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Review

Can Complex Training Improve Acute and Long-Lasting Performance in Basketball Players? A Systematic Review

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Abstract: Basketball demands a sophisticated blend of tactical, technical, physical, and psychological skills, and various methods have been proposed to prepare players for these demands, including resistance training to enhance strength, power, speed, agility, and endurance. Complex training (CT) integrates diverse strength training methodologies by combining heavy-resistance exercises (e.g., squat at 90% of one repetition maximum) with high-velocity movements or plyometrics, both sharing the same biomechanical pattern. However, the optimal application of CT in basketball remains uncertain due to diverse protocols and a lack of consensus in the literature. The aim of this systematic review was to evaluate the acute and chronic effects of CT interventions on physical fitness performance in basketball players and identify the most effective characteristics of moderators. Methods: A bibliographic search was conducted using PubMed, SCOPUS, and Web of Science databases following the Preferred Reporting Items for Systematic Reviews and Meta-analyses guidelines using the PICOS strategy. Results: Fourteen studies met the inclusion criteria, three articles analyzed acute effects, and thirteen analyzed chronic effects. The total number of participants in the studies analyzing acute effects was 50, while for studies examining chronic effects, it was 362. Conclusions: Acutely, CT triggers post-activation potentiation and enhances sprint performance when coupled with brief rest intervals. Over time, these acute improvements contribute to more substantial, long-lasting benefits. Chronic effects of CT improve strength, as evidenced by enhanced 1 RM performance, jumps, sprints, and core muscle strength.

Keywords: basketball training; complex training; post-activation performance enhancement; team sport

1. Introduction

Basketball stands as a multidimensional sport, demanding a sophisticated blend of tactical, technical, physical, and psychological [1,2]. The sport's complexity reveals itself in the high-intensity actions performed by players interspersed with vital recovery periods [3]. These actions encompass explosive jumps, sprints, and changes of direction (CODs), as well as skill-based abilities like shots, dribbling, and rebounds [4]. Particularly during critical game phases, these actions wield significant influence over match outcomes. Consequently, the pursuit of enhancing the physical fitness abilities that optimize these critical actions has become a paramount goal for both players and coaches [5].

Performance in basketball-specific activities, such as jumps, sprints, and CODs, has been linked to the strength and power of the lower extremities [6]. Strength, defined as the peak tension a muscle or muscle group can generate at a given speed, manifests in diverse forms impacting athletic performance, including power, speed, agility, and endurance [7]. The scientific literature presents a broad spectrum of resistance training methods aimed at enhancing the strength and power of basketball players [8,9]. These methods encompass a wide range, including body weight-based exercises [10], machine-based resistance training [8], free-weight training [11], Olympic lifts [12], eccentric training [13], and plyometric training [14]. Each of these methods consistently showcases improvements in key basketball performance metrics, such as vertical jumps, agility, sprinting, and maximum strength [15]. However, the quest to determine the optimal approach for basketball-specific resistance training remains elusive.

In recent years, complex training (CT) has emerged as an approach characterized by the integration of diverse strength training methodologies to address constraints typically associated with their isolated application [15]. This method has been referred to by different names, including contrast training (involving one set of high-intensity strength training followed by one set of low-intensity strength exercises), complex training (involving 2–3 sets of high-intensity strength exercises followed by 2–3 sets of low-intensity strength exercises), or combined training (involving high-intensity strength exercises performed at the beginning) [15]. This innovative approach pairs a heavy resistance exercise, e.g., squat at 90% of one repetition maximum (1 RM), with a high-velocity movement, both sharing the same biomechanical pattern [16]. Typically, a low-intensity plyometric exercise is chosen after a high-intensity strength exercise [15,17]. The physiological basis of CT is the phenomenon of post-activation potentiation enhancement (PAPE), which refers to the improvement in muscular performance (i.e., sprint, jump) following maximal or near-maximal muscular contractions [16,18]. This stimulation enhances motor unit recruitment and increases the force-producing potential of the utilized musculature. The potentiated state of muscle leads to an immediate boost in performance, and when this is consistently achieved through a structured training program, it results in more significant long-term adaptations compared to other training methods [19].

Research indicates that CT can significantly enhance various physical attributes in basketball players, including sprint speed [7,20,21], jump height [7,20–22], upper body power [23], and muscular strength [20,21]. To comprehend the effects of CT, it is essential to distinguish between acute effects, which occur immediately after CT or in the short term (e.g., as a result of employing CT within a warm-up routine) [24,25], and chronic effects, which manifest over the long term (e.g., as a result of incorporating CT into a training regimen) [7,20,26]. A recent systematic review by Uysal et al. [15] concluded that CT was more effective in improving the vertical jump performance of young basketball players than other training methods. In this regard, despite the demonstrated potential of CT, there is a lack of evidence and consensus in the literature regarding its optimal application in basketball. On one hand, much of the existing research has primarily focused on team sports in general or specific sports like soccer [17,27]. On the other hand, there is considerable variability in the protocols employed for CT, encompassing factors such as the type, intensity, volume, and sequence of exercises, as well as the rest duration between sets and the frequency and duration of training sessions [15].

