: **P <0.01** Pre-37 h: $p > 0.05$	114.74% 3.21%	1.29 *(large)* 0.04 *(trivial)*
	Creatine kinase concentration (U/L)	151 ± 31	-	-	467 ± 156	-	-	320 ± 38	-	-	Pre-13 h: **P <0.01** Pre-37 h: **P <0.01**	209.92% 112.05%	2.68 *(very large)* 4.66 *(very large)*
	Lactate dehydrogenase concentration (IU/L)	156 ± 38	-	-	324 ± 25	-	-	287 ± 68	-	-	Pre-13 h: **P <0.01** Pre-37 h: **P <0.01**	108.40% 84.22%	4.99 *(very large)* 2.27 *(very large)*
	Urea concentration (mg/dL)	35.58 ± 3.98	-	-	40.25 ± 3.07	-	-	37.12 ± 3.13	-	-	Pre-13 h: **P <0.01** Pre-37 h: **P <0.01**	13.13% 4.33%	1.26 *(large)* 0.41 *(small)*
	Ammonia concentration (µmol/L)	32.13 ± 3.48	-	-	36.59 ± 2.39	-	-	32.80 ± 2.63	-	-	Pre-13 h: **P <0.01** Pre-37 h: $p > 0.05$	13.88% 2.09%	1.43 *(large)* 0.21 *(small)*
	Cortisol concentration (µg/dL)	12.24 ± 1.71	-	-	12.89 ± 1.71	-	-	12.89 ± 1.89	-	-	Pre-13 h: $p > 0.05$ Pre-37 h: $p > 0.05$	5.31% 5.31%	0.36 *(small)* 0.34 *(small)*

Data presented as mean ± standard deviation. Bolded *p* values indicate a significant difference. Data from Chatzinikolaou et al. (2014) are only reported up to 48 hours post-match to facilitate comparisons across studies and improve readability, as this is the only investigation that included measurements beyond this timeframe. * based on data extracted from this study (Nie et al., 2008), effect size was not computable (pooled standard deviation = 0). *Abbreviations*: ES, effect size; $sVCAM_1$, circulating vascular cell adhesion molecule-1; LDL, low-density lipoprotein; HDL, high-density lipoprotein; RC, responders cluster; NRC, non-responders cluster; N/A, data not available; Ln-rMSSD, log-transformed squared root of the mean sum of the squared differences between R-R intervals.

2014; Pliauga et al., 2015) and myoglobin (Moreira et al., 2014) concentrations between pre-match and 24 hours post-match across different match types (i.e., official and simulated), player sexes, and competitive levels, with some studies showing that CK concentrations were significantly higher than pre-match measurements for up to 37 ($p < 0.01$; ES = 2.27–4.66, *very large*; Level 5 males, official match) (Souglis et al., 2015), 48 ($p < 0.05$; ES = 2.06, *very large*; Level 3 males, simulated match) (Pliauga et al., 2015), and 72 hours ($p < 0.05$; ES = 2.67–2.91, *very large*; Level 5 males, restored at 96 hours after simulated match) (Chatzinikolaou et al., 2014). A further study reported significantly higher myoglobin ($p < 0.05$; ES = 2.85, *very large*) but not CK ($p > 0.05$; ES = 0.83, *moderate*) concentrations at 48 hours following official match-play in Level 5 female players, compared with pre-match measurements (Moreira et al., 2014). Interestingly, another study divided Level 5 male players into "responder" and "non-responder" clusters based on pre-to-post -match increases in CK concentration, showing responders exhibited significant increases in CK concentration at 15 ($p < 0.05$; ES = 3.47, *very large*) but not 39 hours ($p > 0.05$; ES = 0.31, *small*) following a playoff match (Kostopoulos et al., 2017). Additionally, blood LDH concentration was measured in this study, with no significant changes ($p > 0.05$; ES = 0.03–0.12, *trivial*) at 15 and 39 hours post-match compared to pre-match measurements (Kostopoulos et al., 2017).

Inflammation and immune function. In Level 5 male players, inflammatory blood markers (i.e., pro-inflammatory cytokines, leukocyte infiltration, adhesion molecules) generally had significant increases ($p < 0.05$; ES = 0.92–6.95, *moderate-to-very large*) at match-end compared to pre-match measurements across official (Souglis et al., 2015) and simulated matches (Chatzinikolaou et al., 2014), while salivary immunoglobulin A concentrations showed no pre-to-post-match changes ($p > 0.05$; ES = 0.03–1.36, *trivial-to-large*) in Level 4 male players following official (Moreira et al., 2013; Moreira, Crewther, et al., 2012) and simulated (Moreira, Crewther, et al., 2012) matches. Mixed findings were shown in terms of persistent responses following official (Kostopoulos et al., 2017; Souglis et al., 2015) and simulated matches (Chatzinikolaou et al., 2014) among Level 5 male players, with significant increases in leukocyte count at 15 ($p < 0.05$; ES = 1.37, *large*) (Kostopoulos et al., 2017), 24 ($p < 0.05$; ES = 1.08, *moderate*; restored at 48 hours) (Chatzinikolaou et al., 2014) and 39 hours ($p < 0.05$; ES = 1.07, *moderate*) (Kostopoulos et al., 2017), c-reactive protein (CRP) at 13 ($p < 0.01$; ES = 1.29, *large*; restored at 37 hours) (Souglis et al., 2015) and 24 hours ($p < 0.05$; ES = 3.30, *very large*; restored at 48 hours) (Chatzinikolaou et al., 2014), and circulating vascular cell adhesion molecule-1 (sVCAM-1) at 24 hours post-match ($p < 0.05$; ES = 3.38, *very large*; restored at 48 hours), but no significant changes in soluble platelet selectin (sP-selectin), interleukin-1β (IL-1β) (Chatzinikolaou et al., 2014), interleukin-6 (IL-6) (Chatzinikolaou et al., 2014; Souglis et al., 2015), and tumour necrosis factor α (TNF-α) (Souglis et al., 2015) at 13–37 ($p > 0.05$; ES = 0.09–0.29; *trivial-to-small*) (Souglis et al., 2015) and 24–144 hours ($p > 0.05$; ES = −0.14 – 1.68, *trivial-to-large*) (Chatzinikolaou et al., 2014) post-match.

Metabolic processes. Compared to pre-match measurements, markers of carbohydrate (i.e., glucose and insulin concentration), lipid (i.e., fatty acids, triglycerides, glycerol), and protein (i.e., ammonia, urea) metabolism were significantly affected ($p < 0.05$; ES = 1.08–6.17, *moderate-to-very large*) immediately after official (Abdelkrim et al., 2009; Souglis et al., 2015) and simulated (Chatzinikolaou et al., 2014) match-play across different male player samples in all three studies [Level 5 (Chatzinikolaou et al., 2014; Souglis et al., 2015) and Level 3–4 (Abdelkrim et al., 2009)], with the exception of urea in one study ($p > 0.05$; ES = 0.28, *small*) (Chatzinikolaou et al., 2014). Furthermore, markers of protein metabolism in Level 5 male players remained significantly elevated for up to 13 (ammonia: $p < 0.01$; ES = 1.43, *large*; restored at 37 hours) and 37 hours (urea: $p < 0.01$; ES = 0.40–1.26, *small-to-large*) (Souglis et al., 2015) compared with pre-match measurements, while glucose concentration was unaffected ($p > 0.05$; ES = −0.03 – 0.29, *trivial-to-small*) at 15 and 39 hours (Kostopoulos et al., 2017) following official matches.

Oxidative stress. At match-end, a significant ($p < 0.05$; ES = 0.61–3.86, *moderate-to-very large*), detrimental effect on oxidative stress markers was found after a simulated match compared to pre-match measurements in Level 5 male players (Chatzinikolaou et al., 2014), with descriptive comparisons showing a similar trend in youth, Level 3 male players following an official match (Perrea et al., 2014). In the former study, significantly increased ($p < 0.05$; ES = 0.61 – −8.64, *moderate-to-very large*) oxidative stress persisted for up to 24 hours following simulated match-play (normalising at 48 hours) (Chatzinikolaou et al., 2014). In contrast, a third study investigating a playoff match in Level 5 male players found no significant differences ($p > 0.05$; ES = 0.00–0.40, *trivial-to-small*) in uric acid concentration at 15 and 39 hours post-match compared to pre-match measurements (Kostopoulos et al., 2017).

Effects on athlete-reported and sleep-related outcome measures

Overall, nine studies examined changes in athlete-reported and sleep-related outcome measures at match-end ($n = 6$, Table 5) and/or during post-match days ($n = 6$, Table 6), including measures of muscle soreness or pain (5 studies), perceived fatigue and mood states (i.e., perceived tension, depression, anger, vigour, confusion, 4 studies), and sleep outcomes (i.e., objective or athlete-reported outcomes, 3 studies).

Perceived muscle soreness. Regarding changes at match-end, two out of the three studies investigating perceived muscle soreness in males showed significant increases ($p < 0.05$; ES = 1.03, *moderate*) in Level 5 (Chatzinikolaou et al., 2014) and Level 3 players (Cortis et al., 2011) following simulated matches compared with pre-match measurements. In the former study, significantly elevated muscle soreness ($p < 0.05$) persisted up to 24 and 48 hours post-match in the quadriceps and hamstrings, respectively (normalising at 48 and 72 hours) (Chatzinikolaou et al., 2014), while soreness was unaffected ($p = 0.082$; ES = −0.40, *small*) on post-match morning (compared with pre-match morning) in a third study investigating Level 5 male players across official matches (Conte et al., 2021). For females,

Table 5. Changes in athlete-reported outcome measures at match-end (<1 hour post-match) following single matches.

Study	Outcome measure	Pre-match	Post-match	Statistical changes	% change	ES (interpretation)
Chatzinikolaou et al., (2014)	Quadriceps soreness (AU)	1.00 ± N/A	2.27 ± 0.33	**P <0.05**	127.00%	N/A
	Hamstrings soreness (AU)	1.00 ± N/A	2.69 ± 0.30	**P <0.05**	169.00%	N/A
Cortis et al., (2011)	Muscle pain (AU)	2.20 ± 3.00	5.20 ± 2.30	**P = 0.005**	136.36%	1.03 *(moderate)*
Gonzalez-Bono et al., (1999)	Tension (AU)	Win: 5.63 ± 1.15*	Win: 5.13 ± 1.89*	N/A	−8.88%	N/A*
		Loss: 7.38 ± 1.29*	Loss: 11.33 ± 2.69*		53.52%	N/A*
	Depression (AU)	Win: 1.63 ± 0.68*	Win: 3.38 ± 2.68*	N/A	107.36%	N/A*
		Loss: 1.25 ± 0.49*	Loss: 14.50 ± 4.42*		1060.00%	N/A*
	Anger (AU)	Win: 4.13 ± 1.03*	Win: 5.38 ± 2.99*	N/A	30.27%	N/A*
		Loss: 6.71 ± 2.04*	Loss: 24.00 ± 5.80*		13.56%	N/A*
	Vigour (AU)	Win: 12.75 ± 0.84*	Win: 10.25 ± 1.21*	N/A	−19.61%	N/A*
		Loss: 21.50 ± 1.48*	Loss: 12.17 ± 1.74*		−42.46%	N/A*
	Fatigue (AU)	Win: 2.00 ± 0.53*	Win: 5.38 ± 1.57*	N/A	169.00%	N/A*
		Loss: 1.13 ± 0.35*	Loss: 11.50 ± 2.32*		917.70%	N/A*
	Confusion (AU)	Win: 3.00 ± 0.76*	Win: 3.25 ± 1.26*	N/A	8.33%	N/A*
		Loss: 2.13 ± 0.48*	Loss: 7.00 ± 1.51*		228.64%	N/A*
	Total mood score (AU)	Win: 3.63 ± 3.61*	Win: 12.25 ± 9.52*	N/A	237.47%	N/A*
		Loss: −3.57 ± 1.73*	Loss: 56.17 ± 15.07*		1473.39%	N/A*
Gonzalez-Bono et al., (2000)	Profile of Mood States total score (AU)	T1: 102.00 ± 2.84*	T1: 108.22 ± 4.17*	$p > 0.05$	6.44%	N/A*
		T2: 98.00 ± 1.79*	T2: 119.86 ± 9.55*	$p > 0.05$	22.30%	N/A*
	Fatigue (AU)	T1: 1.33 ± 0.55*	T1: 4.00 ± 0.85*	**P <0.01**	200.75%	N/A*
		T2: 1.13 ± 0.58*	T2: 9.13 ± 3.01*	**P <0.03**	707.97%	N/A*
	Vigour (AU)	T1: 14.11 ± 1.53*	T1: 11.11 ± 2.27*	$p > 0.13$	−21.26%	N/A*
		T2: 18.63 ± 2.69*	T2: 14.13 ± 1.68*	**P <0.04**	−24.15%	N/A*
Moreira et al., (2014)	Hamstrings soreness (mm)	7.39 ± 3.02	14.02 ± 7.99	$p > 0.05$	89.72%	1.04 *(moderate)*
Pernigoni et al., (2023)	Muscle soreness (mm)	14.54 ± 8.18	Post-match: 43.54 ± 19.34	Pre – post-match: N/A	199.45%	1.83 *(large)*
			40-min post-match: 39.69 ± 22.98	Pre – 40-min post-match: N/A	172.97%	1.37 *(large)*
	TQR (AU)	15.00 ± 3.00**	Post-match: 13.00 ± 3.00**	Pre – post-match: **P = 0.004**	−13.33%	N/A**
			40-min post-match: 13.00 ± 2.00**	Pre – 40-min post-match: **P = 0.008**	−13.33%	N/A**
	Rating-of-Fatigue scale (AU)	3.00 ± 2.00**	Post-match: 5.00 ± 1.00**	Pre – post-match: **P = 0.004**	66.67%	N/A**
			40-min post-match: 5.00 ± 2.00**	Pre – 40-min post-match: **P = 0.006**	66.67%	N/A**

Data presented as mean ± standard deviation, unless otherwise specified. Bolded *p* values indicate a significant difference; * data reported as mean ± standard error of the mean; ** data reported as median ± interquartile range.
Abbreviations: ES, effect size; AU, arbitrary units; N/A, data not available; T1, Team 1; T2, Team 2; TQR, Total Quality Recovery scale.

