©Journal of Sports Science and Medicine (2025) **24**, 31-51
http://www.jssm.org DOI: https://doi.org/10.52082/jssm.2025.31

Review article

The Effects of High-Intensity Interval Training on Basketball Players: A Systematic Review and Meta-Analysis

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Abstract
This review aims to evaluate the effectiveness of HIIT on basketball players' physical fitness and skill-related performance. This study adhered to the PRISMA guidelines and included randomized controlled trials (RCTs) that investigated the effects of HIIT on basketball players. The databases searched included Web of Science, Scopus, PubMed, and SPORTDiscus (up to 4 March 2024). The meta-analysis used a random-effects model, with effect sizes (ES) calculated for various performance outcomes. A total of 15 studies, with a low risk of bias or some concerns of bias, including 369 players (130 females, 239 males) at the developmental level, national level, and international level, were included in the systematic review, with 7 of these included in the meta-analysis. The systematic review indicated that HIIT significantly improved cardiovascular endurance, power, change of direction (COD) ability, linear sprint, and basketball skill-related performance. However, the effects on certain physical aspects such as VO_{2max}, the Yo-Yo intermittent recovery test level 1 (Yo-Yo IR 1), jump tests, ball throw test, 20-m COD sprint test, T-test, 20-m linear sprint, and basketball-specific skills such as shooting accuracy and passing were inconsistent. The meta-analysis revealed a very large effect on the Yo-Yo IR 1 (ES = 2.32; p = 0.000), a moderate effect on VO_{2max} (ES = 0.90; p = 0.000), T-test performance (ES = 0.91; p = 0.000), and CMJ height (ES = 0.76; p = 0.000), and a small effect on the 20-m sprint test (ES = 0.59; p = 0.006). HIIT appears to be an effective training method for improving general physical fitness and certain basketball-specific skills, particularly endurance, power, and agility. However, its impact on more skill-specific aspects, such as shooting accuracy and passing, requires further investigation. Coaches should consider supplementing HIIT with targeted skill training and carefully plan its timing, ideally incorporating HIIT during preseason or off-season periods for optimal effectiveness. Further research is needed to explore the differential effects of HIIT across various age groups and playing levels.

Key words: HIIT, sprint interval training, physical fitness, cardiovascular, sprint, power.

Introduction

Basketball is a high-intensity, intermittent team sport requiring players to exert maximal or near-maximal effort during competition (García et al., 2020). The game is characterized by high aerobic and anaerobic metabolic demands, encompassing various specific game activities such as accelerations, decelerations, sprinting, jumping, and change of direction (COD) ability (Heishman et al., 2020; Hernández et al., 2018; Ramirez-Campillo et al., 2022a). The mean energy sources contributing to these activities in basketball competitions are adenosine triphosphate (ATP), creatine phosphate (CP), and glycolysis responses (McInnes et al., 1995; Shalom et al., 2023). These three energy sources operate in sequence and overlap to enable basketball players to execute high-intensity actions repeatedly throughout the game, ensuring they can maintain performance over an entire competition (Gottlieb et al., 2021). During lower-intensity moments or rest periods, such as free throws or setting up plays, the aerobic system takes over, replenishing ATP and CP stores and aiding lactate clearance. The ability to efficiently shift between these systems and quickly recover using the aerobic system to clear lactic acid and replenish energy stores is crucial for high-level performance in basketball (Gantois et al., 2017). For example, jogging back on defense after a play utilizes the aerobic system while sprinting during a fast break or jumping for a rebound relies on anaerobic systems (de Araujo et al., 2014).

The physical fitness components directly influence an athlete's ability to perform basketball skills effectively and sustain performance throughout the match. High-intensity interval Training (HIIT) is a training method that alternates short bursts of intense exercise with recovery periods, effectively improving physical fitness such as cardiovascular fitness, anaerobic power, and endurance (Batacan et al., 2017; Ross et al., 2016). The dynamic demand on energy systems makes HIIT an effective conditioning approach for basketball players. HIIT can uniquely target aerobic and anaerobic capacities depending on the type of protocol used (Bucheit and Laursen, 2013; Buchheit and Laursen, 2013). Long-interval HIIT, which involves intervals of 2-4 minutes at high (but submaximal) intensity, primarily targets the aerobic energy system (Buchheit and Laursen, 2013; Milioni et al., 2024). By challenging the cardiovascular system, long-interval HIIT enhances aerobic capacity (e.g., VO_2max), enabling players to recover quickly between intense plays and sustain performance throughout the game (Milioni et al., 2024). Short-interval HIIT, with intervals under 45 seconds of high intensity (e.g., 30-50 Velocity Intermittent Fatigue Test, battle rope exercises), specifically trains the anaerobic glycolytic system by stressing it to provide quick bursts of energy without relying on oxygen (Buchheit, 2011; Quednow et al., 2015). This form of HIIT improves players' ability to perform repeated high-intensity efforts without significant drops in performance, which is essential for the basketball demands.

Received: 20 August 2024 / Accepted: 12 December 2024 / Published (online): 01 March 2025

Repeated sprint training (RST), which involves short (≤10-second) all-out sprints with brief recovery periods, primarily trains the ATP-PC system, enhancing players' explosive power and speed (Boullosa et al., 2022). This type of HIIT helps improve maximum speed and agility (Boullosa et al., 2022), which is critical for basketball movements that rely on quick, powerful bursts of energy. Sprint interval training (SIT) involves longer all-out efforts, usually more than 20-30 seconds, followed by extended recovery periods (Boullosa et al., 2022). SIT primarily targets the anaerobic energy systems but also enhances anaerobic power and lactate tolerance (Boullosa et al., 2022). Finally, Game-based training like small-sided games (SSG) typically uses regimens similar to long-interval HIIT, blending aerobic and anaerobic demands to mirror the energy requirements of sports closely (Clemente et al., 2023). This approach improves cardiovascular fitness and agility and enhances sports skills under realistic conditions, ensuring players are conditioned to game demands (Clemente et al., 2023).

Current research on HIIT has proven its efficacy in improving individual physical fitness. HIIT activates fast-twitch muscle fibers and stimulates the release of anabolic hormones such as testosterone and growth hormone, promoting muscle protein synthesis and resulting in significant gains in strength and power (Liu et al., 2024). Previous reviews showed that HIIT has been an effective conditioning method for athletes across various sports, helping them enhance physical performance (Franchini et al., 2019; Stankovic et al., 2023). For instance, Stankovic et al. (2023) demonstrated that HIIT significantly affected VO_{2max}, repeated sprint ability, change of direction speed, speed, and explosive strength in female team sports, irrespective of competition level (Stankovic et al., 2023). Girard et al. (2018) indicated that HIIT can positively impact certain athletic performance measures, including running, rowing, softball, and hockey, but not swimming endurance performance (Girard et al., 2018). Vasconcelos et al. (2020) found that HIIT significantly improved maximum oxygen uptake and anaerobic power in combat sport athletes, with a minor impact on body composition (Vasconcelos et al., 2020). However, despite the recognized benefits of HIIT, a systematic review and meta-analysis investigating the effects of HIIT in the sport of basket ball still needs to be developed. Hence, this study aims to identify the effects of HIIT on basketball players.

Methods

Protocol and registration

This study adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines (Page et al., 2021). It was registered on the Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY202440058) on April 14th, 2024.

Eligibility criteria

Several inclusion criteria were adhered to according to the PICOS framework: (1) English articles with full text; (2) participants were basketball players at developmental, national, and international levels, and world-class (McKay et al., 2021). Basic fitness level and experience were not set as inclusion criteria; (3) the intervention was high-intensity interval training (HIIT), which is defined as a training method characterized by repeated bouts of high-intensity exercise (eg., VIFT, Tabata, circuit training, repeated sprint training) with a minimum duration of four weeks (Birkett et al., 2019; Buchheit, 2011; Olson, 2014; Racil et al., 2016), monitored through objective measures (eg., ≥80 - 95% of HR_{max}, ≥75 - 90% of VO_{2max}, power output), subjective assessments (eg., RPE), and descriptive terms (eg., "all-out", "at maximal effort and intensity", "as quickly as possible"), interspersed with periods of rest or low-intensity exercise (Astorino et al., 2012; Astorino et al., 2017; Bayati et al., 2011; Benítez-Flores et al., 2019; Birkett et al., 2019; Karlsen et al., 2017; Pinto et al., 2019; Taylor et al., 2019; Thum et al., 2017; Wood et al., 2016); (4) control groups performed regular training without additional HIIT, or studies did not include control groups; (5) outcomes related to the effects of HIIT on physical fitness (body composition, power, speed, agility, flexibility, balance, cardiovascular endurance, muscular strength, muscular endurance, and reaction time) (Cao et al., 2024a; Xiao et al., 2021) and basketball performance (e.g., passing, shooting, dribbling); (6) randomized controlled trials (RCTs) or non-controlled trials. The exclusion criteria were: (1) reviews; (2) studies without HIIT as an intervention; and (3) unpublished studies.

Information sources and search strategy

The search was conducted on 4 March 2024. Web of Science, Scopus, PubMed, and SPORTDiscus databases were queried (Table 1). Specifically, database searches were carried out using keywords and truncations in conjunction with MeSH terms: HIIT (high-intensity interval training*, High-Intensity Intermittent Exercise*, Sprint Interval Training*). The search terms included: HIIT OR "high-intensity interval training*" OR "high-intensity interval exercise*" OR "high-intensity interval activit*" OR "high-intensity intermittent training*" OR "high-intensity intermittent exercise*" OR "high-intensity intermittent activit*" OR "high-intensity training*" OR "high-intensity exercise*" OR "high-intensity activit*" OR "sprint interval training*" AND basketball. Additionally, the references of studies and Google Scholar were screened.

Data selection

Endnote software (X20, Thomson Reuters, New York City, NY, United States) was used to check for duplicates. Two authors (SC and ZL) independently screened the titles, abstracts, and full texts according to the selection criteria. A third author (ZW) collected and double-checked the results. Any discrepancies were discussed and resolved with another author (SKG). The Kappa statistic was calculated using SPSS software (IBM Corp., 2022, Version 29.0), yielding a Kappa value of 1.00, which indicates perfect agreement between reviewers with 100% observed agreement and 0% discrepancies (Narducci et al., 2011).

Data collection

Two authors (SC and ZW) independently collected the data, which included: (1) population characteristics (age, height,

Table 1. Number of hits for the complete search strategy for the databases.