Table 6. Persistent (≥1 hour post-match) changes in athlete-reported and sleep-related outcome measures following single matches.

Study	Outcome measure	Pre-match	Pre-match night/ morning	Post-match night/morning	24 h	Post-match night + 1	48 h	Statistical changes	% change	ES (interpretation)
Chatzinikolaou et al., (2014)	Quadriceps soreness (AU)	1.00 ± N/A	-	-	4.08 ± 0.71	-	1.36 ± 0.43	Pre-24 h: **P <0.05**	308.00%	N/A
								Pre-48 h: $p > 0.05$	36.00%	N/A
	Hamstrings soreness (AU)	1.00 ± N/A	-	-	4.84 ± 0.76	-	2.44 ± 0.44	Pre-24 h: **P <0.05**	384.00%	N/A
								Pre-48 h: **P <0.05**	144.00%	N/A
Conte et al., (2021)	Fatigue (AU)	-	3.57 ± 1.03	2.33 ± 0.86	-	-	-	**P <0.001**	−34.73%	−1.14 *(moderate)*
	Sleep quality (AU)	-	3.62 ± 0.97	3.76 ± 0.89	-	-	-	$p = 0.510$	3.87%	0.13 *(trivial)*
	Soreness (AU)	-	3.14 ± 1.01	2.67 ± 1.02	-	-	-	$p = 0.082$	−14.97%	−0.40 *(small)*
	Stress (AU)	-	4.14 ± 0.85	3.81 ± 0.81	-	-	-	$p = 0.100$	−7.97%	−0.35 *(small)*
	Mood (AU)	-	3.67 ± 0.97	3.57 ± 0.81	-	-	-	$p = 0.367$	−2.72%	−0.10 *(trivial)*
	Total well-being (AU)	-	18.14 ± 3.72	16.14 ± 2.99	-	-	-	**P <0.001**	−11.03%	−0.52 *(small)*
Moreira et al., (2014)	Hamstrings soreness (mm)	7.39 ± 3.02	-	-	27.96 ± 3.04	-	18.02 ± 15.00	Pre-24 h: **P <0.05**	278.35%	6.44 *(very large)*
								Pre-48 h: **P <0.05**	143.84%	0.93 *(moderate)*
	Pectoralis major soreness (mm)	N/A	-	-	N/A	-	-	N/A	11.5 mm**	N/A
Pernigoni et al., (2023)	Muscle soreness (mm)	14.54 ± 8.18	-	-	24.31 ± 15.02	-	-	N/A	67.19%	0.76 *(moderate)*
	TQR (AU)	15.00 ± 3.00*	-	-	14.00 ± 4.00*	-	-	$p > 0.05$	−6.67%	N/A*
	Rating-of-Fatigue scale (AU)	3.00 ± 2.00*	-	-	3.00 ± 1.00*	-	-	$p > 0.05$	0.00%	N/A*
Power et al., (2023)	Total sleep time (min)	-	T: 387 ± 15#	393 ± 23#	-	-	-	T: $p = 1.000$	1.55%	N/A#
			NT: 444 ± 16#					NT: $p = 0.300$	−11.49%	N/A#
	Wake after sleep onset (min)	-	T: 29.00 ± 8.00#	32.00 ± 5.00#	-	-	-	T: $p = 0.990$	10.34%	N/A#
			NT: 48.00 ± 15.00#					NT: $p = 0.910$	−33.33%	N/A#
	Time in bed (min)	-	T: 474 ± 15#	482 ± 28#	-	-	-	T: $p = 1.000$	1.69%	N/A#
			NT: 533 ± 15#					NT: $p = 0.730$	−9.57%	N/A#
	Sleep efficiency (%)	-	T: 83.00 ± 3.00#	84.00 ± 2.00#	-	-	-	T: $p = 1.000$	1.20%	N/A#
			NT: 84.00 ± 3.00#					NT: $p = 1.000$	0.00%	N/A#
	Sleep onset (h:min)	-	T: 23:40 ± 00:12#	24:25 ± 00:18#	-	-	-	T: $p = 0.230$	3.17%	N/A#
			NT: 23:22 ± 00:16#					NT: $p = 0.140$	4.49%	N/A#
	Sleep offset (h:min)	-	T: 06:35 ± 00:09#	07:29 ± 00:15#	-	-	-	T: **P = 0.007**	13.68%	N/A#
			NT: 07:30 ± 00:13#					NT: $p = 1.000$	−0.27%	N/A#
	Perceived sleep quality (AU)	-	T: N/A	T: N/A	-	-	-	T: $p = 0.06$	N/A	N/A#
			NT: N/A	NT: N/A				NT: $p = 0.04$***	N/A	N/A#
Staunton et al., (2017)	Total sleep time (h)	-	7.74 ± 1.65	7.65 ± 1.32	-	8.00 ± 1.30	-	Pre-post-M-night: $p > 0.05$	−1.16%	−0.06 *(trivial)*
								Pre-post-M-night +1: $p > 0.05$	3.36%	0.17 *(trivial)*
	Sleep efficiency (%)	-	91.04 ± 3.94	92.08 ± 3.99	-	92.43 ± 3.04	-	Pre-post-M-night: $p > 0.05$	1.14%	0.25 *(small)*
								Pre-post-M-night +1: $p > 0.05$	1.53%	0.38 *(small)*

Data presented as mean ± standard deviation, unless otherwise specified. Bolded *p* values indicate a significant difference; * data reported as median ± interquartile range; ** percentage change not computable; # data reported as marginal mean ± standard error; *** non-significant difference based on Bonferroni-corrected alpha values in this study (Power et al., 2023). *Abbreviations*: ES, effect size; AU, arbitrary units; N/A, data not available; TQR, Total Quality Recovery scale; T, on-court training sessions were completed earlier that evening, before the reported measurements were performed; NT, no training sessions were completed throughout the day preceding the reported measurements; M, match.

one study in Level 5 players observed no pre-to-post-match changes ($p > 0.05$; ES = 1.04, *moderate*) in hamstring soreness following an official match (despite significant increases at 24–48 hours post-match; $p < 0.05$; ES = 0.93–6.44, *moderate-to-very large*) (Moreira et al., 2014), while descriptive increases were reported in Level 3 players after a simulated match [~-170–200% at match-end (ES = 1.37–1.83, *large*) and ~67% at 24 hours post-match (ES = 0.76, *moderate*), compared to pre-match] (Pernigoni et al., 2023).

Perceived fatigue and mood states. One study (Gonzalez-Bono et al., 2000) examined two teams consisting of Level 5 male players, showing significant increases ($p < 0.03$) in perceived fatigue at match-end following official matches [as also observed after simulated match-play in another study among Level 3 females ($p \leq 0.008$) (Pernigoni et al., 2023)], with significant decreases ($p < 0.04$) in perceived vigour only in one team (the other team remained unchanged: $p > 0.13$), and no significant changes ($p > 0.05$) in Profile of Mood States total score across both teams. In a second study examining Level 5 male players by the same research group, descriptive analysis showed that mood was negatively impacted at match-end, although inferential statistics were not applied to assess changes (Gonzalez-Bono et al., 1999). On post-match days, significant deteriorations ($p < 0.001$; ES = −0.52 – −1.14, *small-to-moderate*) in perceived fatigue and total well-being score were apparent upon awakening on mornings following official matches compared with the previous morning in Level 5 male players (official match-play), while no significant changes ($p \geq 0.100$; ES = −0.10 – −0.35, *trivial-to-small*) were evident for perceived stress and mood (Conte et al., 2021). Finally, a study in Level 3 females did not detect any significant changes ($p > 0.05$) in perceived fatigue at 24 hours after simulated match-play, compared to pre-match (Pernigoni et al., 2023).

Sleep-related outcomes. Perceived sleep quality (Conte et al., 2021; Power et al., 2023), in addition to total sleep time, efficiency (Power et al., 2023; Staunton et al., 2017), time in bed and sleep onset (Power et al., 2023) measured using accelerometry were unchanged ($p > 0.05$; ES = −0.06 – 0.38, *trivial-to-small*) on nights following matches [i.e., one (Conte et al., 2021; Power et al., 2023) and two consecutive nights (Staunton et al., 2017), respectively] compared to the pre-match night in male [Level 5 (Conte et al., 2021)] and female players [Level 5 (Staunton et al., 2017) and Level 4 (Power et al., 2023)] in three separate studies. Only sleep offset was significantly delayed ($p = 0.007$) on post-match nights (compared to pre-match nights preceded by an evening training session) in one of the above-mentioned studies (Power et al., 2023).

Fatigue in congested schedules

Findings from the five studies investigating changes in performance, physiological, and athlete-reported outcome measures during and after congested match schedules are shown in Table 7.

Effects on performance

Significantly decreased ($p < 0.05$; ES = −0.27, *small*) CMJ performance (measured before the first match each day) was observed on the second compared to first day of a 3-day congested period (i.e., two official matches on Day 1, one match on Days 2 and 3) in Level 3 male players (de Lima Pinto et al., 2018). Another study also showed negative changes (ES = −0.26 – −0.77, *small-to-moderate*) in vertical jump, 20-m sprint, agility, Line Drill, and sit-and-reach performance following a 3-day tournament (i.e., one official match per day) compared to pre-tournament measurements in Level 3 male players (Montgomery, Pyne, Hopkins, et al., 2008).

Effects on physiological responses

Substantial, negative changes (ES = 0.44–1.07, *small-to-moderate*) in fatty acid binding protein, CK, and myoglobin concentrations (Montgomery, Pyne, Cox, et al., 2008) were found after a 3-day official tournament (i.e., one match per day) compared with pre-tournament measurements in Level 3, male players, while IL-6 and IL-10 showed no substantial changes (ES = 0.02, *trivial*) and a substantial decrease (ES = −0.21, *small*), respectively (Montgomery, Pyne, Cox, et al., 2008). Contrarily, no significant changes ($p > 0.05$; ES = 0.15–0.37, *trivial-to-small*) in heart rate variability (HRV) were apparent among Level 3 females throughout a 10-day period involving seven official matches (Lukonaitienė et al., 2021).

Effects on athlete-reported outcome measures

Compared with pre-tournament measurements, substantial negative changes (ES = 1.20–5.80, *large-to-very large*) in perceived fatigue and muscle soreness were reported after a 3-day official tournament (i.e., one match per day) in Level 3 male players (Montgomery, Pyne, Hopkins, et al., 2008), with significantly worse ($p = 0.017$; ES = −0.50, *small*) perceived recovery (i.e., Total Quality Recovery scale, TQR) also observed on the last day of a 3-day congested match period (i.e., two official matches on Day 1, one match on Days 2 and 3) in Level 3 male players (de Lima Pinto et al., 2018). In this study, perceived anger, vigour, and total mood disturbance were also significantly poorer ($p < 0.05$; ES = −0.85 – 2.18, *moderate-to-very large*) following each match compared to pre-match measurements, although other outcomes were only partially (i.e., perceived depression and fatigue) or not affected [i.e., perceived tension and confusion, and items from the Daily Analysis of Life Demands for Athletes (DALDA) questionnaire] (de Lima Pinto et al., 2018). Finally, compared to Day 1, perceived well-being significantly declined during the final part of congested match-play in youth, Level 3 female [Days 7 and 10 of a 10-day congested period comprising seven matches (Lukonaitienė et al., 2021); $p \leq 0.04$; ES = −0.68 – −0.78, *moderate*] and male players [Days 4, 5, and 6 of a 6-day period comprising one match per day (García et al., 2023); $p < 0.05$].

Discussion

Identifying fatigue in players following match-play is essential for basketball practitioners to develop appropriate training and recovery interventions, with the main aim of optimising player readiness for subsequent competition. The present review is the

Table 7. Changes in performance, physiological, and athlete-reported outcome measures throughout congested match schedules.

Study	Outcome measure	Timepoints	Statistical changes	% change	ES (interpretation)
de Lima Pinto et al., (2018)	CMJ height (cm)	Day 1: 34.55 ± 5.03 Day 2: 33.11 ± 5.05 Day 3: 33.83 ± 4.75	Day 1-2: **P <0.05** Day 1-3: $p > 0.05$ Day 2-3: $p > 0.05$	−4.17% −2.08% 2.17%	−0.27 *(small)* −0.14 *(trivial)* 0.14 *(trivial)*
	DALDA sources (AU)	Baseline: 18.50 ± 3.00 Day 1: 19.40 ± 3.00 Day 2: 17.60 ± 3.00 Day 3: 19.40 ± 3.00	$p = 0.139$ (main effect of time)	Baseline – Day 1: 7.48% Baseline – Day 2: −2.49% Baseline – Day 3: 7.48%	0.28 *(small)* −0.28 *(small)* 0.28 *(small)*
	DALDA symptoms (AU)	Baseline: 50.50 ± 7.00 Day 1: 47.30 ± 12.00 Day 2: 46.30 ± 6.00 Day 3: 44.60 ± 5.00	$p = 0.141$ (main effect of time)	Baseline – Day 1: −6.34% Baseline – Day 2: −8.32% Baseline – Day 3: −11.68%	−0.30 *(small)* −0.60 *(moderate)* −0.90 *(moderate)*
	Tension (AU)	Pre-Day 1: 48.57 ± 4.86 Post-Day 1: 62.25 ± 6.29 Pre-Day 2: 45.75 ± 8.99 Post-Day 2: 46.31 ± 5.38 Pre-Day 3: 50.52 ± 11.07 Post-Day 3: 51.64 ± 6.75	Pre-Post Day 1: $p > 0.05$ Pre-Post Day 2: $p > 0.05$ Pre-post Day 3: $p > 0.05$	28.17% 1.22% 2.22%	2.26 *(very large)* 0.07 *(trivial)* 0.11 *(trivial)*
	Depression (AU)	Pre-Day 1: 46.98 ± 4.95 Post-Day 1: 58.98 ± 15.60 Pre-Day 2: 45.59 ± 5.14 Post-Day 2: 54.49 ± 7.23 Pre-Day 3: 47.75 ± 8.22 Post-Day 3: 66.61 ± 15.40	Pre-post Day 1: **P <0.05** Pre-post Day 2: **P <0.05** Pre-post Day 3: $p > 0.05$	25.54% 19.52% 39.50%	0.96 *(moderate)* 1.32 *(large)* 1.42 *(large)*
	Anger (AU)	Pre-Day 1: 44.55 ± 3.36 Post-Day 1: 75.92 ± 18.63 Pre-Day 2: 47.67 ± 7.22 Post-Day 2: 63.96 ± 23.76 Pre-Day 3: 51.90 ± 12.45 Post-Day 3: 75.69 ± 20.42	Pre-post Day 1: **P <0.05** Pre-post Day 2: **P <0.05** Pre-post Day 3: **P <0.05**	70.42% 34.17% 45.83%	2.18 *(very large)* 0.86 *(moderate)* 1.31 *(large)*
	Vigour (AU)	Pre-Day 1: 55.37 ± 5.96 Post-Day 1: 44.88 ± 8.14 Pre-Day 2: 53.37 ± 7.22 Post-Day 2: 45.91 ± 8.99 Pre-Day 3: 52.68 ± 8.65 Post-Day 3: 43.60 ± 8.82	Pre-post Day 1: **P <0.05** Pre-post Day 2: **P <0.05** Pre-post Day 3: **P <0.05**	−18.95% −13.98% −17.24%	−1.37 *(large)* −0.85 *(moderate)* −0.97 *(moderate)*
	Fatigue (AU)	Pre-Day 1: 50.25 ± 6.12 Post-Day 1: 52.18 ± 8.31 Pre-Day 2: 50.24 ± 7.46 Post-Day 2: 48.56 ± 9.15 Pre-Day 3: 49.57 ± 7.96 Post-Day 3: 53.29 ± 19.11	Pre-post Day 1: **P <0.05** Pre-post Day 2: $p > 0.05$ Pre-post Day 3: **P <0.05**	3.84% −3.34% 7.50%	0.25 *(small)* −0.19 *(trivial)* 0.24 *(small)*
	Confusion (AU)	Pre-Day 1: 46.48 ± 4.62 Post-Day 1: 50.25 ± 10.74 Pre-Day 2: 45.35 ± 5.86 Post-Day 2: 51.28 ± 14.93 Pre-Day 3: 47.92 ± 7.78 Post-Day 3: 49.65 ± 12.20	Pre-Post Day 1: $p > 0.05$ Pre-Post Day 2: $p > 0.05$ Pre-post Day 3: $p > 0.05$	8.11% 13.08% 3.61%	0.42 *(small)* 0.49 *(small)* 0.16 *(trivial)*
	Total Mood Disturbance (AU)	Pre-Day 1: 100.30 ± 6.40 Post-Day 1: 124.00 ± 14.10 Pre-Day 2: 100.80 ± 5.30 Post-Day 2: 113.30 ± 14.80 Pre-Day 3: 104.70 ± 11.48 Post-Day 3: 123.70 ± 17.30	Pre-Post Day 1: **P <0.001** Pre-Post Day 2: **P = 0.01** Pre-post Day 3: **P = 0.002**	23.63% 12.40% 18.15%	2.01 *(very large)* 1.05 *(moderate)* 1.20 *(large)*

(Continued)

Table 7. (Continued).

Study	Outcome measure	Timepoints	Statistical changes	% change	ES (interpretation)
	TQR (AU)	Day 1: 15.55 ± 1.76	Day 1-2: $p > 0.05$	−6.43%	−0.49 *(small)*
		Day 2: 14.55 ± 2.00	Day 1-3: **P = 0.017**	−11.32%	−0.50 *(small)*
		Day 3: 13.79 ± 1.95	Day 2-3: $p > 0.05$	−5.22%	−0.36 *(small)*
García et al., (2023)	Hooper index (AU)	Day 1: 6.92 (5.62–8.21)*	Day 1-2: $p > 0.05$	10.84%	N/A*
		Day 2: 7.67 (6.37–8.96)*	Day 1-3: $p > 0.05$	16.76%	N/A*
		Day 3: 8.08 (6.79–9.38)*	Day 1-4: **P <0.05**	25.29%	N/A*
		Day 4: 8.67 (7.37–9.96)*	Day 1-5: **P <0.05**	31.21%	N/A*
		Day 5: 9.08 (7.79–10.38)*	Day 1-6: **P <0.05**	40.90%	N/A*
		Day 6: 9.75 (8.45–11.05)*			
Lukonaitienė et al., (2021)	Ln-rMSSD (ms)	Day 1: 4.24 ± 0.66	Day 1-2: $p > 0.05$	3.30%	0.23 *(small)*
		Day 2: 4.38 ± 0.49	Day 1-3: $p > 0.05$	2.36%	0.15 *(trivial)*
		Day 3: 4.34 ± 0.60	Day 1-4: $p > 0.05$	2.36%	0.16 *(trivial)*
		Day 4: 4.34 ± 0.50	Day 1-5: $p > 0.05$	4.72%	0.31 *(small)*
		Day 5: 4.44 ± 0.56	Day 1-6: $p > 0.05$	4.95%	0.33 *(small)*
		Day 6: 4.45 ± 0.57	Day 1-7: $p > 0.05$	3.30%	0.23 *(small)*
		Day 7: 4.38 ± 0.49	Day 1-8: $p > 0.05$	4.95%	0.35 *(small)*
		Day 8: 4.45 ± 0.49	Day 1-9: $p > 0.05$	3.54%	0.24 *(small)*
		Day 9: 4.39 ± 0.53	Day 1-10: $p > 0.05$	4.95%	0.37 *(small)*
		Day 10: 4.45 ± 0.41			
	Well-being (AU)	Day 1: 20.67 ± 1.56	Day 1-2: $p > 0.05$	−2.76%	−0.31 *(small)*
		Day 2: 20.10 ± 1.92	Day 1-3: $p > 0.05$	−5.08%	−0.63 *(moderate)*
		Day 3: 19.62 ± 1.63	Day 1-4: $p > 0.05$	−2.08%	−0.27 *(small)*
		Day 4: 20.24 ± 1.55	Day 1-5: $p > 0.05$	−2.08%	−0.25 *(small)*
		Day 5: 20.24 ± 1.76	Day 1-6: $p > 0.05$	−3.73%	−0.52 *(small)*
		Day 6: 19.90 ± 1.30	Day 1-7: **P = 0.03**	−6.00%	−0.68 *(moderate)*
		Day 7: 19.43 ± 1.91	Day 1-8: $p > 0.05$	−4.84%	−0.63 *(moderate)*
		Day 8: 19.67 ± 1.49	Day 1-9: $p > 0.05$	−5.76%	−0.80 *(moderate)*
		Day 9: 19.48 ± 1.29	Day 1-10: **P = 0.04**	−6.92%	−0.78 *(moderate)*
		Day 10: 19.24 ± 1.95			
Montgomery, Pyne, Hopkins, et al., (2008)	Line Drill Test time (s)	Pre-T: 27.15 ± 1.60 Post-T: 27.6 ± 1.15	N/A	Pre – Post-T: 1.66%	0.31 *(small)*
	20-m sprint time (s)	Pre-T: 3.09 ± 0.11 Post-T: 3.13 ± 0.12	N/A	Pre – Post-T: 1.29%	0.34 *(small)*
	Agility time (s)	Pre-T: 6.48 ± 0.25 Post-T: 6.62 ± 0.26	N/A	Pre – Post-T: 2.16%	0.53 *(small)*
	Vertical jump height (cm)	Pre-M1: 61.09 ± 8.32	N/A	Pre-M1 – Pre-M2: −8.23%	−0.53 *(small)*
		Pre-M2: 56.06 ± 10.11		Pre-M1 – Pre-M3: −6.73%	−0.47 *(small)*
		Pre-M3: 56.98 ± 8.76		Pre-M1 – Post-M3 + 1: −3.32%	−0.26 *(small)*
		Post-M3 + 1: 59.06 ± 6.82			
	Sit-and-reach distance (cm)	Pre-T: 8.50 ± 6.50 Post-T: 3.20 ± 6.90	N/A	Pre – Post-T: −62.35%	−0.77 *(moderate)*
	Fatigue (AU)	Pre-T: 3.60 ± 0.90 Post-T: 5.20 ± 1.60	N/A	Pre – Post-T: 44.44%	1.20 *(large)*
	Muscle soreness (AU)	Pre-M1: 1.60 ± 0.51	N/A	Pre-M1 – Post-M1: 94.38%	1.49 *(large)*
		Post-M1: 3.11 ± 1.30		Pre-M1 – Pre-M2: 63.13%	1.89 *(large)*
		Pre-M2: 2.61 ± 0.53		Pre-M1 – Post-M2: 176.25%	2.28 *(very large)*
		Post-M2: 4.42 ± 1.62		Pre-M1 – Pre-M3: 94.38%	1.82 *(large)*
		Pre-M3: 3.11 ± 1.02		Pre-M1 – Post-M3: 194.38%	2.53 *(very large)*
		Post-M3: 4.71 ± 1.61		Pre-M1 – Post-M3 + 1: 169.38%	1.97 *(large)*
		Post-M3 + 1: 4.31 ± 1.82			

(Continued)

Table 7. (Continued).

Study	Outcome measure	Timepoints	Statistical changes	% change	ES (interpretation)
	Thigh girth (cm)	Pre-T: 55.75 ± 0.66 Post-M1: 56.44 ± 3.44 Post-M2: 56.52 ± 3.52 Post-M3: 56.91 ± 3.71	N/A	Pre-T – Post-M1: 1.24% Pre-T – Post-M2: 1.38% Pre-T – Post-M3: 2.08%	0.27 *(small)* 0.30 *(small)* 0.42 *(small)*
Montgomery, Pyne, Cox, et al., (2008)	Log-transformed fatty acid binding protein concentration (pg/mL)	Pre-M1: 1041.15 ± 961.37 Post-M1: 4961.96 ± 1932.58 6 h post-M1: 2192.73 ± 1530.01 24 h post-M1: 1166.20 ± 740.28 Post-M2: 4924.58 ± 2317.30 6 h post-M2: 2071.83 ± 1567.41 24 h post-M2: 1403.56 ± 1586.14 Post-M3: 4832.36 ± 1560.07 6 h post-M3: 2338.29 ± 1768.99 24 h post-M3: 1382.49 ± 860.55	N/A	Pre-M1 – Post-M1: 376.59% Pre-M1 – 6 h post-M1: 110.61% Pre-M1 – 24 h post-M1: 12.01% Pre-M1 – Post-M2: 372.99% Pre-M1 – 6 h post-M2: 98.99% Pre-M1 – 24 h post-M2: 34.81% Pre-M1 – Post-M3: 364.14% Pre-M1 – 6 h post-M3: 124.59% Pre-M1 – 24 h post-M3: 32.78%	2.50 *(very large)* 0.88 *(moderate)* 0.14 *(trivial)* 2.13 *(very large)* 0.77 *(moderate)* 0.27 *(small)* 2.85 *(very large)* 0.89 *(moderate)* 0.36 *(small)*
	Log-transformed creatine kinase concentration (pg/mL)	Pre-M1: 240.07 ± 399.94 Post-M1: 371.34 ± 439.58 6 h post-M1: 618.73 ± 635.58 24 h post-M1: 475.30 ± 484.98 Post-M2: 752.79 ± 678.33 6 h post-M2: 830.34 ± 68.33 24 h post-M2: 606.31 ± 562.03 Post-M3: 735.18 ± 625.16 6 h post-M3: 768.21 ± 658.08 24 h post-M3: 602.22 ± 531.10	N/A	Pre-M1 – Post-M1: 54.68% Pre-M1 – 6 h post-M1: 157.73% Pre-M1 – 24 h post-M1: 97.98% Pre-M1 – Post-M2: 213.57% Pre-M1 – 6 h post-M2: 245.87% Pre-M1 – 24 h post-M2: 152.56% Pre-M1 – Post-M3: 206.24% Pre-M1 – 6 h post-M3: 219.99% Pre-M1 – 24 h post-M3: 150.85%	0.30 *(small)* 0.69 *(moderate)* 0.51 *(small)* 0.90 *(moderate)* 2.00 *(very large)* 0.73 *(moderate)* 0.92 *(moderate)* 0.94 *(moderate)* 0.75 *(moderate)*
	Log-transformed myoglobin concentration (ng/mL)	Pre-M1: 37.86 ± 17.90 Post-M1: 182.64 ± 114.91 6 h post-M1: 108.86 ± 100.11 24 h post-M1: 47.92 ± 22.66 Post-M2: 192.91 ± 97.22 6 h post-M2: 72.08 ± 57.27 24 h post-M2: 44.24 ± 19.83 Post-M3: 175.86 ± 101.15 6 h post-M3: 83.16 ± 69.26 24 h post-M3: 50.41 ± 21.06	N/A	Pre-M1 – Post-M1: 382.41% Pre-M1 – 6 h post-M1: 187.53% Pre-M1 – 24 h post-M1: 26.57% Pre-M1 – Post-M2: 409.54% Pre-M1 – 6 h post-M2: 90.31% Pre-M1 – 24 h post-M2: 16.85% Pre-M1 – Post-M3: 364.50% Pre-M1 – 6 h post-M3: 119.65% Pre-M1 – 24 h post-M3: 33.15%	1.71 *(large)* 0.96 *(moderate)* 0.48 *(small)* 2.16 *(very large)* 0.78 *(moderate)* 0.33 *(small)* 1.85 *(large)* 0.87 *(moderate)* 0.62 *(moderate)*
	Log-transformed interleukin-6 concentration (pg/mL)	Pre-M1: 1.52 ± 3.87 Post-M1: 6.27 ± 6.06 6 h post-M1: 2.53 ± 2.75 24 h post-M1: 1.59 ± 1.49 Post-M2: 5.84 ± 5.17 6 h post-M2: 1.97 ± 1.93 24 h post-M2: 1.23 ± 0.76 Post-M3: 4.61 ± 2.68 6 h post-M3: 2.44 ± 2.29 24 h post-M3: 1.19 ± 0.92	N/A	Pre-M1 – Post-M1: 312.50% Pre-M1 – 6 h post-M1: 66.45% Pre-M1 – 24 h post-M1: 4.61% Pre-M1 – Post-M2: 284.21% Pre-M1 – 6 h post-M2: 29.61% Pre-M1 – 24 h post-M2: −19.08% Pre-M1 – Post-M3: 203.29% Pre-M1 – 6 h post-M3: 60.53% Pre-M1 – 24 h post-M3: −21.71%	0.91 *(moderate)* 0.29 *(small)* 0.02 *(trivial)* 0.92 *(moderate)* 0.14 *(trivial)* −0.10 *(trivial)* 0.90 *(moderate)* 0.28 *(small)* −0.11 *(trivial)*

(Continued)

Table 7. (Continued).