Database	Complete Search Strategy	Hits 4th March 2024
Web of Science	(AB=(HIIT OR “high-intensity interval training*” OR “high-intensity interval exercise*” OR “high-intensity interval activit*” OR “high-intensity intermittent training*” OR “high-intensity intermittent exercise*” OR “high-intensity intermittent activit*” OR “high-intensity training*” OR “high-intensity exercise*” OR “high-intensity activit*” OR “sprint Interval Training*”)) AND AB=(basketball)	87
EBSCOhost	AB(HlIT OR “high-intensity interval training*OR “high-intensity interval exercise*”OR “high intensity interval activit*”OR“high-intensityintermittent training*”OR“high intensity.intermittent exercise*”OR“high-intensityintermittent activit*”OR“high-intensitytraining*”OR “high-intensity exercise*”OR“high-intensity activit*”OR“sprint IntervalTraining*”)AND AB basketball	89
Scopus	hiit OR "high-intensity interval training*" OR "high-intensity interval exercise*" OR "high-intensity interval activit*" OR "high-intensity intermittent training*" OR "high-intensity intermittent exercise*" OR "high intensity-intermittent activit*" OR "high-intensity training*" OR "high-intensity exercise*" OR "high-intensity activit*" OR "sprint Interval Training*" AND basketball	153
PubMed	(HIIT[Title/Abstract] OR "high-intensity interval training*"[Title/Abstract] OR "high-intensity interval exercise*"[Title/Abstract] OR "high-intensity interval activit*"[Title/Abstract] OR "high-intensity intermittent training*"[Title/Abstract] OR "high-intensity intermittent exercise*"[Title/Abstract] OR "high-intensity intermittent activit*"[Title/Abstract] OR "high-intensity training*"[Title/Abstract] OR "high-intensity exercise*"[Title/Abstract] OR "high-intensity activit*"[Title/Abstract] OR "sprint Interval Training*"[Title/Abstract]) AND (Basketball[Title/Abstract])	78

body mass, etc.); (2) intervention; (3) comparison; (4) intervention characteristics (length, frequency, duration, training protocol, intensity, time of season); (5) measurement; and (6) outcome. The third author (JL) double-checked the results.

Risk of bias assessment and certainty of evidence

The Cochrane risk of bias tool (RoB 2) was utilized by two authors (SC and SKG) to assess the risk of bias in randomized controlled trials (RCTs), following the guidelines by Sterne et al. (2019) (Sterne et al., 2019). The "Grading of Recommendations Assessment, Development, and Evaluation (GRADE)" approach was employed to determine the certainty of the evidence (Goldet and Howick, 2013).

Statistical analysis

When studies provided three or more baseline and follow-up data points for the same variables and included a control group, they were included in the meta-analysis (Borenstein et al., 2021; Ramirez-Campillo et al., 2022b), using Meta-analysis software (version 3), with a statistical significance threshold set at $p < 0.05$. When studies with outcomes that are not comparable to other studies, such as using different measurement methods or scales for the same variables, they were only included in the systematic review (Cao et al., 2024a; Pollock and Berge, 2018). In the meta-analysis, the between-group effect sizes (ES; Hedge’s g) were computed (mean ± SD). A random-effects model with inverse-variance weighting was employed in the meta-analysis to account for heterogeneity among studies. The I^2 statistic was used to evaluate heterogeneity, with values categorized as low (<25%), moderate (25 - 75%), and high (>75%). Group effect sizes (ES) were calculated using Hedge's g, and 95% confidence intervals (CIs) were provided for ES measurements. The effect sizes were classified as follows: trivial (<0.2), small (0.2 - 0.6), moderate (>0.6 - 1.2), large (>1.2 - 2.0), very large (>2.0 - 4.0), and extremely large (>4.0) (Hopkins et al., 2009). The control group's sample size was proportionately divided if trials included two or more intervention groups. When authors did not provide adequate data, attempts were made to contact the corresponding author. The outcomes were excluded from the analysis if the data could not be obtained. WebPlotDigitizer software was used to extract numerical data when the data were only presented in figures or images (Drevon et al., 2017). The extended Egger's test assessed the risk of publication bias across studies (Egger et al., 1997). A sensitivity analysis was conducted when Egger's test yielded a low p-value ($p < 0.05$), suggesting significant asymmetry in the funnel plot. This indicated that smaller studies with non-significant or negative results might be underrepresented in the meta-analysis (Egger et al., 1997). A higher p-value ($p \geq 0.05$) showed a symmetrical funnel plot, suggesting no strong evidence of missing studies based on size and effect (Egger et al., 1997). When bias was detected, the trim and fill method was applied. Stratification of the meta-analyses was conducted for each factor, with a significance level of $p < 0.05$ used to determine statistical significance (Shuster, 2011).

Results

Study Selection

Four hundred and eighteen studies were initially searched, and 216 duplicates were removed using Endnote software (version 20). After screening the titles and abstracts, 52 articles were selected. Ultimately, fifteen full-text articles were chosen for the systematic review, and seven were selected for the meta-analysis based on the inclusion and exclusion criteria (Figure 1). Initially, the Kappa statistic for agreement on the articles included for evaluation was 0.802 ($p < 0.001$). After discussing with a third author (SKG), the Kappa increased to 1.00 ($p < 0.001$).

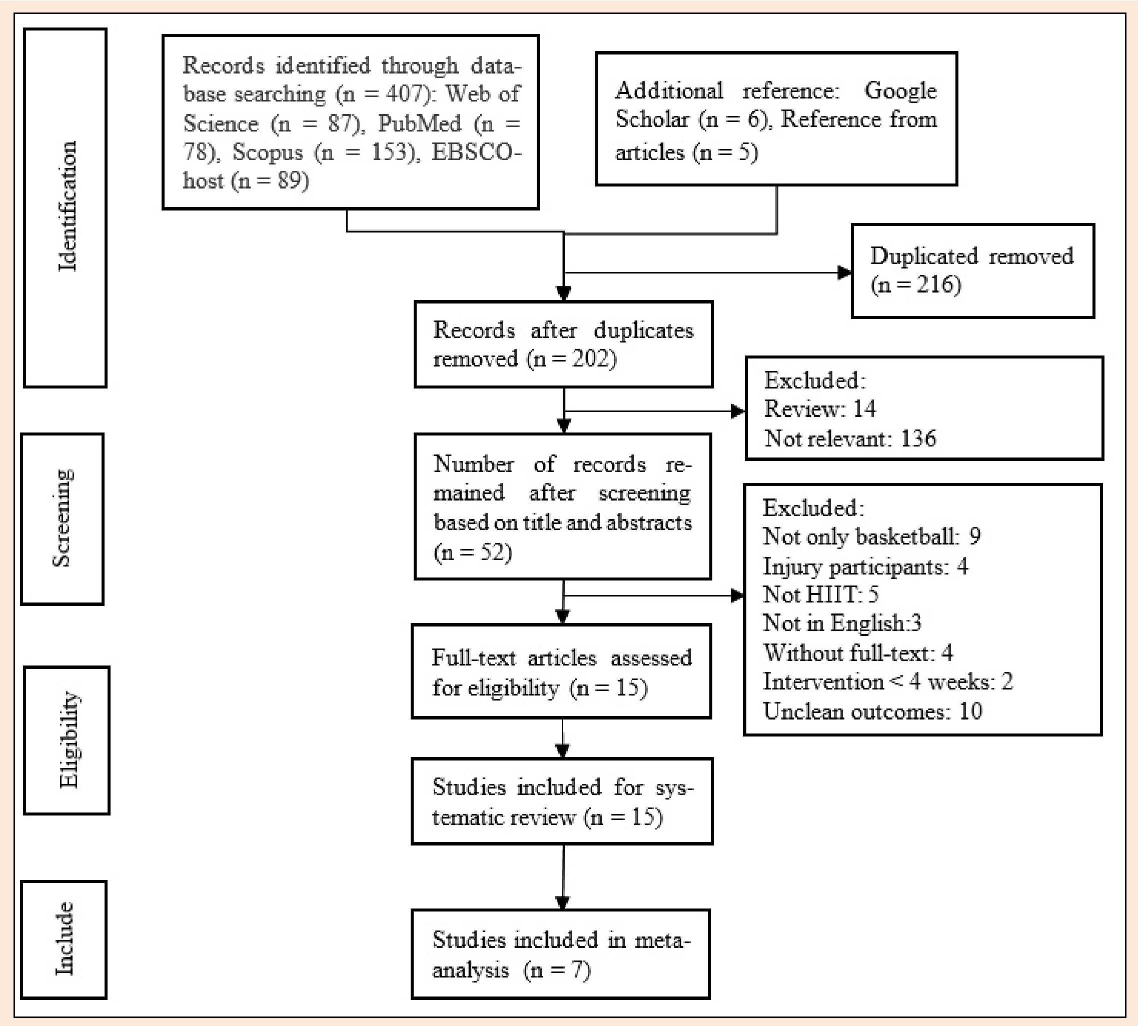

Figure 1. Systematic review search and screening procedure.

Risk of bias assessment and certainty of evidence

The risk of bias for the 15 included studies according to RoB 2 is shown in Figure 2. The overall risk of bias is summarized in Figure 3. Most of the included studies raised concerns regarding the risk of bias, and the summary of findings table generated using GRADEpro GDT indicated that the certainty of evidence ranged from low to very low (Table 2).

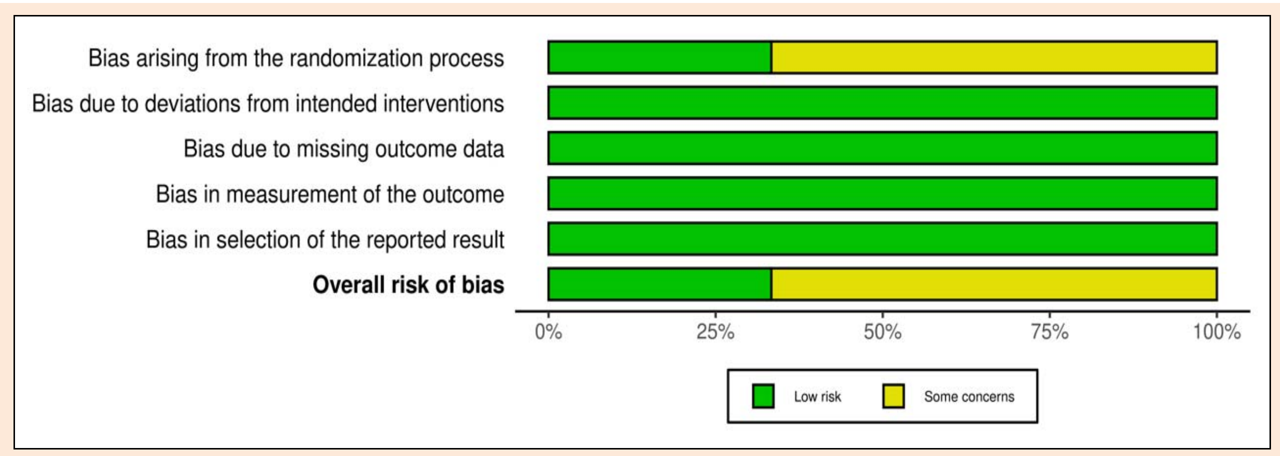

Figure 2. RoB-2 assessments.