Study	Outcome measure	Timepoints	Statistical changes	% change	ES (interpretation)
	Log-transformed interleukin-10 concentration (pg/mL)	Pre-M1: 1.08 ± 1.29	N/A	Pre-M1 – Post-M1: 217.59%	0.65 (*moderate*)
		Post-M1: 3.43 ± 4.79		Pre-M1 – 6 h post-M1: 44.44%	0.47 (*small*)
		6 h post-M1: 1.56 ± 0.52		Pre-M1 – 24 h post-M1: 17.59%	0.15 (*trivial*)
		24 h post-M1: 1.27 ± 1.13		Pre-M1 – Post-M2: 188.89%	1.40 (*large*)
		Post-M2: 3.12 ± 1.54		Pre-M1 – 6 h post-M2: 87.96%	0.56 (*small*)
		6 h post-M2: 2.03 ± 1.94		Pre-M1 – 24 h post-M2: 3.70%	0.04 (*trivial*)
		24 h post-M2: 1.12 ± 0.67		Pre-M1 – Post-M3: 211.11%	0.60 (*moderate*)
		Post-M3: 3.36 ± 5.03		Pre-M1 – 6 h post-M3: 35.19%	0.30 (*small*)
		6 h post-M3: 1.46 ± 1.17		Pre-M1 – 24 h post-M3: −6.48%	−0.07 (*trivial*)
		24 h post-M3: 1.01 ± 0.64			

Data presented as mean ± standard deviation, unless otherwise specified. Bolded *p* values indicate a significant difference; * data reported as estimated marginal means (95% confidence intervals). *Abbreviations*: ES, effect size; CMJ, countermovement jump; DALDA, Daily Analysis of Life Demands for Athletes questionnaire; AU, arbitrary units; TQR, Total Quality Recovery scale; Ln-rMSSD, log-transformed squared root of the mean sum of the squared differences between R-R intervals; T, tournament; M, match; N/A, data not available.

first to comprehensively analyse fatigue and the recovery time-course of performance, physiological, athlete-reported, and sleep-related outcome measures following single and congested basketball matches.

Fatigue following single matches

Effects on performance

Vertical jump and sprint performance were the most investigated outcomes measured across the included studies, which is not surprising given the popularity and specificity of these testing procedures in basketball (Edwards et al., 2018; Wen et al., 2018). It is well known that high-intensity exercise, like that performed in basketball match-play, can impair muscle function (Skorski et al., 2019). Given that both sprint and vertical jump performance depend on the ability to generate high levels of power (Wen et al., 2018), performance impairments in these tasks would be expected following basketball match-play (Edwards et al., 2018). Specifically, the well-established depletion of phosphocreatine and glycogen stores during exercise (Skorski et al., 2019), paired with acidosis, decreased central motor output, inflammation, hormonal changes, and the presence of metabolites (Gandevia, 2001; Silva et al., 2018), may be responsible for these performance decreases following exercise. The present review supports this notion in terms of 20-m sprint performance, as all the included studies documented significantly decreased performance at match-end – compared to pre-match – across various player samples (Delextrat et al., 2012; Izquierdo & Redondo, 2020, 2021). In terms of 10-m performance, three out of five studies [Level 5 (Chatzinikolaou et al., 2014) and Level 3 (Cortis et al., 2011; Pliauga et al., 2015) male players] reported significant impairments from pre-to-post-match, while two studies [Level 3 females (Izquierdo & Redondo, 2020, 2021)], showed that performance was mostly unaffected. This variability could stem from the fact that, in the three studies reporting impaired performance (Chatzinikolaou et al., 2014; Cortis et al., 2011; Pliauga et al., 2015), players completed 40-min matches, with lower playing times apparent for players in the remaining two studies (Izquierdo & Redondo, 2020, 2021). Therefore, differences in playing time among studies may explain the discrepancies observed for 10-m sprint performance, suggesting that further research may be needed to clarify the utility of this testing procedure to identify fatigue surrounding basketball match-play. Regarding vertical jump height, performance at match-end was significantly poorer than pre-match in six out of nine studies across male [Level 5 (Chatzinikolaou et al., 2014) and Level 2 (Díaz-Castro et al., 2018; Liveris et al., 2021), simulated matches] and female players [Level 3 (Izquierdo & Redondo, 2020, 2021) and Level 5 (Delextrat et al., 2012), official matches], with no significant changes in two studies [Level 3 males (Cortis et al., 2011; Pliauga et al., 2015), simulated matches] and significantly better performance in one study [Level 4 males (Moreno-Perez et al., 2020), official match]. The variability reported across these findings may be due to multiple factors. Firstly, it was not always clear whether a pre-match warm-up was used, and what it entailed if it was used, which could potentially influence vertical jump performance measured at pre-match (Pliauga et al., 2015). Secondly, the exact time at which post-match testing occurred following match-end was not precisely stipulated in all studies, which may affect fatigue status among players at the time of testing (Pliauga et al., 2015). In summary, although most of the existing evidence suggests that basketball match-play produces a fatiguing effect on sprint and jump performance at match-end, further research is warranted to better understand factors that may impact this fatigue response, such as the age, sex, and competitive level of players, warm-up procedures followed, testing protocols adopted, and precise match demands encountered.

When considering changes in performance on post-match days (compared to pre-match), 10-m sprint performance was significantly reduced among males until 24 hours following simulated match-play in Level 5 players (restored at 48 hours) (Chatzinikolaou et al., 2014) and for up to 48 hours in Level 3 players (Pliauga et al., 2015). Variations in the persistent fatigue in sprint performance between these studies may be attributed to the different competitive levels of player samples, with Level 5 male players investigated by Chatzinikolaou et al. (2014) potentially being more resilient to fatigue (Ferioli et al., 2019; Moreira et al., 2014) and restoring sprinting abilities within 48 hours after a match due to greater physical fitness (Ferioli et al., 2018). Similarly, CMJ height significantly decreased in all studies between pre-match and 24 (Chatzinikolaou et al., 2014; Delextrat et al., 2014; Delextrat, Calleja-González, et al., 2013; Pliauga et al., 2015) to 48 hours (Chatzinikolaou et al., 2014; Pliauga et al., 2015) following simulated and official match-play across a range of male players, with concomitant reductions in change-of-direction ability (via the T-test) and anaerobic performance (via the Line Drill Test) in Level 5 male players up to 48 hours post-simulated match (Chatzinikolaou et al., 2014). In contrast to male players, females displayed no changes in CMJ height (Level 3) (Delextrat et al., 2014; Delextrat, Calleja-González, et al., 2013) and change-of-direction ability (Level 5) (Moreira et al., 2014) 24 hours after official matches (Delextrat et al., 2014; Delextrat, Calleja-González, et al., 2013; Moreira et al., 2014). Evidence indicates that female players typically spend higher proportions of match-play performing low-intensity activities than males (Stojanović et al., 2018), which may induce less fatigue and promote more recovery opportunities throughout matches (Goulart et al., 2022). Furthermore, a recent review (Goulart et al., 2022) suggested that physiological differences (e.g., higher mitochondrial intrinsic respiratory rates, greater capillary density per unit of skeletal muscle, different proportions of muscle fibre types) may promote better fatigue resistance in females compared to males, indicating that an inherent difference in the recovery time-course for performance may be apparent across sexes.

In addition to single-effort linear sprinting, the effects of match-play on RSA were assessed at match-end in two studies, showing diminished performance using a range of outcome measures. Specifically, one study highlighted a significant, pre-to-post-match decrease in RSA total and ideal times following an official match in youth, Level 2 male players (Caprino et al., 2012). Another study examined various kinetic and kinematic outcomes during a RSA test performed before and after an official match in Level 3 male players, reporting significant declines in speed, horizontal force, vertical force, and stride frequency, coupled with significantly increased stride duration and contact time (Delextrat, Baliqi, et al., 2013). In terms of persistent fatigue, no significant impairments in RSA performance were observed for either Level 3 male and female players between pre-match and 24 hours after official matches across two studies (Delextrat et al., 2014; Delextrat, Calleja-González, et al., 2013). Hence, while RSA performance appears to be negatively affected by official matches likely due to various mechanisms such as the depletion of phosphocreatine and muscle glycogen stores, acidosis, dehydration, accumulation of metabolites, and decreased muscle activation (Caprino et al., 2012; Delextrat, Baliqi, et al., 2013), these impairments appear to be short-lived, with no apparent fatigue in the days following match-play (Delextrat et al., 2014; Delextrat, Calleja-González, et al., 2013).

Although strength outcomes were not readily measured across studies, 1RM chest-press and leg-press performance were significantly impaired from pre-to-post-match in Level 5 male players across a simulated match (Chatzinikolaou et al., 2014). The authors attributed these impairments to a match-induced catabolic state, likely leading to decreased protein synthesis and increased degradation of muscle proteins and neurotransmitters, potentially contributing to a reduced force output (Chatzinikolaou et al., 2014). However, persistent decreases from pre-match up to 48 hours following matches were only evident in leg-press performance, suggesting that lower-body musculature may be more susceptible to strength deterioration after match-play (Chatzinikolaou et al., 2014). Separately, hamstrings, but not quadriceps, isokinetic peak torque and hamstrings:quadriceps peak torque ratio showed significant decreases at match-end compared with pre-match measurements in Level 5 female players (Delextrat et al., 2012). The greater strength loss in the hamstrings could be explained by the higher proportion of type II muscle fibres apparent within this muscle group compared to the quadriceps (Bergh et al., 1978; Garrett et al., 1984; Jacobs et al., 1987), which are more fatigable than type I fibres (Delextrat et al., 2012). Regarding hamstrings:quadriceps peak torque ratio, previous research has suggested that lower values may be related to neuromuscular imbalances and increased injury risk in females (Hewett et al., 2004). However, a recent review revealed that using this measure in isolation may have limited value for the prediction of hamstrings and knee injuries (Kellis et al., 2023). In Level 5 female players, no significant differences in 1RM leg-press and bench-press performance were evident at 24 and 48 hours after official match-play compared with pre-match measurements (Moreira et al., 2014). However, players in this study only completed 18.2 ± 7.5 min of playing time, which is considerably lower than that experienced by the Level 5 male [i.e., full 40-min simulated match (Chatzinikolaou et al., 2014)] and female [i.e., 25.0 ± 9.1 min, official match (Delextrat et al., 2012)] players who experienced significant declines in strength in other studies.

Finally, different flexibility tests have been used to compare joint range of motion from pre-to-post-match in two studies. Ankle dorsiflexion range of motion significantly improved immediately after match-play in Level 4 male players (returning to baseline after 48 hours) (Moreno-Perez et al., 2020), while knee range of motion only decreased at 24–48 hours in the dominant leg, and at 24 hours in the non-dominant leg among Level 5 male players after a simulated match, showing no alterations at match-end (Chatzinikolaou et al., 2014). The preservation of joint range of motion immediately after match-play may be explained by increases in tissue extensibility caused by higher temperatures in surrounding soft tissues (Moreno-Perez et al., 2020). At a later stage [i.e., 24–48 hours after exercise (Doeven et al., 2018)], match-induced muscle damage and swelling (Ispirlidis et al., 2008; Moreno-Perez et al., 2020) may cause impairments to the mechanical and neural properties of the muscle-tendon unit, resulting in reduced range of motion (Moreno-Perez et al., 2020). Considering that limited joint range of motion has been previously associated with injuries (Backman & Danielson, 2011; Fousekis et al., 2011; Ruiz-Pérez et al., 2021), the present findings suggest that knee injury risk may be increased in the days following match-play, especially in the dominant limb – likely due to its more prominent involvement in basketball actions compared with the non-dominant limb (Chatzinikolaou et al., 2014). Therefore, the use of adequate pre-session warm-up strategies, including joint mobility exercises, may be advisable in the days following competition, as they have been shown to improve joint range of motion (Padua et al., 2019). However, while persistent impairments in knee range of motion were observed in the present review, the impact of match-play on ankle dorsiflexion is less clear (Moreno-Perez et al., 2020), as this measurement was carried out only at 48 hours post-match. Therefore, future research including the assessment of ankle range of motion at intermediate timepoints (e.g., 24 hours post-match) is warranted to better elucidate its recovery time-course.

Effects on physiological responses

Concentrations of haematological and salivary hormonal markers were the most assessed physiological outcomes in the present review. The significant increases in cortisol concentrations at match-end across different player samples (Abdelkrim et al., 2009; Arruda et al., 2014, 2017; Chatzinikolaou et al., 2014; Gonzalez-Bono et al., 1999; Moreira et al., 2013, 2018; Moreira, Crewther, et al., 2012; Moreira, McGuigan, et al., 2012; Souglis et al., 2015) indicates increased stress levels immediately following matches compared with pre-match measurements, with potential immunosuppressive, catabolic, and inhibitory protein synthesis effects in the short-term (Lee et al., 2017). However, compared to pre-match measurements, no significant increases in blood cortisol concentration were found at 13–37 (official match-play) (Souglis et al., 2015), and from 24 to 144 hours post-match (simulated) (Chatzinikolaou et al., 2014) in Level 5 male players, indicating that the match-induced cortisol response may play a predominant role shortly after match-play, rather than during the following hours and days. Conversely, the contrasting findings regarding testosterone concentration warrant further research to determine a definitive understanding of testosterone responses following basketball matches (Kamarauskas & Conte, 2022).

Alongside higher stress levels, high-intensity exercise augments muscle damage markers which are typically related to muscle soreness and reductions in functional capacity (e.g., maximal voluntary contraction, vertical jump height, linear sprint speed) (Skorski et al., 2019), and may impact basketball performance. While two studies examining Level 2 (simulated match) (Díaz-Castro et al., 2018) and Level 5 (official match) (Souglis et al., 2015) male players documented significantly increased CK concentrations at match-end compared to pre-match, no significant changes were observed across match-play in a third study investigating Level 5 male players following a simulated match (Chatzinikolaou et al., 2014). Nevertheless, a trend towards CK increases (albeit non-significant) was observed at match-end, and significantly higher CK concentrations were evident at 24 hours post-match (persisting until 72 hours and normalising after 96 hours) compared with pre-match measurements, indicating that the delayed kinetics of CK release into circulation (Chatzinikolaou et al., 2014) may explain the lack of an increase at match-end in this study. In the other studies assessing persistent changes in muscle damage markers, pre-match CK concentrations increased significantly at 24 (Koyama et al., 2022; Pliauga et al., 2015) and 48 hours (Pliauga et al., 2015) after simulated matches in Level 3 male players, and 13–37 hours following a playoff match in Level 5 male players (accompanied by significant increases in LDH concentration) (Souglis et al., 2015). Surprisingly, one study reported no significant changes in LDH concentration between pre-match and 15 and 39 hours after a playoff match in Level 5 male players (Kostopoulos et al., 2017). However, the average playing time of the examined players was relatively low in the former study (16.4 ± 6.0 min) (Kostopoulos et al., 2017), compared to the latter (full 40-min match) (Souglis et al., 2015), and may have been insufficient to elicit significant changes in LDH concentration. Examining Level 5 female players, Moreira et al (2014) reported no significant, pre-to-post-match changes in CK and myoglobin concentrations at match-end, which in turn significantly increased at 24 hours (CK and myoglobin) and 48 hours (myoglobin). In summary, basketball match-play appears to induce increases in muscle damage markers which may last 24–96 hours, with different magnitudes and recovery times possibly depending on playing time.

Exercise-induced muscle damage is associated with an inflammatory response consisting of an early release of inflammatory cytokines (e.g., IL-6, IL-1β, TNF-α), adhesion molecules (e.g., sVCAM-1) and leukocyte infiltration into the damaged muscle (Peake et al., 2017), all of which induce the release of acute phase proteins, such as CRP (Silva et al., 2018). The present findings reflect this sequence of events, as significant pre-to-post-match increases were found for leukocyte count, sVCAM-1, IL-1β (Chatzinikolaou et al., 2014), IL-6 (Chatzinikolaou et al., 2014; Souglis et al., 2015) and TNF-α (Souglis et al., 2015) immediately after simulated (Chatzinikolaou et al., 2014) and official (Souglis et al., 2015) match-play in Level 5 male players. Among Level 5 male players, leukocyte count [15 (Kostopoulos et al., 2017), 24 (Chatzinikolaou et al., 2014), and 39 hours (Kostopoulos et al., 2017) post-match] and sVCAM-1 [24 hours post-match (Chatzinikolaou et al., 2014)] showed persistent, significant increases compared to pre-match measurements, alongside CRP [13 (Souglis et al., 2015) and 24 hours (Chatzinikolaou et al., 2014)] and platelet count [15 and 39 hours (Kostopoulos et al., 2017)]. In summary, the present data reveal that residual inflammation may be present between 13–48 hours following basketball match-play (Chatzinikolaou et al., 2014; Souglis et al., 2015), potentially amplifying muscle damage and delaying performance recovery (Silva et al., 2018). Indeed, alterations in inflammatory markers were accompanied by performance impairments at 24–48 hours after a simulated match in Level 5 male players (Chatzinikolaou et al., 2014), which may partly explain these performance-related findings.

Markers related to carbohydrate, lipid, and protein metabolism were also significantly affected at match-end across various male players samples (Abdelkrim et al., 2009; Chatzinikolaou et al., 2014; Souglis et al., 2015), except for urea in Level 5 male players after a simulated match (Chatzinikolaou et al., 2014). The significantly increased blood glucose concentrations from pre-to-post-match – alongside significantly decreased insulin release (Abdelkrim et al., 2009) – indicate activation of glycogenolysis and gluconeogenesis, likely due to higher catecholamine release across matches (Abdelkrim et al., 2009). The elevated fatty acid, triglyceride, and glycerol concentrations at match-end compared to pre-match (Abdelkrim et al., 2009; Chatzinikolaou et al., 2014) show that match-play also activates lipolysis (Chatzinikolaou et al., 2014). Taken together, the variations in glycaemia and lipolytic activity suggest that compensatory mechanisms are recruited to provide adequate energy supply and counteract usage of muscle glycogen stores during match-play (Abdelkrim et al., 2009). Meanwhile, significant, pre-to-post-match increases in ammonia (Chatzinikolaou et al., 2014; Souglis et al., 2015) and urea concentrations (Souglis et al., 2015) were apparent at match-end among Level 5 male players following simulated (Chatzinikolaou et al., 2014) and official (Souglis et al., 2015) match-play, remaining elevated for 13 (ammonia) and 37 hours (urea) in one study (Souglis et al., 2015). These findings may indicate increased adenosine triphosphate (ATP) turnover (Finsterer, 2012; Palacios et al., 2015) and protein oxidation (Palacios et al., 2015) following match-play, which may extend beyond exercise cessation. In summary, elevated energy expenditure during basketball match-play may reduce substrate availability (e.g., muscle glycogen) and promote muscle protein breakdown, with potential negative effects on performance capacity (Skorski et al., 2019).

Finally, the presence of exercise-induced inflammation activates the release of reactive oxygen and nitrogen species, which can increase sharply in concentration during exercise, potentially causing significant damage to cell structures (i.e., oxidative stress) (Powers et al., 2020). One of the three studies included in this review (Level 5 male players) reported that pre-match levels of oxidative stress markers significantly increased at match-end and up to 24 hours after a simulated match (Chatzinikolaou et al., 2014), with descriptive findings from a second study (Level 3 male players) also reporting a 15% increase in total serum peroxides immediately after official competition (Perrea et al., 2014). Contrarily, a third study in Level 5 male players found no significant differences in uric acid and thiobarbituric acid reactive substances at 15 and 39 hours following a playoff match compared to pre-match measurements (Kostopoulos et al., 2017), probably due to the lower average playing time apparent among examined players (16.4 ± 6.0 min) compared to those examined by Chatzinikolaou et al. (2014) (full 40-min matches), as longer exercise promotes greater oxidative stress compared to shorter bouts (Powers et al., 2020). Taken together, the present findings suggest that playing a full basketball match represents a "pro-oxidant insult" which may have detrimental effects on force production (Powers et al., 2020) until 24 hours post-match, although lower playing times among players may not promote significant elevations in oxidative stress.

Effects on athlete-reported and sleep-related outcome measures

Muscle soreness in athletes is a common symptom of exercise-induced muscle damage and is typically associated with impaired muscle function, pain, stiffness, and swelling (Bongiovanni et al., 2020; Hotfiel et al., 2018). In this review, two studies in Level 3 (Cortis et al., 2011) and Level 5 (Chatzinikolaou et al., 2014) male players reported significant increases in perceived muscle soreness immediately after simulated match-play compared to pre-match measurements, which persisted up to 24 (quadriceps) and 48 hours (hamstrings) in Level 5 players (Chatzinikolaou et al., 2014). Conversely, a third study in Level 5 male players did not find significant increases in perceived muscle soreness between measurements conducted on pre-match morning and post-match morning following official matches (Conte et al., 2021). A possible explanation for this finding may be related to the relatively low playing time of the players examined in this study (22.8 ± 8.0 min) (Conte et al., 2021), compared with those examined by Chatzinikolaou et al (2014), where playing a full 40-min match significantly increased muscle soreness up to 48 hours post-match. Regarding females, Moreira et al. found significantly increased perceived hamstrings soreness between pre-match and 24–48 hours after an official match in Level 5 players (although no changes were observed at match-end) (Moreira et al., 2014), while a separate study (Level 3 players) reported descriptive, *moderate-to-large* increases in lower-limb muscle soreness at match-end (~170–200%) and 24 hours (~67%) following a simulated match (Pernigoni et al., 2023). Taken together, findings in both sexes suggest that muscle soreness may be present in the days following match-play, even in well-trained players (i.e., Level 5) who likely benefit from the repeated bout effect (Hyldahl et al., 2017). Specifically, hamstring muscles are largely activated during eccentric actions (to slow hip flexion and knee extension during braking and landing) (Moreira et al., 2014), which may explain the longer time required for recovery in this muscle group compared with quadriceps (Chatzinikolaou et al., 2014). Considering the general trend examined in the present review, the use of recovery strategies aimed at alleviating muscle soreness and optimising player well-being in the days following matches (Pernigoni et al., 2022) may prove useful in basketball.

In addition to perceived muscle soreness, perceived fatigue and mood states were compared pre-to-post-match-play. In this regard, perceived tension, depression, anger, confusion (Gonzalez-Bono et al., 1999), vigour (Gonzalez-Bono et al., 1999, 2000) and fatigue (Gonzalez-Bono et al., 1999, 2000; Pernigoni et al., 2023) were negatively affected at match-end in Level 5 male players (Gonzalez-Bono et al., 1999, 2000) and Level 3 females (Pernigoni et al., 2023), while Profile of Mood State total score was unaltered (Gonzalez-Bono et al., 2000).

Regarding the persistent effects of match-play, one study in Level 5 male players reported significant increases in perceived fatigue and decreased total well-being scores upon awakening on post-match mornings compared with pre-match mornings (official match-play), while no significant changes were found for perceived stress and mood (Conte et al., 2021). Conversely, perceived fatigue returned to baseline (i.e., pre-match values) after 24 hours in Level 3 female players following a simulated match (Pernigoni et al., 2023). In summary, basketball match-play seems to increase perceived fatigue at match-end, while the persistent effects of match-play on perceived fatigue (in addition to alterations in mood state, both at match-end and over the following days) are unclear. These mixed findings may be related to contextual factors, as match type (i.e., official versus simulated), opponent level, match difficulty, and match outcome may generate differing perceptual responses (de Lima Pinto et al., 2018; Gonzalez-Bono et al., 2000; Marqués-Jiménez et al., 2017).

Finally, post-match changes in sleep-related measures were assessed in three studies. Previous research in basketball has shown that player sleep may be negatively impacted (i.e., later sleep onset, shorter time in bed, and lower sleep duration) by training (Lastella et al., 2020) and competition (Fox, Scanlan, et al., 2020), [particularly following high-load, evening matches (Fox, Scanlan, et al., 2020)], which in turn may affect performance, mood stability, cell growth, and glycogen availability (Bonnar et al., 2018). In the present review directly assessing pre-to-post-match changes, no significant alterations in perceived sleep quality were reported on post-match mornings, compared to pre-match mornings, in Level 5 male players following official matches (Conte et al., 2021). Similarly, perceived sleep quality (Power et al., 2023) and objectively-measured total sleep time, efficiency (Power et al., 2023; Staunton et al., 2017), time in bed, and sleep onset (Power et al., 2023) did not significantly change on post-match nights [i.e., one (Power et al., 2023) or two (Staunton et al., 2017) consecutive nights, Level 4 and Level 5 female players, respectively] following official match-play, compared with pre-match nights [the only exception being delayed sleep offset on post-match nights compared to pre-match nights preceded by an evening training session (Power et al., 2023)]. In summary, sleep patterns were generally not impacted by a single basketball match. However, research is currently limited in terms of the players assessed and outcomes collected, suggesting future studies are needed to better elucidate the temporal impact of basketball match-play on subsequent sleep.

Fatigue in congested match schedules

Effects on performance

Both studies assessing the effect of congested match schedules on performance outcomes investigated male players participating in official matches (de Lima Pinto et al., 2018; Montgomery, Pyne, Hopkins, et al., 2008). De Lima Pinto et al (2018) conducted daily assessments of morning CMJ performance during a 3-day period in Level 3 players, and found a significant decrease on Day 2 compared to Day 1, although measurements returned to baseline levels on Day 3. It is possible that the longer playing time encountered throughout Day 1 (i.e., two matches vs one match on Days 2 and 3) promoted greater decreases in performance (Doeven et al., 2018), resulting in a significantly poorer CMJ height on Day 2, which may indicate the importance of load distribution throughout a congested period on the subsequent fatigue response. Another study in Level 3 players reported negative changes in 20-m sprint, repeated Line Drill, agility, vertical jump, and sit-and-reach performance following a 3-day tournament compared with pre-tournament measurements (Montgomery, Pyne, Hopkins, et al., 2008). In summary, the impact of congested match schedules on performance is currently unclear, as only one of two studies documented cumulative fatigue. Methodological differences between research protocols such as match durations [40 (de Lima Pinto et al., 2018) vs 48 min (Montgomery, Pyne, Hopkins, et al., 2008)], data reporting methods [statistical (de Lima Pinto et al., 2018) vs clinical (Montgomery, Pyne, Hopkins, et al., 2008) significance], and other match-related contextual factors may explain these differences, warranting future research to clarify the impact of congested match-play on fatigue in basketball players across wider samples.

Effects on physiological responses

Two studies examined physiological responses to congested match schedules. During a 3-day official tournament (i.e., one match per day) in Level 3 male players, significant increases were found immediately after each match for fatty-acid binding protein, myoglobin, CK (persisting at 6 hours post-match), IL-6, and IL-10 concentrations (Montgomery, Pyne, Cox, et al., 2008), indicating similar effects to what was observed following single matches. In terms of cumulative effects (i.e., pre-to-post-tournament), IL-6 and IL-10 showed no significant changes and a significant decrease, respectively, while fatty-acid binding protein, CK, and myoglobin concentrations significantly increased, indicating that a *small*-to-*moderate* degree of muscle damage was induced by congested match-play (Montgomery, Pyne, Cox, et al., 2008).

In addition to disruption in biochemical markers, physical exercise – including basketball activity (Aras et al., 2023; Pernigoni, Calleja-González, et al., 2024; Pernigoni, Perazzetti, et al., 2024) – has been shown to affect cardiac autonomic activity, an important component of post-exercise recovery commonly assessed through HRV (Stanley et al., 2013). However, in the present review, Lukonaitienė et al. (2021) reported no significant changes in parasympathetic activation in Level 3 female players during a 10-day congested period including seven official matches, indicating that adequate restoration of cardiovascular homeostasis was achieved throughout the congested period.