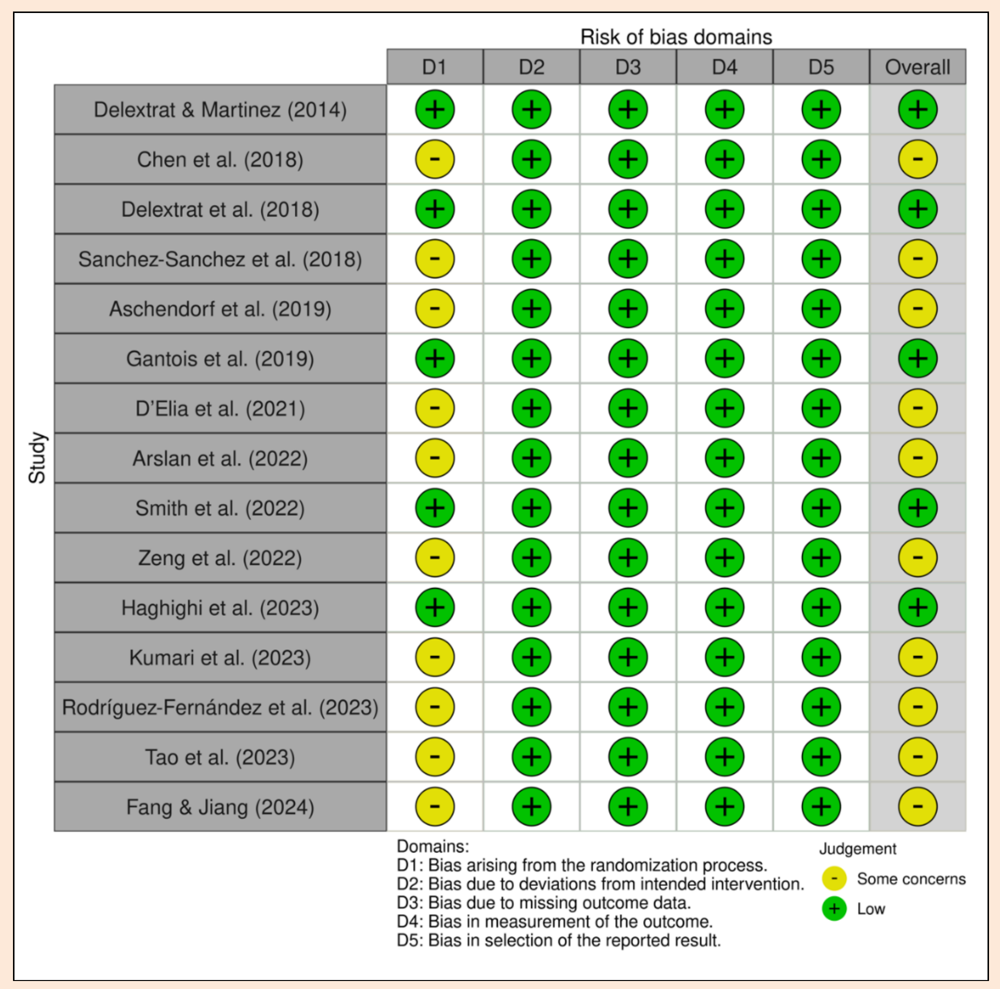

Figure 3. Risk of overall bias.

Table 2. GRADE analyses.

Certainty assessment							Certainty
Number of studies (and participants)	**Study design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other considerations**	
Cardiovascular endurance (follow-up: range 4 weeks to 12 weeks)							
14 (345 participants)	randomized trials	serious[a]	serious[b]	not serious	serious[c,d]	publication bias strongly suspected[e]	⊕◯◯◯ Very low
Power (follow-up: range 4 weeks to 8 weeks)							
10 (280 participants)	randomized trials	serious[a]	serious[b]	not serious	serious[c,d]	none	⊕◯◯◯ Very low
Change of direction ability (follow-up: range 4 weeks to 8 weeks)							
10 (269 participants)	randomized trials	serious[a]	serious[b]	not serious	serious[c,d]	none	⊕◯◯◯ Very low
Sprint (follow-up: range 4 weeks to 6 weeks)							
11 (253 participants)	randomized trials	serious[a]	serious[b]	not serious	serious[c,d]	none	⊕◯◯◯ Very low
Muscular Strength (follow-up: mean 6 weeks)							
1 (30 participants)	Randomized trials	serious[a]	not serious	not serious	serious[c]	none	⊕⊕◯◯ Low
Muscular Endurance (follow-up: mean 8 weeks)							
1 (30 participants)	randomized trials	serious[a]	not serious	not serious	serious[c]	none	⊕⊕◯◯ Low
Basketball performance (follow-up: range 4 weeks to 8 weeks)							
6 (163 participants)	randomized trials	serious[a]	serious[b]	not serious	serious[c,d]	none	⊕◯◯◯ Very low

a: Some included articles had some concerns of bias. b: There were different outcomes among studies. c: The sample size was not calculated by the appropriate method in some included studies. d: The total number of participants is below the optimal information size required to reliably detect a meaningful effect in some included studies. e: The results indicated a significant Egger's test ($p < 0.05$).

Participant characteristics

1. Sample Size. The fifteen articles included 369 subjects (130 females, 239 males), with individual studies ranging from 12 (Sanchez-Sanchez et al., 2018) to 40 participants (Fang and Jiang, 2024; Kumari et al., 2023). The mean sample size across these studies was 24.60 participants (SD = 8.37) (Table 3).
2. Age. The age of participants varied across the studies, with the youngest participants being approximately 14.1 years old (Delextrat et al., 2018) and the oldest being around 26.2 years old (Tao et al., 2023).
3. Sex. Eight studies focused on males (Arslan et al., 2022; Chen et al., 2018; D'Elia et al., 2021; Delextrat et al., 2018; Delextrat and Martinez, 2014; Gantois et al., 2019; Kumari et al., 2023; Tao et al., 2023), six studies focused on females (Aschendorf et al., 2019; Haghighi et al., 2023; Rodríguez-Fernández et al., 2023; Sanchez-Sanchez et al., 2018; Smith et al., 2022; Zeng et al., 2022), and one study included both males and females (Fang and Jiang, 2024).
4. Playing Level. According to the participant classification framework (McKay et al., 2021), eleven studies focused on national-level players (Aschendorf et al., 2019; Delextrat et al., 2018; Delextrat and Martinez, 2014; Fang and Jiang, 2024; Gantois et al., 2019; Kumari et al., 2023; Rodríguez-Fernández et al., 2023; Sanchez-Sanchez et al., 2018; Smith et al., 2022; Tao et al., 2023; Zeng et al., 2022), three studies examined developmental-level players (Arslan et al., 2022; D'Elia et al., 2021; Haghighi et al., 2023), and one study focused on international-level players (Chen, W. H. et al., 2018).

Table 3. **Data extraction from selected articles.**

References	Population	Intervention	C	Intervention Characteristics				Measurement	Outcome	
				Len/F/D	TP	Intensity	Season		Time	Groups
Delextrat & Martinez (2014)	N = 18 M; TB: 6.8-7.2 years; EG1: A = 16.0 ± 0.6 years, H = 181 ± 7 cm, BM = 73.5 ± 6.9 kg; EG2: A = 16.3 ± 0.8 years, H = 182 ± 9 cm, BM: 74.2 ± 6.3 kg; PL: national	EG1: HIIT; EG2: SSG	N/A	Len: 6 weeks; F: 2 sessions /week; D: 8-13 min	95% of VIFT for 15-s, followed by 15-s of active recovery	HRmean: 90.5 ± 2.2% of HRmax	In-season	Cardiovascular endurance (30-15 VIFT); Repeated sprint (RSA); COD ability (T-test); Power (MBT, HJ); BP (shooting, passing skills, control dribble)	EG1 and EG2: 30-15 VIFT, control dribble test, passing skills ↑; other ↔	T-test, MBT, shooting skills ↓; others ↔ in EG1 vs. EG2
Chen et al. (2018)	N = 30 M; TB: 6.7 ± 3.8 years; EG1: A = 21.1 ± 1.7 years, H = 179.6 ± 9.6 cm, BM = 79.2 ±14.2 kg; EG2: A = 20.6 ± 1.8 years, H = 183.6 ± 9 cm, BM: 82.4 ± 14.7 kg; PL: international	EG1: HIIT EG2: shuttle run	N/A	Len: 8 weeks; F: 3 sessions /week; D: 30-36 min	Battle rope training and shuttle run training: 30-36 sets, 15-20-s exercise, 40-45-s rest	>85% of HRmax	Off-season	Cardiovascular endurance (PACER); Power (WAT, basketball chest pass, CMJ); COD ability (T-test); Muscular endurance (core endurance test); BP (free throw shooting, dynamic shooting)	EG1: all ↑ except T-test ↔; EG2: PACER, basketball chest pass ↑; WAT, CMJ, core endurance, shooting, T-test ↔	Dynamic shooting ↑; others ↔ in EG1 vs. EG2
Delextrat et al. (2018)	N = 20 M; TB: 5.2 ± 3.6 years; EG1: A = 14.4 ± 0.5 years, H = 177.6 ± 10.5 cm, BM = 76.1 ± 9.5 kg; EG2: A = 14.1 ± 0.6 years, H = 175.9 ± 13.5 cm, BM: 73.5 ± 10.0 kg; PL: national	EG1: HIIT; EG2: SSG	N/A	Len: 6 weeks; F: 2 sessions /week; D: 8-13 min	95% of VIFT for 15-s, followed by 15-s of active recovery	HRmean: 90.5 ± 2.2% of HRmax RPE: 7.8 ± 0.9	In-season	Cardiovascular endurance (30-15 VIFT); Repeated sprint (RSA)	EG1: all ↑; EG2: all ↑	NR

A, age; H, height; BM, body mass; PL, playing level; M, male; FM, female; PT plyometric training; NR not reported, N/A, not applicable; CG, control group; EG, experimental group; F, frequency; D, duration; Len: length; HR, heart rate; RPE, rated perceived exertion (0-10) scale; C, comparison; TP, training protocol; BT, basketball training; RT, regular training; CMJ, countermovement jump; SJ, squat jump; DJ, drop jump; SLJ, standing long jump; VJ, vertical jump; HJ, horizontal jump; LH, lateral hop; RAST, running-based anaerobic sprint test; MAC, maximal voluntary contractions; Yo-Yo IR 1, Yo-Yo intermittent recovery test level 1; IAT, Illinois agility test; RSA, repeated sprint ability; BAST, basketball-based anaerobic specific test; RAST, running-based anaerobic sprint test; BSFT, basketball-specific field test; VIFT, velocity in intermittent fitness test; PACER, progressive aerobic cardiovascular endurance run; WAT, Wingate anaerobic test; RM, repetition maximum; MBT, medicine ball throw; COD change of direction; ↑, significantly positive effect; ↓, significantly negative effect; ↔, no effect.

Table 3. Continued…

References	Population	Intervention	C	Intervention Characteristics				Measurement	Outcome	
				Len/F/D	TP	Intensity	Season		Time	Groups
Sanchez-Sanchez et al. (2018)	N = 12 FM; TB: 8 years at least; A = 17.2 ± 1.1 years, H = 171.1 ± 6.3 cm, BM = 64.1 ± 7.9 kg; PL: national	EG1: HIIT with 3 COD EG2: HIIT with 1 COD	N/A	Len: 6 weeks; F: 2 sessions /week; D: 15 min	90% of VIFT for 10-s, followed by 10-s of active recovery with 3 or 1 COD (180°), 2 sets, 6-min of passive recovery between sets	90% of VIFT	NR	COD ability (modified T-test, V-cut); Cardiovascular endurance (30-15 VIFT); Repeated sprint (RSA)	EG1: all ↑; EG2: V-cut↑, T-test, RSA, 30-15 VIFT↔;	RSA, 30-15 VIFT↑; others ↔ in EG1 vs. EG2
Aschendorf et al. (2019)	N = 24 FM; TB: NR; A = 15.1 ± 1.1 years, H = 170 ± 5.2 cm, BM = 60.9 ± 6.0 kg; PL: national	HIIT	RT	Len: 5 weeks; F: 2 sessions /week; D: 25 min	Basketball-specific high-intensity training; A: 4 sets * 4-min high-intensity intervals, 3-min rest between sets; B: 2 sets * 15 reps * 30-s high-intensity intervals, 15-s rest between reps, 3-min rest between sets	90–95% of HRmax	In-season	Cardiovascular endurance (Yo-Yo IR 1); COD ability (20-m COD sprint); Power (CMJ, SJ, SLJ, basketball chest pass)	EG : Yo-Yo ↑; others ↔	Yo-Yo ↑; others ↔
Gantois et al. (2019)	N = 17 M; TB: NR; A = 21.2 ± 2.3 years, H = 180 ± 5.8 cm, BM = 81.1 ± 12.6 kg, PL: national	HIIT	RT	Len: 6 weeks; F: 3-4 sessions /week; D: 9-15 min	Repeated sprint training: 2-3 set * 6 reps, 20-s of passive recovery between reps and 3-min of active recovery between sets;	All-out	Pre-season	Repeated sprint (RSA); Power (CMJ, repeated VJ); Cardiovascular endurance (VO_{2max})	EG: RSA, CMJ ↑; repeated VJ, VO_{2max} ↔; CG: all ↔	NR
D'Elia et al. (2021)	N = 22 M; TB: NR; A = 19.1 ± 1.1 years, H = 185 ± 5.2 cm, BM = 70.9 ± 6.0 kg; PL: developmental	HIIT	RT	Len: 12 weeks; F: 3 sessions /week; D: 20 min	Tabata workout protocol, including push-ups, split squats, box jumps, burpees, jumping rope, jumping jacks and more; 4 sets * 8 reps, 10-s to 20-s rest between sets, 10-s rest between reps	170% of VO_{2max}	Pre-season	Cardiovascular endurance (VO_{2max}, anaerobic threshold)	EG: all ↑; CG: all ↔	NR
Arslan et al. (2022)	N = 32 M; TB: 3 years at least; EG1: A = 14.6 ± 0.5 years, H = 180.2 ± 3.7 cm, BM = 69.8 ± 3.3 kg; EG2: A = 14.4 ± 0.5 years, H = 178.3 ± 3.7 cm, BM: 70.2 ± 3.3 kg; PL: developmental	EG1: HIIT; EG2: SSG	N/A	Len: 6 weeks; F: 3 sessions /week; D: 6-9 min	90-95% of VIFT for 15-s, followed by-15 s of passive recovery	>85% of HRmax	Pre-season	Cardiovascular endurance (Yo-Yo IR 1, VO_{2max}, 30-15 VIFT); Linear sprint (5-m, 10-m, 20-m, 30-m); Repeated sprint (RSA); Power (CMJ, CMJ with arm, SJ, DJ); BP (passing, dribbling, shooting skills); COD ability (T-test)	EG1: all ↑ EG2: all ↑	30-m sprint ↑; dribbling and shooting skill ↓ in EG1 vs. EG2

A, age; H, height; BM, body mass; PL, playing level; M, male; FM, female; PT plyometric training; NR not reported, N/A, not applicable; CG, control group; EG, experimental group; F, frequency; D, duration; Len: length; HR, heart rate; RPE, rated perceived exertion (0-10) scale; C, comparison; TP, training protocol; BT, basketball training; RT, regular training; CMJ, countermovement jump; SJ, squat jump; DJ, drop jump; SLJ, standing long jump; VJ, vertical jump; HJ, horizontal jump; LH, lateral hop; RAST, running-based anaerobic sprint test; MAC, maximal voluntary contractions; Yo-Yo IR 1, Yo-Yo intermittent recovery test level 1; IAT, Illinois agility test; RSA, repeated sprint ability; BAST, basketball-based anaerobic specific test; RAST, running-based anaerobic sprint test; BSFT, basketball-specific field test; VIFT, velocity in intermittent fitness test; PACER, progressive aerobic cardiovascular endurance run; WAT, Wingate anaerobic test; RM, repetition maximum; MBT, medicine ball throw; COD change of direction; ↑, significantly positive effect; ↓, significantly negative effect; ↔, no effect.

Table 3. Continued…

References	Population	Intervention	C	Intervention Characteristics				Measurement	Outcome	
				Len/F/D	TP	Intensity	Season		Time	Groups
Smith et al. (2022)	N = 25 FM; TB: 10 years at least; EG1: A = 20.8 ± 1.9 years, H = 173.5 ± 6.8 cm, BM = 74.2 ± 7.4 kg; EG2: A = 20.6 ± 2.0 years; H = 174.4 ± 4.8 cm; BM = 68.4 ± 4.1kg; PL: national	EG1 = hypoxic HIIT (altitude of 3052 m); EG2 = normoxic HIIT (altitude of sea level)	N/A	Len: 4 weeks; F: 2 sessions /week; D: 43 min	HIIT on devices, including a rowing ergometer, a motorized treadmill, battle ropes, a ski ergometer, an assault bike, and a treadmill run, positioned inside an attitude room; 6 sets * 6 reps * 6 exercises, 30-s rest between reps, 2-min rest between sets	Maximal effort	Off-season	Power (SJ, CMJ); Repeated sprint (1-min 17-m shuttle run); Cardiovascular endurance (Yo-Yo IR 1);	EG1: 1 min shuttle run ↑; others ↔; EG2: all ↔	All ↔ in EG1 vs. EG2
Zeng et al. (2022)	N = 19 FM; TB: 5.5 ± 1.9 years; A = 19.9 ± 1.1 years, H = 166.1 ± 5.7 cm, BM = 60.4 ± 12.1 kg; PL: national	EG1: HIIT EG2: SSG	N/A	Len: 4 weeks; F: 3 sessions /week; D: 6-9 min	90-95% of VIFT for 15-s, followed by 15-s of passive recovery, on a 20-m field with COD (180°)	HRmean: 90 ± 3.2% of HRmax RPE: 7.6 ± 0.4	Pre-season	Linear sprint (20-m); Repeated sprint (RSA); COD ability (modified T-test); Cardiovascular endurance (30-15 VIFT); Power (CMJ); BP (shooting accuracy, 1-min shooting, passing, defensive movement, control dribble)	EG1: 30-15 VIFT, RSA, T-test, defensive movement, control dribble ↑; others ↔; EG2: 20-m sprint, CMJ, shooting accuracy, passing ↔; others ↑	NA
Haghighi et al. (2023)	N = 24 FM; TB: 5.1-5.3 years; EG1: A = 15.1 ± 1.6 years, H = 167.0 ± 5.5 cm, BM = 52.5 ± 3.0 kg; EG2: A = 14.6 ± 1.5 years, H = 168.3 ± 8.7 cm, BM = 61.7 ± 10.3 kg; CG: A = 15.1 ± 1.8 years, H = 165.8 ± 9.7 cm, BM = 56.7 ± 13.6 kg; PL: developmental	EG1: HIIT EG2: PT	RT	Len: 6 weeks; F: 2 sessions /week; D: 5-10 min	Training circle including jumps, ball throw, burpees, lunges, high knees, running back and forth; 1-2 sets * 1-2 reps * 30s to 45-s, 2-min rests between sets and reps	Maximum effort	Pre-season	Linear sprint (20-m); Power (Sargent jump power, MBT, BAST for maximum anaerobic power); COD ability (lane agility drill); BP (basketball-specific test, dribble/pass/shot skills)	EG1: all ↑; EG2: all ↑; CG: dribble/ pass skill ↑; others ↔	20-m sprint, Basketball-specific performance, dribble skills ↑ in EG1 and EG2 vs. CG

A, age; H, height; BM, body mass; PL, playing level; M, male; FM, female; PT plyometric training; NR not reported, N/A, not applicable; CG, control group; EG, experimental group; F, frequency; D, duration; Len: length; HR, heart rate; RPE, rated perceived exertion (0-10) scale; C, comparison; TP, training protocol; BT, basketball training; RT, regular training; CMJ, countermovement jump; SJ, squat jump; DJ, drop jump; SLJ, standing long jump; VJ, vertical jump; HJ, horizontal jump; LH, lateral hop; RAST, running-based anaerobic sprint test; MAC, maximal voluntary contractions; Yo-Yo IR 1, Yo-Yo intermittent recovery test level 1; IAT, Illinois agility test; RSA, repeated sprint ability; BAST, basketball-based anaerobic specific test; RAST, running-based anaerobic sprint test; BSFT, basketball-specific field test; VIFT, velocity in intermittent fitness test; PACER, progressive aerobic cardiovascular endurance run; WAT, Wingate anaerobic test; RM, repetition maximum; MBT, medicine ball throw; COD change of direction; ↑, significantly positive effect; ↓, significantly negative effect; ↔, no effect.