Effects on athlete-reported outcome measures

In male players, schedule congestion (i.e., official matches) significantly and negatively impacted perceived anger, vigour, total mood disturbance, recovery (i.e., TQR) (de Lima Pinto et al., 2018), fatigue, muscle soreness (Montgomery, Pyne, Hopkins, et al., 2008), and overall well-being (i.e., Hooper index) (García et al., 2023) across three studies examining Level 3 players. Collectively, these findings support the notion that schedule congestion impacts overall perceived well-being (Doeven et al., 2021) to a certain extent in male players, which in turn may adversely affect competitive readiness (Sansone et al., 2020;

Selmi et al., 2021), injury risk (Doma et al., 2018), technical performance (Nedelec et al., 2014; Selmi et al., 2021), and tactical performance (Selmi et al., 2021). However, some mood state components were only partially influenced [i.e., perceived depression (de Lima Pinto et al., 2018)] or did not show any significant change [i.e., DALDA scores, perceived tension, and perceived confusion (de Lima Pinto et al., 2018)] throughout the congested period in one of these two studies. Previous research suggests that the effects of match-play on mood state may vary depending on several contextual factors, such as match outcome (Gonzalez-Bono et al., 1999; Marqués-Jiménez et al., 2017), although this phenomenon did not occur in this study, as significant changes in anger (i.e., increase) and vigour (decrease) were observed after both won and lost games (de Lima Pinto et al., 2018). Therefore, future research should analyse the influence of various contextual factors during congested match schedules to better clarify their role in fatigue development. Regarding females, one study showed significantly lower perceived well-being during the latter stages of a congested period in Level 3 players (i.e., Days 7 and 10 of a 10-day congested period, compared with Day 1) (Lukonaitienė et al., 2021). However, when under-18 and under-20 players were analysed separately, only under-18 showed significantly lower well-being towards the end of the tournament (Lukonaitienė et al., 2021), which may potentially indicate that older players, who possessed greater training histories, may be able to better tolerate congested match-play than their younger counterparts.

Limitations

Although this systematic review presents interesting findings, it is important to acknowledge its potential limitations. Mainly, the samples and outcome measures analysed in the included studies presented a high degree of heterogeneity, in terms of the analysed samples (i.e., sex, age and competitive level), investigated fatigue outcome measures, and timepoints examined (especially in terms of persistent fatigue). Specifically, the competitive levels of players recruited across studies ranged from Level 2 to Level 5. Due to the varied match demands encountered (Stojanović et al., 2018) and physical fitness of players (Ferioli et al., 2018) across competitive levels, the fatigue-related responses experienced surrounding matches are likely to be heterogeneous according to this factor. Additionally, different outcome measures were assessed at various timepoints, which limited the possibility to pool data for specific measures at certain points during post-match recovery. This factor is especially important given that the wide breadth of fatigue-related markers adopted within the literature capture different physical and systemic responses, which are likely to respond in specific patterns following match-play (in terms of both match-end and persistent changes). In turn, the use of varied timepoints to assess fatigue in the hours and days following matches (i.e., from 2 hours to 144 hours) creates further difficulties in pooling data, given the time-dependent nature of neuromuscular and physiological fatigue markers following exercise. For the above-mentioned reasons, it was not possible to conduct a meta-analysis, as data were not extensive enough for specific outcomes to be grouped according to certain player subgroups.

Conclusion

The general trends highlighted within the present review are indicative of varied player samples, encompassing different competitive levels, ages, and sexes. Accordingly – as described in detail throughout the discussion – readers are advised to consider the effect that such factors may have on fatigue responses following match-play, thereby accounting for the discrepancies observed across studies.

Overall, the main findings of this review show that vertical jump performance may be impaired at match-end (<1 hour following the end of match-play) across various player samples (Levels 2, 3 and 5). Persistent impairments (≥1 hour post-match) at 24–48 hours following match-play were consistently observed in males (Levels 3 and 5) but not females (Level 3), whose jumping performance was fully restored after 24 hours. Additionally, linear sprinting performance and RSA were generally hindered at match-end (Level 2, 3 and 5 players), with persistent impairments lasting up to 24–48 hours for sprinting, but not RSA, which returned to baseline levels at 24 hours post-match.

In terms of physiological responses, match-play induced consistent increases in cortisol concentrations at match-end, while inconsistent changes in testosterone concentrations were reported across studies (both markers assessed in Level 3, 4 and 5 players), with neither marker showing persistent changes compared to pre-match measurements. Muscle damage markers mainly rose at 13–72 hours post-match across studies (generally peaking at 24–48 hours; Level 3 and 5 players), together with inflammation markers (13–48 hours post-match; Level 5 players), which may partly explain the observed performance impairments in the days following match-play. Furthermore, carbohydrate, lipid, and protein metabolism markers (assessed in Level 3, 4 and 5 players) were generally affected at match-end, with elevated concentrations of ammonia and urea also indicating potentially increased ATP and protein turnover up to 13–37 hours post-match. Finally, increases in oxidative stress may depend on playing time, as only players (Level 5) completing high (i.e., full 40-min matches) but not low (i.e., ~16 min per match) playing times had augmented oxidative stress 15–39 hours post-match.

Regarding athlete-reported outcomes, the time-course of muscle soreness varied among studies [potentially due to differences in the investigated player samples (Levels 3 and 5) and their associated playing times during matches], although it appears that significant soreness is generally present 24–48 hours post-match. Perceived fatigue presented consistent increases at match-end (compared to pre-match; Level 3 and 5 players), while the effects of match-play on mood states (both at match-end, and on post-match days; Level 5 players) were unclear, possibly due to the influence that several contextual factors (e.g., opponent level, match difficulty, match outcome) may exert on mood. Conversely, sleep-related outcomes did not generally appear to be impacted by basketball match-play (Level 4 and 5 players), although current research is limited.

As opposed to fatigue elicited by single matches, research assessing the impact of congested match schedules is sparse. Firstly, the effects of congested match schedules on performance were unclear, with only some data reporting a cumulative fatigue effect (Levels 3 players). Secondly, physiological assessment showed a potentially negative cumulative effect of a 3-day tournament on muscle damage and inflammation markers in male players, while restoration of cardiovascular homoeostasis in the form of HRV was appropriately achieved in female players throughout a 10-day tournament (both Level 3). Finally, perceived muscle soreness, fatigue, recovery and overall well-being showed consistent impairments during 3–6 days of match congestion in male players, while findings related to measures of mood states varied considerably (all Level 3 players). Overall, differences in the investigated player samples (i.e., sex, age, and competitive level), match durations, individual playing times, schedule congestion scenarios, and other contextual factors could explain these discrepancies, warranting further research to improve the limited understanding currently available in this area.

Practical applications

While phenomena such as exercise-induced muscle damage, inflammation, and oxidative stress are a vital part of the adaptive processes that take place after exercise (Owens et al., 2019), the present review suggests that these alterations may contribute to impairments in vertical jump performance, linear sprinting, muscle soreness, and perceived fatigue up to 24–48 hours following basketball match-play. Therefore, the use of post-match recovery strategies (e.g., adequate nutrition, cold water immersion, whole-body cryotherapy) may prove useful when the priority is to improve readiness and well-being in the days following match-play (e.g., during the in-season phase or tournaments) (Pernigoni et al., 2022). Additionally, load management in real-time during match-play could limit the fatiguing effects encountered by players, as lower playing times were generally accompanied by lower fatigue over the hours and days following match-play. Even more so, the implementation of recovery and load management strategies should also be considered during congested match schedules. However, the optimal balance between maximising time on the court for the best players and ensuring they are able to overcome fatigue following match-play for subsequent performance likely varies between players, requiring precise monitoring and data acquisition processes embedded within teams for individualised evidence to be generated. Furthermore, the noticeable research gaps regarding fatigue responses during congested match schedules, as well as changes in sleep outcomes surrounding any form of basketball match-play, highlight the need for more research on these topics to better inform evidence-based decision-making in practice. Finally, the present findings suggest that female players may potentially recover faster following match-play compared with males, possibly due to different match demands and intrinsic physiological characteristics. However, future comparative research across sexes should be conducted to verify this notion.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

The author(s) reported there is no funding associated with the work featured in this article.

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References

Abdelkrim, N. B., Castagna, C., Fazaa, S. E., Tabka, Z., & Ati, J. E. (2009). Blood metabolites during basketball competitions. *The Journal of Strength & Conditioning Research*, *23*(3), 765–773. https://doi.org/10.1519/JSC.0b013e3181a2d8fc

Abdelkrim, N. B., El Fazaa, S., & El Ati, J. (2007). Time–motion analysis and physiological data of elite under-19-year-old basketball players during competition. *British Journal of Sports Medicine*, *41*(2), 69–75. https://doi.org/10.1136/bjsm.2006.032318

Aras, D., Samil Onlu, A., Durmus, T., Cengiz, C., Guler, D., Guler, Y., Ugurlu, A., Aldhahi, M. I., & Gülü, M. (2023). A brief body scan mindfulness practice has no positive effect on the recovery of heart rate variability and cognitive tasks in female professional basketball players. *Frontiers in Psychology*, *14*, 1196066. https://doi.org/10.3389/fpsyg.2023.1196066

Arruda, A. F. S., Aoki, M. S., Drago, G., & Moreira, A. (2019). Salivary testosterone concentration, anxiety, perceived performance and ratings of perceived exertion in basketball players during semi-final and final matches. *Physiology & Behavior*, *198*, 102–107. https://doi.org/10.1016/j.physbeh.2018.10.008

Arruda, A. F. S., Aoki, M. S., Freitas, C. G., Drago, G., Oliveira, R., Crewther, B. T., & Moreira, A. (2014). Influence of competition playing venue on the hormonal responses, state anxiety and perception of effort in elite basketball athletes. *Physiology & Behavior*, *130*, 1–5. https://doi.org/10.1016/j.physbeh.2014.03.007

Arruda, A. F. S., Aoki, M. S., Paludo, A. C., & Moreira, A. (2017). Salivary steroid response and competitive anxiety in elite basketball players: Effect of opponent level. *Physiology & Behavior*, *177*, 291–296. https://doi.org/10.1016/j.physbeh.2017.05.017

Backman, L. J., & Danielson, P. (2011). Low range of ankle dorsiflexion predisposes for patellar tendinopathy in junior elite basketball players. *The American Journal of Sports Medicine*, *39*(12), 2626–2633. https://doi.org/10.1177/0363546511420552

Bergh, U., Thorstensson, A., Sjödin, B., Hultén, B., Piehl, K., & Karlsson, J. (1978). Maximal oxygen uptake and muscle fiber types in trained and untrained humans. *Medicine and Science in Sports*, *10*(3), 151–154.

Bongiovanni, T., Genovesi, F., Nemmer, M., Carling, C., Alberti, G., & Howatson, G. (2020). Nutritional interventions for reducing the signs and symptoms of exercise-induced muscle damage and accelerate recovery in athletes: Current knowledge, practical application and future perspectives. *European Journal of Applied Physiology*, *120*(9), 1965–1996. https://doi.org/10.1007/s00421-020-04432-3

Bonnar, D., Bartel, K., Kakoschke, N., & Lang, C. (2018). Sleep interventions designed to improve athletic performance and recovery: A systematic review of current approaches. *Sports Medicine*, *48*(3), 683–703. https://doi.org/10.1007/s40279-017-0832-x

Calleja-González, J., Terrados, N., Mielgo-Ayuso, J., Delextrat, A., Jukic, I., Vaquera, A., Torres, L., Schelling, X., Stojanovic, M., & Ostojic, S. M. (2016).