Table 3. **Continued…**

References	Population	Intervention	C	Intervention Characteristics				Measurement	Outcome	
				Len/F/D	TP	Intensity	Season		Time	Groups
Kumari et al. (2023)	N = 40 M; TB: NR; EG: A = 21.4 ± 2.6 years, H = 177.4 ± 6.0 cm, BM = 69.3 ± 7.1 kg; CG: A = 21.9 ± 2.4 years, H = 184.6 ± 12.1 cm, BM: 77.9 ± 9.7 kg; PL: national	HIIT	RT	Len: 5 weeks; F: 2 sessions /week; D: 25 min	Basketball-specific high-intensity training; A: 4 sets * 4-min high-intensity intervals, 3-min rest between sets; B: 2 sets * 15 reps * 30-s high-intensity intervals, 15-s rest between reps, 3-min rest between sets	90–95% of HRmax	NR	Cardiovascular endurance (VO_{2max}); COD ability (T-test); BP(wall passing, dribbling, 1-min shooting); Power (VJ, seated chest passing)	EG: all ↑; CG: dribbling ↓; others ↔	NR
Rodríguez-Fernández et al. (2023)	N = 16 FM; TB: 5 years at least; EG1: A = 17.9 ± 0.6 years, H = 175.4 ± 6.5 cm, BM = 68.1 ± 7.2 kg; EG2: A = 18.0 ± 0.4 years, H = 175.6 ± 3.6 cm, BM: 69.8 ± 5.0 kg; PL: national	EG1: cardiopulmonary-based HIIT; EG2: neuromuscular-based HIIT	N/A	Len: 6 weeks; F: 2 sessions /week; D: 18-27 min	40-m shuttle running; EG1: 2 sets * 12-min 90% of VIFT for 30-s, followed by 30-s of passive recovery, 3-min rest between sets; EG2: 2 sets * 6-min 100% of VIFT for 15-s, followed by 15-s of passive recovery, 6-min rest between sets	90-100% of VIFT	Pre-season	Cardiovascular endurance (30-15 VIFT); Repeated sprint (RSA)	EG1 and EG2: VIFT↑; RSA ↔	NR
Tao et al. (2023)	N = 30 M; TB: 8.1-8.7 years; EG1: A = 25.7 ± 2.5 years, H = 188 ± 8 cm, BM = 85.9 ± 9.5 kg; EG2: A = 25.3 ± 1.8 years, H = 189 ± 7 cm, BM = 87.0 ± 7.6 kg; CG: A = 26.2 ± 1.7 years, H = 186 ± 8 cm, BM: 85.0 ± 7.6 kg; PL: national	EG1: basketball-specific sprint interval training EG2: sprint interval training;	BT	Len: 6 weeks; F: 2 sessions /week; D: 30 min	3 sets × 7-10 reps, all out run (EG1) without ball or (EG2) with ball; 15-s run, 15-s rest between reps, 3-min rest between sets	Maximal effort	Off-season	Muscular strength (1-RM leg press); Power (VJ, SLJ); Linear sprint (20-m); COD ability (T-test, IAT); Cardiovascular endurance (Yo-Yo IR 1, VO_{2max})	EG1: all ↑; EG2: all ↑; CG: all ↔	All ↑ in EG1 and EG2 vs. CG; IAT, Yo-Yo ↑ in EG1 vs EG2
Fang & Jiang (2024)	N = 20 M, 20 FM; TB: 7.2-8.4 years; EG1: A = 22.4 ± 2.2 years, H = 185.4 ± 4.1 cm, BM = 85.8 ± 8.3 kg; EG2: A = 23.5 ± 1.8 years, H = 177.4 ± 2.6 cm, BM = 71.8 ± 2.2 kg; CG1: A = 22.7 ± 2.4 years, H = 182.8 ± 4.5 cm, BM = 87.2 ± 7.8 kg; CG2: A = 23.1± 1.5 years, H = 176.8 ± 2.5 cm, BM: 72.2 ± 2.8 kg; PL: national	EG1 (M): HIIT EG2 (FM): HIIT	CG1 (M) BT CG2 (FM): BT	Len: 6 weeks; F: 3 sessions /week; D: 20 min	3 sets * 10 reps all-out run; 5-s run, 15-s rest between reps, 3-min rest between sets	RPE: 6.6-7.5	Off-season	Power (VJ); COD ability (T-test, IAT); Linear speed (20-m); Cardiovascular endurance (Yo-Yo IR 1, VO_{2max})	EG1 and EG2: all ↑; CG 1 and CG 2: all ↔	All ↑ in EG1 and EG2 vs. CG1 and CG2;

A, age; H, height; BM, body mass; PL, playing level; M, male; FM, female; PT plyometric training; NR not reported, N/A, not applicable; CG, control group; EG, experimental group; F, frequency; D, duration; Len: length; HR, heart rate; RPE, rated perceived exertion (0-10) scale; C, comparison; TP, training protocol; BT, basketball training; RT, regular training; CMJ, countermovement jump; SJ, squat jump; DJ, drop jump; SLJ, standing long jump; VJ, vertical jump; HJ, horizontal jump; LH, lateral hop; RAST, running-based anaerobic sprint test; MAC, maximal voluntary contractions; Yo-Yo IR 1, Yo-Yo intermittent recovery test level 1; IAT, Illinois agility test; RSA, repeated sprint ability; BAST, basketball-based anaerobic specific test; RAST, running-based anaerobic sprint test; BSFT, basketball-specific field test; VIFT, velocity in intermittent fitness test; PACER, progressive aerobic cardiovascular endurance run; WAT, Wingate anaerobic test; RM, repetition maximum; MBT, medicine ball throw; COD change of direction; ↑, significantly positive effect; ↓, significantly negative effect; ↔, no effect.

Intervention characteristics

1. Training Program Length. The training programs ranged from 4 (Smith et al., 2022; Zeng et al., 2022) to 12 weeks (D'Elia et al., 2021), with a mean duration of 6.1 weeks (SD = 1.9) (Table 3).
2. Training Duration. The training duration per session ranged from 5 (Haghighi et al., 2023) to 43 minutes (Smith et al., 2022), with a mean duration of 19.3 minutes (SD = 10.6).
3. Training Frequency. The training frequency varied, with programs consisting of two, three, or four sessions per week.
4. Intensity Monitoring. Nine studies utilized objective measurements to monitor HIIT intensity, including the HRmean index(Delextrat et al., 2018; Delextrat and Martinez, 2014; Zeng et al., 2022), HRmax index (Arslan et al., 2022; Chen et al., 2018; Kumari et al., 2023), VO2max index (D'Elia et al., 2021), and 90 - 100% VIFT (Rodríguez-Fernández et al., 2023; Sanchez-Sanchez et al., 2018). Seven studies employed subjective measurements, such as the Borg Rating of Perceived Exertion (RPE) scale (Delextrat et al., 2018; Fang and Jiang, 2024; Zeng et al., 2022), which describes effort to the point of maximal exertion, which refers to the highest level of effort the player can sustain during HIIT intervention (Haghighi et al., 2023; Smith et al., 2022; Tao et al., 2023) or "all-out" intensity (Gantois et al., 2019).
5. Training Time of Season. Six studies implemented HIIT during the pre-season (Arslan et al., 2022; D'Elia et al., 2021; Gantois et al., 2019; Haghighi et al., 2023; Rodríguez-Fernández et al., 2023; Zeng et al., 2022), three during the in-season (Aschendorf et al., 2019; Delextrat et al., 2018; Delextrat and Martinez, 2014), and four during the off-season (Chen et al., 2018; Fang and Jiang, 2024; Smith et al., 2022; Tao et al., 2023). Two studies did not report the training period (Kumari et al., 2023; Sanchez-Sanchez et al., 2018).

Outcomes

The outcomes of HIIT on basketball players varied, encompassing aspects such as physical fitness (cardiovascular endurance, power, change of direction ability, sprinting, muscular strength, and muscular endurance) and basketball skill-related performance.

Effect of HIIT on cardiovascular endurance

Fourteen studies investigated the effects of HIIT on cardiovascular endurance using various measurements, including the 30-15 velocity in the intermittent fitness test (VIFT) (Arslan et al., 2022; Delextrat et al., 2018; Delextrat and Martinez, 2014; Rodríguez-Fernández et al., 2023; Sanchez-Sanchez et al., 2018; Zeng et al., 2022), the progressive aerobic cardiovascular endurance run (PACER) test (Chen et al., 2018), the Yo-Yo IR 1 (Arslan et al., 2022; Aschendorf et al., 2019; Fang and Jiang, 2024; Smith et al., 2022; Tao et al., 2023), VO_{2max} value (Arslan et al., 2022; D'Elia et al., 2021; Fang and Jiang, 2024; Gantois et al., 2019; Kumari et al., 2023; Tao et al., 2023), and anaerobic threshold measurement, which is a key indicator of cardiovascular endurance and defined as the exercise intensity at which lactate begins to accumulate in the blood, signaling a shift from predominantly aerobic to anaerobic energy systems (D'Elia et al., 2021). All studies indicated that HIIT significantly improved cardiovascular endurance performance, except for Gantois et al. (2019) and Smith et al. (2022), which showed insignificant improvements in VO_{2max} value and the Yo-Yo IR 1, respectively.

Six studies were included in the meta-analysis for cardiovascular endurance. Three studies (n = 70) indicated a p-value of 0.02 in Egger's test for the Yo-Yo IR 1. A sensitivity analysis revealed that excluding one study yielded an Egger's test p-value ≥ 0.05 (Aschendorf et al., 2019). Ultimately, two studies involving four experimental groups and two control groups were included in the meta-analysis, demonstrating that HIIT had a very large effect on the Yo-Yo IR 1 (ES = 2.32; 95% CI = 1.71-2.91; p = 0.000) (Figure 4). The heterogeneity among the studies was low (I^2 = 0.0%).

Conversely, five studies (n = 119) indicated a p-value of 0.002 in Egger's test for VO_{2max} value. A sensitivity analysis showed that excluding one study resulted in an Egger's test p-value ≥ 0.05 (Tao et al., 2023). Ultimately, four studies involving five experimental groups and four control groups were included in the meta-analysis, demonstrating that HIIT had a moderate effect on VO_{2max} value (ES = 0.90; 95% CI = 0.53-1.27; p = 0.000) (Figure 5). The heterogeneity among the studies was low (I^2 = 23.3%).

Study name	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Tao et al. (2023) EG1	2.815	0.728	0.530	1.388	4.242	3.867	0.000
Tao et al. (2023) EG2	2.117	0.644	0.415	0.854	3.380	3.286	0.001
Fang & Jiang (2024) EG1	2.470	0.580	0.336	1.334	3.607	4.262	0.000
Fang & Jiang (2024) EG2	2.039	0.536	0.287	0.988	3.090	3.804	0.000
	2.312	0.305	0.093	1.714	2.910	7.581	0.000

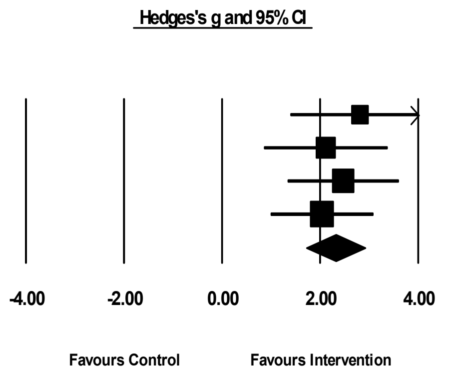

Figure 4. Forest plot of HIIT on Yo-Yo IR 1.

Study name	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Aschendorf et al. (2019)	0.133	0.396	0.157	-0.643	0.909	0.335	0.737
Gantois et al. (2019)	0.715	0.477	0.228	-0.220	1.651	1.499	0.134
Tao et al. (2023) EG1	1.035	0.549	0.301	-0.041	2.111	1.885	0.059
Tao et al. (2023) EG2	0.654	0.529	0.280	-0.383	1.692	1.237	0.216
Fang & Jiang (2024) EG1	1.120	0.463	0.215	0.212	2.028	2.416	0.016
Fang & Jiang (2024) EG2	1.196	0.468	0.219	0.279	2.114	2.555	0.011
	0.760	0.193	0.037	0.382	1.138	3.940	0.000

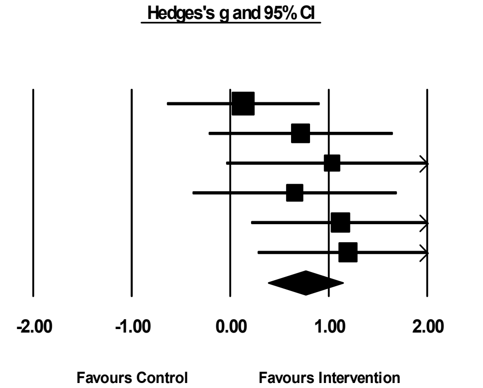

Figure 5. **Forest plot of HIIT on VO_2max value.**

Study name	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Aschendorf et al. (2019)	0.133	0.396	0.157	-0.643	0.909	0.335	0.737
Gantois et al. (2019)	0.715	0.477	0.228	-0.220	1.651	1.499	0.134
Tao et al. (2023) EG1	1.035	0.549	0.301	-0.041	2.111	1.885	0.059
Tao et al. (2023) EG2	0.654	0.529	0.280	-0.383	1.692	1.237	0.216
Fang & Jiang (2024) EG1	1.120	0.463	0.215	0.212	2.028	2.416	0.016
Fang & Jiang (2024) EG2	1.196	0.468	0.219	0.279	2.114	2.555	0.011
	0.760	0.193	0.037	0.382	1.138	3.940	0.000

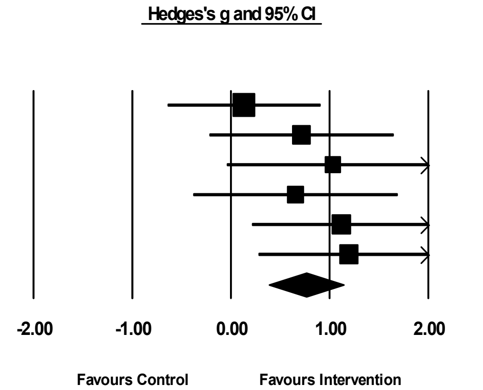

Figure 6. **Forest plot of HIIT on CMJ height test.**

Effect of HIIT on power

Eleven articles investigated the effects of HIIT on power, and many used jump test measurement as an indicator of power. While not directly measuring power in watts, jump tests are validated proxies for assessing explosive power in practical athletic settings. For instance, Hoffman et al. (2000) found a significant correlation between jump height and anaerobic power output, suggesting that vertical jump height can be a valid indicator of explosive power in athletes (Hoffman et al., 2000). Markovic and Jaric (2007) conclude that vertical jump height and jump force are valid indicators of lower-body explosive power, especially in field settings (Markovic and Jaric, 2007). In the present review, anaerobic power was measured using tests such as the Wingate anaerobic test (WAT) (Chen, W. H. et al., 2018) and the basketball-based anaerobic specific test (BAST) (Haghighi et al., 2023), with significant improvements observed following HIIT.

Explosive power was assessed using various measurements: medicine ball throw (MBT) (Delextrat and Martinez, 2014; Haghighi et al., 2023), horizontal jump (HJ) (Delextrat and Martinez, 2014), basketball chest pass (Aschendorf et al., 2019; Chen et al., 2018), countermovement jump (CMJ) (Arslan et al., 2022; Aschendorf et al., 2019; Chen et al., 2018; Gantois et al., 2019; Smith et al., 2022; Zeng et al., 2022), squat jump (SJ) (Aschendorf et al., 2019; Smith et al., 2022), standing long jump (SLJ) (Arslan et al., 2022; Aschendorf et al., 2019; Tao et al., 2023), drop jump (DJ) (Arslan et al., 2022), vertical jump (VJ) (Fang and Jiang, 2024; Gantois et al., 2019; Kumari et al., 2023; Tao et al., 2023), Sargent jump power (Haghighi et al., 2023), and seated chest passing tests (Kumari et al., 2023). Six studies reported significant improvements in explosive power, including MBT, HJ, basketball chest pass, CMJ, SJ, SLJ, DJ, repeated VJ, Sargent jump, and seated chest passing tests (Arslan et al., 2022; Chen et al., 2018; Fang and Jiang, 2024; Haghighi et al., 2023; Kumari et al., 2023; Tao et al., 2023). However, five studies found no significant improvements in MBT, HJ, CMJ, SJ, SLJ, VJ, and basketball chest pass tests following HIIT (Aschendorf et al., 2019; Delextrat and Martinez, 2014; Gantois et al., 2019; Smith et al., 2022; Zeng et al., 2022).

Four studies were included in the meta-analysis for power, involving six experimental groups and four control groups (n = 111). The results (Figure 6) demonstrated that HIIT moderately affected the CMJ height test (ES = 0.76; 95% CI = 0.38-1.14; p = 0.000). The heterogeneity among the studies was low (I^2 = 0.0%). The Egger's test showed a p-value of 0.20, indicating no significant publication bias among the studies.

Effect of HIIT on Change of Direction Ability (COD)

Ten articles investigated the impact of HIIT on change of direction (COD) ability using various assessments: T-test (Arslan et al., 2022; Chen et al., 2018; Delextrat and Martinez, 2014; Fang and Jiang, 2024; Kumari et al., 2023; Tao et al., 2023), modified T-test (Sanchez-Sanchez et al.,

Study name	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Kumari et al. (2023)	-1.476	0.351	0.123	-2.164	-0.788	-4.204	0.000
Tao et al. (2023) EG1	-1.172	0.558	0.312	-2.266	-0.078	-2.100	0.036
Tao et al. (2023) EG2	-0.424	0.521	0.272	-1.446	0.598	-0.813	0.416
Fang & Jiang (2024) EG1	-0.627	0.440	0.193	-1.489	0.234	-1.427	0.154
Fang & Jiang (2024) EG2	-0.512	0.436	0.190	-1.366	0.342	-1.174	0.240
	-0.913	0.198	0.039	-1.302	-0.525	-4.607	0.000

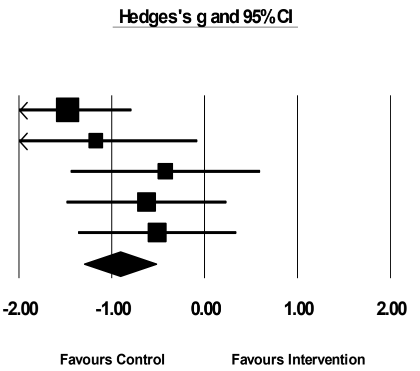

Figure 7. Forest plot of HIIT on T-test.

2018; Zeng et al., 2022), V-cut test (Sanchez-Sanchez et al., 2018), 20-m COD sprint test (Aschendorf et al., 2019), lane agility drill test (Haghighi et al., 2023), and Illinois agility test (IAT) (Fang and Jiang, 2024; Tao et al., 2023). Seven studies found that HIIT significantly improved COD ability (Arslan et al., 2022; Fang and Jiang, 2024; Haghighi et al., 2023; Kumari et al., 2023; Sanchez-Sanchez et al., 2018; Tao et al., 2023; Zeng et al., 2022). However, three studies indicated that HIIT did not significantly enhance performance in the T-test and 20-m COD sprint test (Aschendorf et al., 2019; Chen et al., 2018; Delextrat and Martinez, 2014).

The meta-analysis included three studies, encompassing five experimental and three control groups (n = 110). The results demonstrated that HIIT moderately affected the T-test (ES = 0.91; 95% CI = 0.53-1.30; p = 0.000). The heterogeneity among the studies was low (I^2 = 19.0%). The Egger's test showed a p-value of 0.34 (Figure 7), indicating no significant publication bias among the studies.

Effect of HIIT on Sprint Ability

Eleven studies investigated the impact of HIIT on sprint ability, including both linear sprint and repeated sprint ability. Linear sprint ability was assessed using 5-m, 10-m, 20-m, and 30-m sprint tests in five studies (Arslan et al., 2022; Fang and Jiang, 2024; Haghighi et al., 2023; Tao et al., 2023; Zeng et al., 2022). Four studies demonstrated significant improvements in linear sprint ability following HIIT, while one did not (Zeng et al., 2022). Repeated sprint ability was measured using repeated sprint tests (Arslan et al., 2022; Delextrat et al., 2018; Delextrat and Martinez, 2014; Gantois et al., 2019; Rodríguez-Fernández et al., 2023; Sanchez-Sanchez et al., 2018; Zeng et al., 2022) and the 1-min 17-m shuttle run test (Smith et al., 2022) in eight studies. Six studies reported that HIIT significantly improved repeated sprint ability (Arslan et al., 2022; Delextrat et al., 2018; Gantois et al., 2019; Sanchez-Sanchez et al., 2018; Smith et al., 2022; Zeng et al., 2022), while two did not (Delextrat and Martinez, 2014; Rodríguez-Fernández et al., 2023).

The meta-analysis on sprint ability included three studies comprising five experimental groups and three control groups (n = 94). The results indicated that HIIT had a small effect on the 20-m sprint test (ES = 0.59; 95% CI = 0.17-1.01; p = 0.006). The heterogeneity among the studies was low (I^2 = 0.0%). Egger's test yielded a p-value of 0.99 (Figure 8), indicating no significant publication bias among the studies.

Effect of HIIT on muscular strength

Only one study investigated the effect of HIIT on muscular strength, demonstrating that HIIT significantly improved 1-RM leg press performance (Tao et al., 2023).

Effect of HIIT on muscular endurance

Only one study explored the effect of HIIT on muscular endurance. It found that HIIT significantly enhanced core endurance, including trunk flexor, trunk extensor, and bilateral side bridge tests (Chen, W. H. et al., 2018).

Study name	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Haghighi et al. (2023)	-0.603	0.485	0.235	-1.552	0.347	-1.244	0.214
Tao et al. (2023) EG1	-0.735	0.533	0.284	-1.779	0.309	-1.379	0.168
Tao et al. (2023) EG2	-0.345	0.519	0.270	-1.363	0.673	-0.664	0.507
Fang & Jiang (2024) EG1	-0.393	0.433	0.187	-1.241	0.455	-0.908	0.364
Fang & Jiang (2024) EG2	-0.888	0.451	0.203	-1.772	-0.005	-1.971	0.049
	-0.593	0.214	0.046	-1.013	-0.173	-2.767	0.006

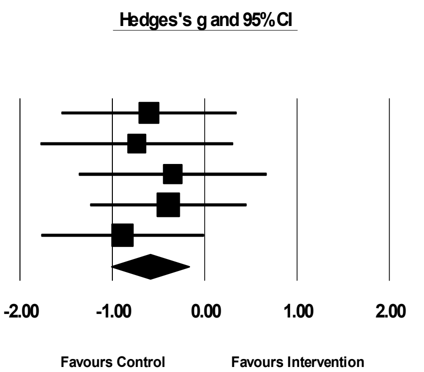

Figure 8. Forest plot of HIIT on 20-m print test.

Effect of HIIT on basketball performance

Six studies examined the impact of HIIT on basketball performance, assessing various skills such as basketball shooting, passing, dribbling, free throw, defensive movement, and basketball-specific tests (Arslan et al., 2022; Chen, W. H. et al., 2018; Delextrat and Martinez, 2014; Haghighi et al., 2023; Kumari et al., 2023; Zeng et al., 2022). Four studies indicated that HIIT significantly improved performance in various passing, dribbling, shooting, and basketball-specific tests (Arslan et al., 2022; Chen et al., 2018; Haghighi et al., 2023; Kumari et al., 2023). One study showed significant improvements in dribbling and passing but no improvement in shooting performance (Delextrat and Martinez, 2014). Another study reported significant improvements in defensive movement and dribbling but no improvement in shooting and passing performance (Zeng et al., 2022).