Evidence-based post-exercise recovery strategies in basketball. *The Physician and Sportsmedicine*, *44*(1), 74–78. https://doi.org/10.1080/00913847.2016.1102033
Cao, S., Geok, S. K., Roslan, S., Sun, H., Lam, S. K., & Qian, S. (2022). Mental fatigue and basketball performance: A systematic review. *Frontiers in Psychology*, *12*, 819081. https://doi.org/10.3389/fpsyg.2021.819081
Caprino, D., Clarke, N. D., & Delextrat, A. (2012). The effect of an official match on repeated sprint ability in junior basketball players. *Journal of Sports Sciences*, *30*(11), 1165–1173. https://doi.org/10.1080/02640414.2012.695081
Chatzinikolaou, A., Draganidis, D., Avloniti, A., Karipidis, A., Jamurtas, A. Z., Skevaki, C. L., Tsoukas, D., Sovatzidis, A., Theodorou, A., Kambas, A., Papassotiriou, I., Taxildaris, K., & Fatouros, I. (2014). The microcycle of inflammation and performance changes after a basketball match. *Journal of Sports Sciences*, *32*(9), 870–882. https://doi.org/10.1080/02640414.2013.865251
Clemente, F. M., Mendes, B., Bredt da, S. G. T., Praça, G. M., Silvério, A., Carriço, S., & Duarte, E. (2019). Perceived training load, muscle soreness, stress, fatigue, and sleep quality in professional basketball: A full season study. *Journal of Human Kinetics*, *67*(1), 199–207. https://doi.org/10.2478/hukin-2019-0002
Conte, D., Kamarauskas, P., Ferioli, D., Scanlan, A. T., Kamandulis, S., Paulauskas, H., & Lukonaitienė, I. (2021). Workload and well-being across games played on consecutive days during in-season phase in basketball players. *The Journal of Sports Medicine and Physical Fitness*, *61*(4), 534–541. https://doi.org/10.23736/S0022-4707.20.11396-3
Conte, D., Kolb, N., Scanlan, A. T., & Santolamazza, F. (2018). Monitoring training load and well-being during the in-season phase in national collegiate athletic association division i men's basketball. *International Journal of Sports Physiology and Performance*, *13*(8), 1067–1074. https://doi.org/10.1123/ijspp.2017-0689
Cortis, C., Tessitore, A., Lupo, C., Pesce, C., Fossile, E., Figura, F., & Capranica, L. (2011). Inter-limb coordination, strength, jump, and sprint performances following a youth men's basketball game. *The Journal of Strength & Conditioning Research*, *25*(1), 135–142. https://doi.org/10.1519/JSC.0b013e3181bde2ec
Davis, J. K., Oikawa, S. Y., Halson, S., Stephens, J., O'Riordan, S., Luhrs, K., Sopena, B., & Baker, L. B. (2022). In-season nutrition strategies and recovery modalities to enhance recovery for basketball players: A narrative review. *Sports Medicine*, *52*(5), 971–993. https://doi.org/10.1007/s40279-021-01606-7
Delextrat, A., Baliqi, F., & Clarke, N. (2013). Repeated sprint ability and stride kinematics are altered following an official match in national-level basketball players. *The Journal of Sports Medicine and Physical Fitness*, *53*(2), 112–118.
Delextrat, A., Calleja-González, J., Hippocrate, A., & Clarke, N. D. (2013). Effects of sports massage and intermittent cold-water immersion on recovery from matches by basketball players. *Journal of Sports Sciences*, *31*(1), 11–19. https://doi.org/10.1080/02640414.2012.719241
Delextrat, A., Hippocrate, A., Leddington-Wright, S., & Clarke, N. D. (2014). Including stretches to a massage routine improves recovery from official matches in basketball players. *The Journal of Strength & Conditioning Research*, *28*(3), 716–727. https://doi.org/10.1519/JSC.0b013e3182aa5e7c
Delextrat, A., Trochym, E., & Calleja-González, J. (2012). Effect of a typical in-season week on strength jump and sprint performances in national-level female basketball players. *The Journal of Sports Medicine and Physical Fitness*, *52*(2), 128–136.
de Lima Pinto, J. C. B., Menezes, T. C. B., Fortes, L. D. S., & Mortatti, A. L. (2018). Monitoring stress, mood and recovery during successive basketball matches. *Journal of Physical Education and Sport*, *18*(2), 677–685. https://doi.org/10.7752/jpes.2018.02099
Díaz-Castro, F., Astudillo, S., Calleja-González, J., Zbinden Foncea, H., Ramirez-Campillo, R., & Castro-Sepúlveda, M. (2018). Change in marker of hydration correspond to decrement in lower body power following basketball match. *Science & Sports*, *33*(3), e123–8. https://doi.org/10.1016/j.scispo.2017.10.007
Doeven, S. H., Brink, M. S., Huijgen, B. C. H., de Jong, J., & Lemmink, K. A. P. M. (2021). Managing load to optimize well-being and recovery during short-term match congestion in elite basketball. *International Journal of Sports Physiology and Performance*, *16*(1), 45–50. https://doi.org/10.1123/ijspp.2019-0916
Doeven, S. H., Brink, M. S., Kosse, S. J., & Lemmink, K. A. P. M. (2018). Postmatch recovery of physical performance and biochemical markers in team ball sports: A systematic review. *BMJ Open Sport & Exercise Medicine*, *4*(1), e000264. https://doi.org/10.1136/bmjsem-2017-000264
Doma, K., Leicht, A., Sinclair, W., Schumann, M., Damas, F., Burt, D., & Woods, C. (2018). Impact of exercise-induced muscle damage on performance test outcomes in elite female basketball players. *The Journal of Strength & Conditioning Research*, *32*(6), 1731–1738. https://doi.org/10.1519/JSC.0000000000002244
Drevon, D., Fursa, S. R., & Malcolm, A. L. (2017). Intercoder reliability and validity of WebPlotDigitizer in extracting graphed data. *Behavior Modification*, *41*(2), 323–339. https://doi.org/10.1177/0145445516673998
Edwards, T., Spiteri, T., Piggott, B., Bonhotal, J., Haff, G. G., & Joyce, C. (2018). Monitoring and managing fatigue in basketball. *Sports*, *6*(1), 19. https://doi.org/10.3390/sports6010019
Enoka, R. M., & Duchateau, J. (2016). Translating fatigue to human performance. *Medicine & Science in Sports & Exercise*, *48*(11), 2228–2238. https://doi.org/10.1249/MSS.0000000000000929
Esteves, P. T., Mikolajec, K., Schelling, X., & Sampaio, J. (2021). Basketball performance is affected by the schedule congestion: NBA back-to-backs under the microscope. *European Journal of Sport Science*, *21*(1), 26–35. https://doi.org/10.1080/17461391.2020.1736179
Ferioli, D., Rampinini, E., Bosio, A., La Torre, A., Azzolini, M., & Coutts, A. J. (2018). The physical profile of adult male basketball players: Differences between competitive levels and playing positions. *Journal of Sports Sciences*, *36*(22), 2567–2574. https://doi.org/10.1080/02640414.2018.1469241
Ferioli, D., Rampinini, E., Bosio, A., Torre, A. L., & Maffiuletti, N. A. (2019). Peripheral muscle function during repeated changes of direction in basketball. *International Journal of Sports Physiology and Performance*, *14*(6), 739–746. https://doi.org/10.1123/ijspp.2018-0366
Ferioli, D., Rampinini, E., Martin, M., Rucco, D., la Torre, A., Petway, A., & Scanlan, A. (2020). Influence of ball possession and playing position on the physical demands encountered during professional basketball games. *Biology of Sport*, *37*(3), 269–276. https://doi.org/10.5114/biolsport.2020.95638
Ferioli, D., Scanlan, A. T., Conte, D., Tibiletti, E., & Rampinini, E. (2021). The business end of the season: A comparison between playoff and regular-season workloads in professional basketball players. *International Journal of Sports Physiology and Performance*, *16*(5), 655–662. https://doi.org/10.1123/ijspp.2020-0405
Ferioli, D., Schelling, X., Bosio, A., la Torre, A., Rucco, D., & Rampinini, E. (2020). Match activities in basketball games: Comparison between different competitive levels. *The Journal of Strength & Conditioning Research*, *34*(1), 172–182. https://doi.org/10.1519/JSC.0000000000003039
Finsterer, J. (2012). Biomarkers of peripheral muscle fatigue during exercise. *BMC Musculoskeletal Disorders*, *13*(1), 218. https://doi.org/10.1186/1471-2474-13-218
Fousekis, K., Tsepis, E., Poulmedis, P., Athanasopoulos, S., & Vagenas, G. (2011). Intrinsic risk factors of non-contact quadriceps and hamstring strains in soccer: A prospective study of 100 professional players. *British Journal of Sports Medicine*, *45*(9), 709–714. https://doi.org/10.1136/bjsm.2010.077560
Fox, J. L., O'Grady, C. J., & Scanlan, A. T. (2020). Game schedule congestion affects weekly workloads but not individual game demands in semi-professional basketball. *Biology of Sport*, *37*(1), 59–67. https://doi.org/10.5114/biolsport.2020.91499
Fox, J. L., Scanlan, A. T., Stanton, R., O'Grady, C. J., & Sargent, C. (2020). Losing sleep over it: Sleep in basketball players affected by game but not training workloads. *International Journal of Sports Physiology and Performance*, *15*(8), 1117–1124. https://doi.org/10.1123/ijspp.2019-0676
Gandevia, S. C. (2001). Spinal and supraspinal factors in human muscle fatigue. *Physiological Reviews*, *81*(4), 1725–1789. https://doi.org/10.1152/physrev.2001.81.4.1725
García, F., Castellano, J., Vicens-Bordas, J., Vázquez-Guerrero, J., & Ferioli, D. (2023). Impact of a 6-day official tournament on physical demands,

perceptual–physiological responses, well-being, and game performance of under-18 basketball players. *International Journal of Sports Physiology and Performance*, *18*(10), 1109–1115. https://doi.org/10.1123/ijspp.2022-0460

Garrett, W. E., Califf, J. C., & Bassett, F. H. (1984). Histochemical correlates of hamstring injuries. *The American Journal of Sports Medicine*, *12*(2), 98–103. https://doi.org/10.1177/036354658401200202

Gonzalez-Bono, E., Salvador, A., Ricarte, J., Serrano, M. A., & Arnedo, M. (2000). Testosterone and attribution of successful competition. *Aggressive Behavior*, *26*(3), 235–240. https://doi.org/10.1002/(SICI)1098-2337(2000)26:3<235::AID-AB3>3.0.CO;2-L

Gonzalez-Bono, E., Salvador, A., Serrano, M. A., & Ricarte, J. (1999). Testosterone, cortisol, and mood in a sports team competition. *Hormones and Behavior*, *35*(1), 55–62. https://doi.org/10.1006/hbeh.1998.1496

González-Devesa, D., Molina, A. J., Ayán, C., Suárez-Iglesias, D., & Vaquera, A. (2023). The effectiveness of a practical half-time re-warm-up strategy in youth female basketball players. *Journal of Physical Education and Sport*, *23*(2), 310–318. https://doi.org/10.7752/jpes.2023.02037

Goulart, K. N. O., Coimbra, C. C., Campos, H. O., Drummond, L. R., Ogando, P. H. M., Brown, G., Couto, B. P., Duffield, R., & Wanner, S. P. (2022). Fatigue and recovery time course after female soccer matches: A systematic review and meta-analysis. *Sports Medicine - Open*, *8*(1), 72. https://doi.org/10.1186/s40798-022-00466-3

Hewett, T. E., Myer, G. D., & Ford, K. R. (2004). Decrease in neuromuscular control about the knee with maturation in female athletes. *The Journal of Bone and Joint Surgery*, *86*(8), 1601–1608. https://doi.org/10.2106/00004623-200408000-00001

Hoffman, J. R., Williams, D. R., Emerson, N. S., Hoffman, M. W., Wells, A. J., McVeigh, D. M., McCormack, W. P., Mangine, G. T., Gonzalez, A. M., & Fragala, M. S. (2012). L-alanyl-L-glutamine ingestion maintains performance during a competitive basketball game. *Journal of the International Society of Sports Nutrition*, *9*(1), 1–8. https://doi.org/10.1186/1550-2783-9-4

Hopkins, W. G., Marshall, S. W., Batterham, A. M., & Hanin, J. (2009). Progressive statistics for studies in sports medicine and exercise science. *Medicine & Science in Sports & Exercise*, *41*(1), 3–12. https://doi.org/10.1249/MSS.0b013e31818cb278

Hotfiel, T., Freiwald, J., Hoppe, M. W., Lutter, C., Forst, R., Grim, C., Bloch, W., Hüttel, M., & Heiss, R. (2018). Advances in Delayed-Onset Muscle Soreness (DOMS): Part I: Pathogenesis and diagnostics. *Sportverletzung·Sportschaden*, *32*(4), 243–250. https://doi.org/10.1055/a-0753-1884

Hyldahl, R. D., Chen, T. C., & Nosaka, K. (2017). Mechanisms and mediators of the skeletal muscle repeated bout effect. *Exercise and Sport Sciences Reviews*, *45*(1), 24–33. https://doi.org/10.1249/JES.0000000000000095

Ispirlidis, I., Fatouros, I. G., Jamurtas, A. Z., Nikolaidis, M. G., Michailidis, I., Douroudos, I., Margonis, K., Chatzinikolaou, A., Kalistratos, E., Katrabasas, I., Alexiou, V., & Taxildaris, K. (2008). Time-course of changes in inflammatory and performance responses following a soccer game. *Clinical Journal of Sport Medicine*, *18*(5), 423–431. https://doi.org/10.1097/JSM.0b013e3181818e0b

Izquierdo, J. M., & Redondo, J. C. (2020). Acute effects of basketball competition on physical performance factors in under-18 female players. [Influencia de la competición sobre los factores de rendimiento físico en jugadoras de baloncesto sub-18]. *RICYDE Revista Internacional de Ciencias del Deporte*, *16*(61), 285–297. https://doi.org/10.5232/ricyde2020.06104

Izquierdo, J. M., & Redondo, J. C. (2021). Quantitative assessment of the effects of official match on physical performance factors on under-16 and under-18 female basketball players at national league level. *European Journal of Human Movement*, *46*. https://doi.org/10.21134/eurjhm.2021.46.594

Izquierdo, J. M., Redondo, J. C., Marqués-Jiménez, D., Zarauz-Moreno, A., & Fernández-Lázaro, D. (2024). How hormones, vertical jump and perceived exertion change in clutch time. A season case study of an amateur basketball team. *International Journal of Performance Analysis in Sport*, *24*(2), 158–169. https://doi.org/10.1080/24748668.2023.2277627

Jacobs, I., Esbjörnsson, M., Sylvén, C., Holm, I., & Jansson, E. (1987). Sprint training effects on muscle myoglobin, enzymes, fiber types, and blood lactate. *Medicine & Science in Sports & Exercise*, *19*(4), 368–374. https://doi.org/10.1249/00005768-198708000-00008

Kamarauskas, P., & Conte, D. (2022). The effect of basketball matches on salivary markers: A systematic review. *Biology of Sport*, *39*(4), 791–808. https://doi.org/10.5114/biolsport.2022.107481

Kamarauskas, P., Lukonaitienė, I., Scanlan, A. T., Ferioli, D., Paulauskas, H., & Conte, D. (2022). Weekly fluctuations in salivary hormone responses and their relationships with load and well-being in semiprofessional, male basketball players during a congested In-season phase. *International Journal of Sports Physiology and Performance*, *17*(2), 263–269. https://doi.org/10.1123/ijspp.2021-0106

Kellis, E., Sahinis, C., & Baltzopoulos, V. (2023). Is hamstrings-to-quadriceps torque ratio useful for predicting anterior cruciate ligament and hamstring injuries? A systematic and critical review. *Journal of Sport and Health Science*, *12*(3), 343–358. https://doi.org/10.1016/j.jshs.2022.01.002

Kostopoulos, N., Apostolidis, N., Mexis, D., Mikellidi, A., & Nomikos, T. (2017). Dietary intake and the markers of muscle damage in elite basketball players after a basketball match. *Journal of Physical Education and Sport*, *17*(1), 394–401. https://doi.org/10.7752/jpes.2017.01058

Koyama, T., Rikukawa, A., Nagano, Y., Sasaki, S., Ichikawa, H., & Hirose, N. (2022). High-acceleration movement, muscle damage, and perceived exertion in basketball games. *International Journal of Sports Physiology and Performance*, *17*(1), 16–21. https://doi.org/10.1123/ijspp.2020-0963

Lastella, M., Roach, G. D., Vincent, G. E., Scanlan, A. T., Halson, S. L., & Sargent, C. (2020). The impact of training load on sleep during a 14-day training camp in elite, adolescent, female basketball players. *International Journal of Sports Physiology and Performance*, *15*(5), 724–730. https://doi.org/10.1123/ijspp.2019-0157

Lee, E. C., Fragala, M. S., Kavouras, S. A., Queen, R. M., Pryor, J. L., & Casa, D. J. (2017). Biomarkers in sports and exercise: Tracking health, performance, and recovery in athletes. *The Journal of Strength & Conditioning Research*, *31*(10), 2920–2937. https://doi.org/10.1519/JSC.0000000000002122

Liveris, N. I., Tsarbou, C., Tsimeas, P. D., Papageorgiou, G., Xergia, S. A., & Tsiokanos, A. (2021). Evaluating the effects of match-induced fatigue on landing ability; the case of the basketball game. *International Journal of Exercise Science*, *14*(6), 768–778.