Discussion

This systematic review and meta-analysis aimed to investigate the effects of HIIT on physical fitness and basketball performance in basketball players. The review revealed that most included studies demonstrated that HIIT significantly improved physical fitness, such as cardiovascular endurance, power, change of direction (COD) ability, sprint ability, muscular strength, muscular endurance, and basketball skill-related performance.

Effect of HIIT on cardiovascular endurance

Players with superior cardiovascular endurance recover more rapidly between sprints, jumps, and high-intensity efforts. This swift recovery is crucial for maintaining high performance during games (Cao et al., 2024a). In the present study, twelve investigations demonstrated that HIIT significantly positively affects cardiovascular endurance, as evidenced by improvements in 30-15 VIFT, Yo-Yo IR 1, VO_{2max} value, and anaerobic threshold. Smith et al. (2022) reported no significant difference in HIIT's effect on the Yo-Yo IR 1 from pretest to posttest. Still, the distance achieved in the Yo-Yo IR 1 improved markedly from an average of 868.6 meters to 1188.6 meters (Smith et al., 2022). For non-professionals in this study, initial adaptations to HIIT can result in noticeable performance gains due to their lower baseline fitness levels.

The effect size (ES) calculation in the present review revealed a moderate effect on VO_{2max} (ES = 0.90), higher than in a previous review involving young athletes (Engel et al., 2018). Manuel Clemente et al. (2021) conducted a systematic review and meta-analysis on the effects of HIIT on male soccer players, showing significant improvements in VO_2max (Manuel Clemente et al., 2021). The ES calculation in this review revealed a very large effect on Yo-Yo IR 1 (ES = 2.32). Although the 30-15 VIFT was not included in the meta-analysis due to heterogeneity, all included studies demonstrated a significantly positive effect of HIIT on this measure. HIIT involves repeated bouts of intense exercise that push the body to its aerobic limits, stimulating adaptations that enhance the ability to consume and utilize oxygen (Laursen and Jenkins, 2002). This process also leads to increased cardiac output, improved stroke volume, and enhanced capillary density in muscle tissues, facilitating more excellent oxygen delivery and utilization (Laursen and Buchheit, 2019).

Additionally, high-intensity running or exercises improve the lactate threshold, the exercise intensity at which lactate accumulates in the blood (Esfarjani and Laursen, 2007). This adaptation results from increased enzyme activity in lactate metabolism, improved buffering capacity, and enhanced blood flow, allowing athletes to sustain higher intensities for extended periods before fatigue sets in (Germano et al., 2015). Furthermore, HIIT enhances the efficiency of recovery processes (Wiewelhove et al., 2015), enabling athletes to recover more quickly between high-intensity bouts in both the Yo-Yo IR 1 and 30-15 VIFT.

Effect of HIIT on power

Power, encompassing anaerobic and explosive power, is crucial in basketball. Anaerobic power measures the body's ability to produce high power output under anaerobic conditions over a brief period. In basketball, fast breaks, chasing opponents, and quick transitions between offence and defence demand substantial anaerobic power (Pojskić et al., 2015). Explosive power focuses on force generation speed, essential for quick and high-force movements such as rebounding, shot-blocking, and dunking in basketball (Aksovıć et al., 2021; Marta and Neldi, 2023). In the present study, anaerobic power, measured by the Wingate Anaerobic Test (WAT), was significantly improved following HIIT. The results are in line with the previous review. Boullosa et al. (2022) indicate the high effectiveness of HIIT in improving anaerobic power in physically active young, healthy adults and athletes (Boullosa et al., 2022). HIIT enhances the muscle's capacity to store and rapidly regenerate phosphocreatine (Torma et al., 2019), a key energy substrate, during short, intense efforts like those in the WAT. In addition, the high-intensive exercises in included studies, like battle rope training, ball throws, and jumps, require quick bursts of maximal effort, typically lasting a few seconds (Chen et al., 2018; Haghighi et al., 2023). These short movements rely heavily on the ATP-PC system (adenosine triphosphate-phosphocreatine system), the primary energy system for high-intensity, short-duration activities (Smith and Hill, 1991). Repeated bouts of these high-intensity efforts in a HIIT session train the body to rapidly regenerate ATP, allowing for sustained high-power output in anaerobic conditions (Bangsbo et al., 2001). Over time, these exercises enhance the efficiency and availability of the ATP-PC system, improving the ability to sustain robust efforts without quickly depleting energy reserves (Plowman and Smith, 2007; Tortu et al., 2024).

However, results for explosive power, including upper and lower limb power, needed to be more consistent. Researchers used various jump tests to measure lower body power, medicine ball throws, and seated chest passes for upper body power. Most studies demonstrated a significantly positive effect of HIIT on both lower and upper body power, with the effect size calculation in the present review revealing a moderate impact on countermovement jump (CMJ) height (ES = 0.76), which is higher than the previous review that indicating a small effect size on CMJ height (Engel et al., 2018). Although one study reported no significant changes in repeated vertical jump indices, practical analyses suggested that HIIT provided stimuli from “likely” to “very likely” to improve the repeated vertical jump test (Gantois et al., 2019).

Several factors can explain this improvement. First, by incorporating exercises like repeated sprints, jumps, burpees, and lunges into HIIT, these studies enhance general explosive power and provide multi-directional force production (Cao et al., 2024b; Megahed et al., 2023). This multi-directional training may indirectly contribute to jump improvements by improving the lower-body musculature and neuromuscular efficiency, which can complement vertical force production (Scribbans et al., 2014). Additionally, high-intensity exercises boost the capacity and recovery of the phosphocreatine energy system, facilitating rapid ATP resynthesis during short, intense efforts such as jumps (Forbes et al., 2008). The efficiency of glycolysis is also improved during HIIT, allowing for sustained high-intensity efforts and better lactate tolerance, which helps maintain power output across multiple jumps (Abe et al., 2015). Furthermore, exercises such as ball throws, and battle rope training in HIIT may increase muscle mass and explosive strength, leading to greater force production during throws and passes (Chen et al., 2018; Sayers and Bishop, 2017).

Some studies have reported that HIIT did not improve explosive power, which aligns with the previous review that showed no significant improvements in vertical jump height (Manuel Clemente et al., 2021). These results can be attributed to several factors. In studies by Delextrat and Martinez (2014) and Aschendorf et al. (2019), the participants were adolescents aged 15 to 16. Individuals in this age group undergo significant physiological and hormonal changes, and their musculoskeletal systems are still developing compared to adults over 20 (Loeser, 2010). This ongoing development may influence their response to high-intensity training, as younger athletes often exhibit differences in muscle fiber composition and adaptive capacity relative to older athletes (Hester et al., 2022). Adolescents’ muscles may have a reduced capacity for hypertrophy and may not adapt to HIIT as effectively as adults (Bucheit and Laursen, 2013).

Additionally, both studies implemented HIIT during the competitive season. In-season athletes are already exposed to a substantial training load through regular practices and games, contributing to cumulative fatigue (Cao et al., 2024b). Introducing additional HIIT sessions on top of this existing workload may risk overtraining and limit recovery, thereby hindering potential gains in explosive power (Cao et al., 2024b). Lastly, excessively long training sessions might also be a contributing factor (Smith et al., 2022). There is an optimal duration for HIIT that provides the necessary stimulus for adaptation without causing excessive fatigue. Exceeding this optimal duration may not yield additional benefits and can lead to diminishing returns (Bucheit and Laursen, 2013). Overall, for adolescent athletes, focusing on HIIT protocols that are specific, manageable, and integrated with their existing training demands are essential to optimize gains in explosive power without compromising recovery and performance.

Effect of HIIT on Change of Direction Ability

Change of direction (COD) ability could significantly impact an athlete's capacity to execute quick and agile movements during the game (Spiteri et al., 2014). In the present review, most studies demonstrated that HIIT significantly affected COD tests. The effect size (ES) calculation in this review revealed a moderate effect on the T-test (ES = 0.91), consistent with a previous review, which showed the significant benefits of HIIT in the COD test in soccer players (Clemente et al., 2021). The HIIT programs in the included studies, involving exercises performed at 90 - 95% of the VIFT, included jumps, ball throws, burpees, lunges, and high knees, which can significantly improve COD in basketball players. For example, exercising at 90 - 95% of the VIFT can enhance anaerobic capacity (Arazi et al., 2017), enabling athletes to perform repeated high-intensity efforts, such as quick sprints and directional changes, without rapidly fatiguing. Jumps can develop explosive power in the legs, which is crucial for quick take-offs and landings during changes in direction (Suarez-Arrones et al., 2020). Lunges, especially lateral lunges, strengthen the lower body muscles, including the quadriceps, hamstrings, and glutes, and improve balance and stability (Turner et al., 2016). This strengthening is essential for maintaining control during directional changes (Riemann et al., 2013; Turner et al., 2016).

However, three studies did not demonstrate a significant effect of HIIT on COD ability (Aschendorf et al., 2019; Chen et al., 2018; Delextrat and Martinez, 2014). The reasons for the lack of significance in the two studies could be attributed to the participants' young age (15.1 - 16.3 years old) and the in-season timing of the HIIT implementation, as mentioned before (Aschendorf et al., 2019; Delextrat and Martinez, 2014). Chen et al. (2018) showed that HIIT significantly improved other aspects of physical fitness, such as cardiovascular endurance, power, and muscular endurance, but not COD ability as measured by the T-test. This study used international-level players as participants and employed battle rope HIIT as the intervention. Since battle rope exercises primarily target the upper body and core, with limited direct engagement of the lower body muscles and movement patterns crucial for COD ability (Calatayud et al., 2015), the training might not have provided sufficient specific stimulus to the neuromuscular pathways involved in rapid directional changes.

Additionally, international-level players likely already possess a high level of COD ability due to their advanced training background (Baker and Newton, 2008). This high baseline level can make it challenging to achieve significant improvements without particular and targeted training (Rumpf et al., 2012). In contrast, studies involving national or developmental-level participants have shown improvements in COD ability (Arslan et al., 2022; Fang and Jiang, 2024; Haghighi et al., 2023; Kumari et al., 2023; Sanchez-Sanchez et al., 2018; Tao et al., 2023; Zeng et al., 2022), likely because these athletes start with lower baseline levels, allowing for more noticeable gains through general or moderate training interventions (Lloyd and Oliver, 2012).

Effect of HIIT on sprint

Linear sprint ability and repeated sprint ability significantly impact players' effectiveness in both offensive and defensive situations, thereby influencing overall game performance (Gonzalo-Skok et al., 2016; Maggioni et al., 2019; Pamuk et al., 2023). In the present review, most studies indicated that HIIT had a significantly positive effect on both linear sprint ability and repeated sprint ability. The effect size (ES) calculation revealed a small effect on the 20-m linear sprint (ES = 0.59). The results are in line with previous reviews. Clemente et al., (2021) indicated a significant favouring effect of HIIT for improving linear sprinting time in soccer players (Clemente et al., 2021). Engel et al. (2018) showed a small positive effect of HIIT on repeated sprint ability (Engel et al., 2018). By repeatedly practicing high-intensity sprints during HIIT, players can enhance their acceleration and top speed (Gökkurt and Kıvrak, 2021).

Additionally, the high-intensity nature of HIIT trains the neuromuscular system to operate more efficiently, improving muscle coordination and movement patterns specific to sprinting (Eken and Kafkas, 2022). HIIT also enhances anaerobic capacity, enabling players to sustain high-intensity efforts across multiple sprints, as seen in tests for RSA, rather than just a single maximal sprint (Boullosa et al., 2022). This is crucial for maintaining sprint speed throughout a basketball game. Furthermore, by incorporating high-intensity sprints followed by short recovery periods, HIIT trains the body to recover quickly between efforts (Subekti et al., 2022). This is essential for repeated sprint scenarios in basketball. Overall, HIIT can improve both linear sprint and repeated sprint ability in basketball players.

However, two studies (Delextrat and Martinez, 2014; Rodríguez-Fernández et al., 2023), using VIFT as HIIT intervention, reported no significant effect of HIIT on RSA. The VIFT primarily targets aerobic and cardiovascular fitness (Buchheit, 2010). While beneficial for overall endurance, it may not be intense or specific enough to elicit the neuromuscular adaptations needed to improve RSA, which relies more heavily on anaerobic power and rapid recovery between sprints (Bishop et al., 2011). Conversely, a previous study demonstrated that while RSA remained unchanged after 7 weeks of HIIT training, it significantly improved following an equivalent duration of specific RSA training (Bravo et al., 2008). This suggests that more targeted, high-intensity training may be essential for substantial gains in RSA performance (Castagna et al., 2007). In addition, one study (Zeng et al., 2022) using a 4-week VIFT as the HIIT intervention showed insignificant improvement in the 20-m sprint. Compared to the 6-week HIIT protocols used in other studies, a 4-week program may be insufficient for eliciting measurable improvements in the sprint speed, especially when using VIFT, which focuses on aerobic capacity rather than directly targeting the explosive power and neuromuscular adaptations required for sprinting (Buchheit, 2010).

Effect of HIIT on muscular strength

Muscular strength is integral to basketball performance, influencing basic skills such as shooting and rebounding and more complex aspects like defense, injury prevention, and overall endurance (Alemdaroğlu, 2012; Guimarães et al., 2021; Maffiuletti et al., 2000). In the present review, only one study examined the effect of HIIT on muscular strength, demonstrating a significant improvement in 1-RM leg press performance (Tao et al., 2023). Tao et al. (2023) employed all-out running as the HIIT intervention. All-out sprints engage the quadriceps, hamstrings, glutes, and calves-muscle groups, which are also primary movers in the leg press (Castagna et al., 2007; Nuell et al., 2021). The underlying mechanisms behind this improvement likely involve several key adaptations. First, all-out sprints induce repeated maximal contractions (Guilhem et al., 2012), which increase neuromuscular activation by enhancing motor unit recruitment, synchronization, and firing frequency (Bergstrom et al., 2013). This heightened motor unit activation strengthens muscle coordination and facilitates more excellent force production in exercises like the leg press (Bergstrom et al., 2013).

Additionally, the intense contractions during sprinting lead to muscle hypertrophy, especially in fast-twitch (Type II) fibres, which are highly recruited during maximal efforts (Guilhem et al., 2012). Sprinting places high demands on these fibres, leading to adaptations that contribute to increased muscle strength and power (Howard et al., 2018). The repeated high-intensity nature of all-out sprints may also improve muscle stiffness and tendon elasticity, allowing for more effective force transfer during exercises requiring lower body strength (Kubo et al., 2000).

However, it would be premature to draw conclusions about HIIT's effectiveness in improving muscular strength, particularly for exercises like the leg press, based on just one study. A more comprehensive assessment of HIIT's effectiveness for muscular strength would require additional studies.

Effect of HIIT on muscular endurance

Muscular endurance enables players to execute repetitive actions such as shooting, passing, defending, and rebounding (Cengizhan et al., 2019; Kamble et al., 2012). In the present review, only one study examined the effect of HIIT on muscular endurance, revealing that HIIT significantly improved core endurance as measured by static tests, including trunk flexor, trunk extensor, and bilateral side bridge tests (Chen et al., 2018). Chen et al. (2018) employed battle rope training as the HIIT intervention in their study. Battle rope exercises involve continuous, repetitive movements that engage muscles for extended periods (Chen et al., 2018). Although the core endurance tests are static, the dynamic nature of battle rope exercises can still enhance performance in static endurance tests. Battle rope movements require sustained core activation to stabilize the body against the forces generated by rapid and repetitive rope movements (Calatayud et al., 2015). This continuous engagement strengthens core stabilizing muscles, improving their endurance and ability to sustain contractions, even in static postures (Antony and Palanisamy, 2016).

While a single study demonstrating significant improvements in muscular endurance through HIIT provides valuable insights, it is insufficient to conclusively determine that HIIT is universally effective for enhancing muscular endurance. Consequently, further research is necessary to confirm these results, investigate the effects of various HIIT protocols, and compare HIIT with other training methods.

Effect of HIIT on basketball performance

Six included studies, utilizing methods such as 90%-95% VIFT, battle rope training, and circuit training, investigated the effect of HIIT as part of a comprehensive training program on various aspects of basketball performance, including shooting, passing, dribbling, and defensive movements (Arslan et al., 2022; Chen, W. H. et al., 2018; Delextrat and Martinez, 2014; Haghighi et al., 2023; Kumari et al., 2023; Zeng et al., 2022). While players were not absent from their regular sport-specific skills training, all studies demonstrated that HIIT significantly improved basketball performance.

In terms of shooting performance, exercises such as jumps and ball throws in HIIT programs enhance explosive power in both the legs and upper body (Hammami et al., 2021). This increase in strength and stability is crucial for consistent and powerful shooting, particularly in dynamic game situations (Aksović et al., 2020; Candra, 2018). HIIT also improves cardiovascular efficiency, enhancing oxygen delivery to the muscles (Astorino et al., 2011). Better oxygenation helps maintain shooting form and accuracy during high-intensity periods, such as dynamic shooting drills. Regarding passing performance, HIIT involving ball throws and similar exercises improves neuromuscular coordination, leading to more accurate and quicker passing, as seen in wall passing drills (Al Kitani, 2024).

For dribbling performance, HIIT drills like high knees, burpees, and cone drills improve foot speed, agility, and coordination, which are essential for effective dribbling (Lennemann et al., 2013). These exercises develop key physical attributes that directly enhance dribbling skills in several ways. First, HIIT engages fast-twitch muscle fibres during high-intensity intervals, contributing to enhanced neuromuscular adaptations crucial for COD, essential for explosive movements and sudden directional shifts (Bucheit and Laursen, 2013). This increased neuromuscular efficiency allows players to control their bodies better and quickly adjust while dribbling (Ahmed, 2015). Additionally, drills like high knees and running back and forth improve lower body strength and coordination, leading to enhanced stability and balance (Fredericson and Moore, 2005). This stability is crucial when dribbling at high speeds or changing directions. Still, HIIT drills that involve rapid direction changes improve a player's ability to move efficiently in defensive situations (Stankovic et al., 2023). This improvement translates to better on-ball defense and the ability to stay in front of an offensive player. The endurance developed through HIIT allows players to move effectively for extended periods, which is crucial for effective defense throughout a game (Ní Chéilleachair et al., 2017).

However, two of the six included studies found no significant improvement in shooting and passing performance (Delextrat and Martinez, 2014; Zeng et al., 2022). The shooting and passing tests used in these studies, such as 60-s shooting with the rebound, 40-s jump shots, 60-s shooting with a backward run to the centre line, and two-handed chest pass tests, were comparable to those in other studies that reported significant improvements. Further research is needed to investigate the exact mechanisms by which HIIT affects shooting and passing performance. Studies with varied HIIT protocols, including adjustments in duration, intensity, and basketball-specific movements, could provide more insight into the conditions under which HIIT enhances these technical skills.

Limitations

Some limitations should be considered when interpreting the results. First, a few included studies did not specify whether the HIIT interventions were implemented during the pre-season, in-season, or off-season. This omission limits the ability to account for potential differences in training adaptations and recovery that might occur based on the timing of the intervention. Why is this important?

Additionally, a risk of bias analysis revealed several potential sources of bias among the included studies. For instance, some studies had inadequate blinding of participants and assessors, which may influence the outcomes reported. These biases may lead to overestimating or underestimating HIIT's effects on basketball performance. Finally, due to the limited number of available articles, the study performed no separate analyses based on age (e.g., adolescents vs. adults) or playing level (e.g., international vs. national levels). This limitation may obscure potential differences in the effectiveness of HIIT across different demographic and competitive groups.

Conclusion

This systematic review and meta-analysis provide valuable insights into the effects of HIIT on basketball players, highlighting its potential to enhance physical fitness and basketball performance. The findings suggest that HIIT is particularly effective in improving cardiovascular endurance, power, change of direction (COD) ability, sprint performance, and basketball skill-related performance. However, the effects on some physical aspects, such as VO_{2max}, Yo-Yo IR 1, jump tests, ball throw test, 20-m COD sprint test, T-test, 20-m linear sprint, and specific basketball skills like shooting accuracy and passing, are less consistent. This variability is likely due to the need for more targeted, skill-specific training. The analysis also reveals that younger athletes (aged 15-16 years) and those undergoing in-season training might not experience the same level of benefit from HIIT as older or off-season athletes, potentially due to factors such as ongoing physical development and the cumulative fatigue associated with in-season play.

Practical implications

Coaches and trainers looking to implement HIIT with basketball players should consider integrating it strategically within the broader training regimen. Ideally, HIIT sessions should be scheduled during the off-season or pre-season periods to avoid adding excessive load during the in-season when players are already engaged in frequent practices and games. In addition, when designing HIIT protocols, incorporating basketball-specific movements (e.g., lateral shuffles, and defensive slides) can make the training more applicable to game scenarios. This approach not only improves fitness but also reinforces movement patterns that players frequently use in games. However, there are some considerations to keep in mind. Moreover, while HIIT is beneficial for conditioning, it may not provide the skill-specific training needed for improvements in basketball techniques such as shooting accuracy or passing precision. Coaches should balance HIIT with dedicated skill practice.

Acknowledgments

The experiments comply with the current laws of the country where they were performed. The authors have no conflict of interest to declare. The datasets generated during and/or analyzed during the current study are not publicly available but are available from the corresponding author who organized the study.

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Key points

- HIIT significantly improves cardiovascular endurance, power, change of direction ability, and sprint performance in basketball players, with particularly strong effects on endurance measures like the Yo-Yo IR 1.
- The effects of HIIT on basketball-specific skills like shooting and passing are inconsistent, suggesting that HIIT should be supplemented with specific skill training.
- Coaches should carefully time HIIT interventions, particularly during the season, and tailor them to the player's age and skill level for optimal benefits.

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