Lukonaitienė, I., Conte, D., Paulauskas, H., Pliauga, V., Kreivyte, R., Stanislovaitiene, J., & Kamandulis, S. (2021). Investigation of readiness and perceived workload in junior female basketball players during a congested match schedule. *Biology of Sport*, *38*(3), 341–349. https://doi.org/10.5114/biolsport.2021.99702

Marqués-Jiménez, D., Calleja-González, J., Arratibel, I., Delextrat, A., & Terrados, N. (2017). Fatigue and recovery in soccer: Evidence and challenges. *The Open Sports Sciences Journal*, *10*(1), 52–70. https://doi.org/10.2174/1875399X01710010052

Mihajlovic, M., Cabarkapa, D., Cabarkapa, D. V., Philipp, N. M., & Fry, A. C. (2023). Recovery methods in basketball: A systematic review. *Sports*, *11*(11), 230. https://doi.org/10.3390/sports11110230

Montgomery, P. G., Pyne, D. B., Cox, A. J., Hopkins, W. G., Minahan, C. L., & Hunt, P. H. (2008). Muscle damage, inflammation, and recovery interventions during a 3-day basketball tournament. *European Journal of Sport Science*, *8*(5), 241–250. https://doi.org/10.1080/17461390802251844

Montgomery, P. G., Pyne, D. B., Hopkins, W. G., Dorman, J. C., Cook, K. K., & Minahan, C. L. (2008). The effect of recovery strategies on physical performance and cumulative fatigue in competitive basketball. *Journal of Sports Sciences*, *26*(11), 1135–1145. https://doi.org/10.1080/02640410802104912

Moreira, A., Aoki, M. S., Arruda, A. F. S., Da Silva Machado, D. G., Elsangedy, H. M., & Okano, A. H. (2018). Salivary BDNF and cortisol responses during high-intensity exercise and official basketball matches in sedentary individuals and elite players. *Journal of Human Kinetics*, *65*(1), 139–149. https://doi.org/10.2478/hukin-2018-0040

Moreira, A., Bacurau, R. F. P., Napimoga, M. H., Arruda, A. F. S., Freitas, C. G., Drago, G., & Aoki, M. (2013). Salivary IL-21 and IGA responses to a competitive match in elite basketball players. *Biology of Sport*, *30*(4), 243–247. https://doi.org/10.5604/20831862.1077548

Moreira, A., Crewther, B., Freitas, C. G., Arruda, A. F. S., Costa, E. C., & Aoki, M. S. (2012). Session RPE and salivary immune-endocrine responses to simulated and official basketball matches in elite young male athletes. *The Journal of Sports Medicine and Physical Fitness*, *52*(6), 682–687.

Moreira, A., McGuigan, M. R., Arruda, A. F. S., Freitas, C. G., & Aoki, M. S. (2012). Monitoring internal load parameters during simulated and official basketball matches. *The Journal of Strength & Conditioning Research*, *26*(3), 861–866. https://doi.org/10.1519/JSC.0b013e31822645e9

Moreira, A., Nosaka, K., Nunes, J. A., Viveiros, L., Jamurtas, A. Z., & Aoki, M. S. (2014). Changes in muscle damage markers in female basketball players. *Biology of Sport*, *31*(1), 3–7. https://doi.org/10.5604/20831862.1083272

Moreno-Perez, V., Del Coso, J., Raya-Gonzalez, J., Nakamura, F. Y., Castillo, D., & Moreno-Pérez, V. (2020). Effects of basketball match-play on ankle dorsiflexion range of motion and vertical jump performance in semi-professional players. *The Journal of Sports Medicine and Physical Fitness*, *60*(1), 110–118. https://doi.org/10.23736/S0022-4707.19.09918-3

Nedelec, M., McCall, A., Carling, C., Legall, F., Berthoin, S., & Dupont, G. (2014). The influence of soccer playing actions on the recovery kinetics after a soccer match. *The Journal of Strength & Conditioning Research*, *28*(6), 1517–1523. https://doi.org/10.1519/JSC.0000000000000293

Nie, J., Tong, T. K., Shi, Q., Lin, H., Zhao, J., & Tian, Y. (2008). Serum cardiac troponin response in adolescents playing basketball. *International Journal of Sports Medicine*, *29*(6), 449–452. https://doi.org/10.1055/s-2007-989236

Owens, D. J., Twist, C., Cobley, J. N., Howatson, G., & Close, G. L. (2019). Exercise-induced muscle damage: What is it, what causes it and what are the nutritional solutions? *European Journal of Sport Science*, *19*(1), 71–85. https://doi.org/10.1080/17461391.2018.1505957

Padua, E., D'Amico, A. G., Alashram, A., Campoli, F., Romagnoli, C., Lombardo, M., Quarantelli, M., DiPinti, E., Tonanzi, C., & Annino, G. (2019). Effectiveness of warm-up routine on the ankle injuries prevention in young female basketball players: A randomized controlled trial. *Medicina*, *55*(10), 690. https://doi.org/10.3390/medicina55100690

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., ... Whiting, P. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, *372*, n71. https://doi.org/10.1136/bmj.n71

Palacios, G., Pedrero-Chamizo, R., Palacios, N., Maroto-Sánchez, B., Aznar, S., & González-Gross, M. (2015). Biomarkers of physical activity and exercise. *Nutricion Hospitalaria*, *31 Suppl 3*, 237–244. https://doi.org/10.3305/nh.2015.31.sup3.8771

Peake, J. M., Neubauer, O., Gatta, P. A. D., & Nosaka, K. (2017). Muscle damage and inflammation during recovery from exercise. *Journal of Applied Physiology*, *122*(3), 559–570. https://doi.org/10.1152/japplphysiol.00971.2016

Pernigoni, M., Calleja-González, J., Lukonaitienė, I., Tessitore, A., Stanislovaitienė, J., Kamarauskas, P., & Conte, D. (2024). Comparative effectiveness of active recovery and static stretching during post-exercise recovery in elite youth basketball. *Research Quarterly for Exercise and Sport*, *95*(1), 272–280. https://doi.org/10.1080/02701367.2023.2195457

Pernigoni, M., Conte, D., Calleja-González, J., Boccia, G., Romagnoli, M., & Ferioli, D. (2022). The application of recovery strategies in basketball: A worldwide survey. *Frontiers in Physiology*, *13*, 887507. https://doi.org/10.3389/fphys.2022.887507

Pernigoni, M., Ferioli, D., Butautas, R., La Torre, A., & Conte, D. (2021). Assessing the external load associated with high-intensity activities recorded during official basketball games. *Frontiers in Psychology*, *12*, 668194. https://doi.org/10.3389/fpsyg.2021.668194

Pernigoni, M., Kreivytė, R., Lukonaitienė, I., Toper, C. R., Kamandulis, S., & Conte, D. (2023). Is foam rolling as effective as its popularity suggests? A randomised crossover study exploring post-match recovery in female basketball. *Journal of Sports Sciences*, *41*(18), 1718–1725. https://doi.org/10.1080/02640414.2023.2296718

Pernigoni, M., Perazzetti, A., Digno, M., Tessitore, A., Kamandulis, S., & Conte, D. (2024). Chill without thrill: A crossover study on whole-body cryotherapy and postmatch recovery in high-level youth basketball players. *International Journal of Sports Physiology and Performance*, 1–9. https://doi.org/10.1123/ijspp.2024-0085

Perrea, A., Vlachos, I. S., Korou, L. M., Doulamis, I. P., Exarhopoulou, K., Kypraios, G., Kalofoutis, A., & Perrea, D. N. (2014). Comparison of the short-term oxidative stress response in national league basketball and soccer adolescent athletes. *Angiology*, *65*(7), 624–629. https://doi.org/10.1177/0003319713497991

Pliauga, V., Kamandulis, S., Dargevičiute, G., Jaszczanin, J., Kliziene, I., Stanislovaitiene, J., & Stanislovaitis, A. (2015). The effect of a simulated basketball game on players' sprint and jump performance, temperature and muscle damage. *Journal of Human Kinetics*, *46*(1), 167–175. https://doi.org/10.1515/hukin-2015-0045

Power, C. J., Fox, J. L., Teramoto, M., & Scanlan, A. T. (2023). Sleep patterns fluctuate following training and games across the season in a semi-professional, female basketball team. *Brain Sciences*, *13*(2), 238. https://doi.org/10.3390/brainsci13020238

Powers, S. K., Deminice, R., Ozdemir, M., Yoshihara, T., Bomkamp, M. P., & Hyatt, H. (2020). Exercise-induced oxidative stress: Friend or foe? *Journal of Sport and Health Science*, *9*(5), 415–425. https://doi.org/10.1016/j.jshs.2020.04.001

Qarouach, A., Sansone, P., Pernigoni, M., Kreivyte, R., & Conte, D. (2024). Inside the defensive playbook: Pick-and-roll tactical adjustments impact the external and internal loads during small-sided games in female basketball players. *International Journal of Sports Physiology and Performance*, 1–7. https://doi.org/10.1123/ijspp.2024-0218

Rampinini, E., Connolly, D. R., Ferioli, D., La Torre, A., Alberti, G., & Bosio, A. (2016). Peripheral neuromuscular fatigue induced by repeated-sprint exercise: Cycling vs. running. *The Journal of Sports Medicine and Physical Fitness*, *56*(1–2), 49–59.

Ruiz-Pérez, I., López-Valenciano, A., Hernández-Sánchez, S., Puerta-Callejón, J. M., De Ste Croix, M., de Baranda, P., & Ayala, F. (2021). A field-based approach to determine soft tissue injury risk in elite futsal using novel machine learning techniques. *Frontiers in Psychology*, *12*, 610210. https://doi.org/10.3389/fpsyg.2021.610210

Russell, J. L., McLean, B. D., Impellizzeri, F. M., Strack, D. S., & Coutts, A. J. (2021). Measuring physical demands in basketball: An explorative systematic review of practices. *Sports Medicine*, *51*(1), 81–112. https://doi.org/10.1007/s40279-020-01375-9

Sansone, P., Tschan, H., Foster, C., & Tessitore, A. (2020). Monitoring training load and perceived recovery in female basketball: Implications for training design. *The Journal of Strength & Conditioning Research*, *34*(10), 2929–2936. https://doi.org/10.1519/JSC.0000000000002971

Selmi, O., Gonçalves, B., Ouergui, I., Levitt, D. E., Sampaio, J., & Bouassida, A. (2021). Influence of well-being indices and recovery state on the technical and physiological aspects of play during small-sided games. *The Journal of Strength & Conditioning Research*, *35*(10), 2802–2809. https://doi.org/10.1519/JSC.0000000000003228

Shibata, S., Kodai, S., & Takemura, M. (2023). The effect of a basketball game on balance ability: A study using a dual task paradigm. *Journal of Bodywork and Movement Therapies*, *36*, 343–348. https://doi.org/10.1016/j.jbmt.2023.05.015

Silva, J. R., Rumpf, M. C., Hertzog, M., Castagna, C., Farooq, A., Girard, O., & Hader, K. (2018). Acute and residual soccer match-related fatigue: A systematic review and meta-analysis. *Sports Medicine*, *48*(3), 539–583. https://doi.org/10.1007/s40279-017-0798-8

Skorski, S., Mujika, I., Bosquet, L., Meeusen, R., Coutts, A. J., & Meyer, T. (2019). The temporal relationship between exercise, recovery processes, and changes in performance. *International Journal of Sports Physiology and Performance*, *14*(8), 1015–1021. https://doi.org/10.1123/ijspp.2018-0668

Souglis, A., Bogdanis, G. C., Giannopoulou, I., Papadopoulos, C., & Apostolidis, N. (2015). Comparison of inflammatory responses and muscle damage indices following a soccer, basketball, volleyball and handball game at an elite competitive level. *Research in Sports Medicine*, *23*(1), 59–72. https://doi.org/10.1080/15438627.2014.975814

Stålnacke, B. M., Tegner, Y., & Sojka, P. (2003). Playing ice hockey and basketball increases serum levels of S-100B in elite players: A pilot study. *Clinical Journal of Sport Medicine*, *13*(5), 292–302. https://doi.org/10.1097/00042752-200309000-00004

Stanley, J., Peake, J. M., & Buchheit, M. (2013). Cardiac parasympathetic reactivation following exercise: Implications for training prescription. *Sports Medicine*, *43*(12), 1259–1277. https://doi.org/10.1007/s40279-013-0083-4

Staunton, C., Gordon, B., Custovic, E., Stanger, J., & Kingsley, M. (2017). Sleep patterns and match performance in elite Australian basketball athletes. *Journal of Science and Medicine in Sport*, *20*(8), 786–789. https://doi.org/10.1016/j.jsams.2016.11.016

Stojanović, E., Stojiljković, N., Scanlan, A., Dalbo, V., Berkelmans, D., & Milanović, Z. (2018). The activity demands and physiological responses encountered during basketball match-play: A systematic review. *Sports Medicine*, *48*(1), 111–135. https://doi.org/10.1007/s40279-017-0794-z

Thorpe, R. T., Atkinson, G., Drust, B., & Gregson, W. (2017). Monitoring fatigue status in elite team-sport athletes: Implications for practice. *International Journal of Sports Physiology and Performance*, *12*(s2), S2–34. https://doi.org/10.1123/ijspp.2016-0434

Wen, N., Dalbo, V. J., Burgos, B., Pyne, D. B., & Scanlan, A. T. (2018). Power testing in basketball: Current practice and future recommendations. *The Journal of Strength & Conditioning Research*, *32*(9), 2677–2691. https://doi.org/10.1519/JSC.0000000000002459