In light of this, the present systematic review aimed to gather evidence regarding the application of CT in basketball to enhance our understanding of both the chronic and acute effects of this training method, while also providing insight into the characteristics of the moderators utilized in the various programs employed in existing scientific studies. Consistent with previous studies in basketball [15] and other team sports [17], CT would be effective at enhancing specific physical fitness aspects of basketball players. The primary research question guiding this review was What is the impact of complex training on the performance of basketball players. The second question was What are the main characteristics of moderators (i.e., volume, intensity, series, and reps) that optimize the effects of CT.

2. Materials and Methods

This systematic review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidance [28]. The electronic databases employed for the search included PubMed, Scopus, and Web of Science (WOS), with no temporal limitations. The last search was conducted on 29 December 2023. Keywords were selected using experts' opinions and based on previous reviews conducted on CT in other team sports [15,17,27]. The search algorithm using the PICOS approach (population, intervention, comparator, outcomes, and study design) strategy with the following keywords: "basket*" or "complex training" or "contrast training" or "combine training" or "compound training" or "combination of strength training and plyometrics". The search strategy used in PubMed, Scopus, and Web of Science (WOS) was basket* AND ("complex training" OR "contrast training" OR "combine training" OR "compound training" OR "combined strength training and plyometrics" OR "combined resistance training and plyometrics"). The reference lists of relevant articles were reviewed to discover additional articles suitable for inclusion in the systematic review. The full search strategies for all databases, including any filters and limits used, are provided in Figure 1.

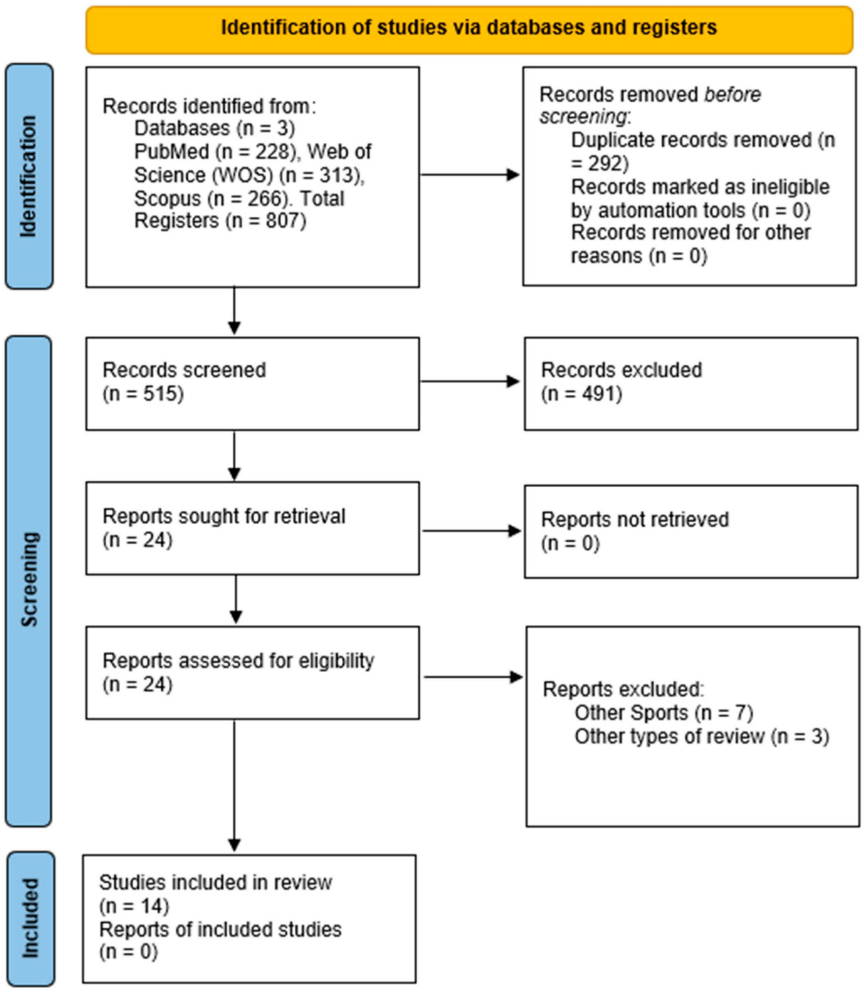

Figure 1. Diagram flow of the review.

2.1. Elegibility Criteria

The PICOS criteria were employed to select eligible studies. The inclusion and exclusion criteria for this systematic are detailed in Table 1. Duplicate identification was carried out using Mendeley reference management software (v. 2.111.0, Copyright © 2024 Elsevier Ltd., Barcelona, Spain). The authors EFG and ARF conducted a screening process for the title, abstract, and reference list of each study to locate potentially relevant studies. A third author (AV) participated in discussions to address any discrepancies in the selection process.

Table 1. Selection criteria used according to PICOS model.

PICOS Category	Inclusion Criteria	Exclusion Criteria
P (Population)	Basketball players from any sex (female/male) or competitive level without age restrictions (amateur to professional level).	Sports other than basketball (e.g., soccer, football, volleyball) or with injuries.
I (Intervention)	Studies analyzing acute (effect of CT implemented how warm-up) or chronic (effect of CT implemented how training strategy) effects of CT with a specified applied load	Interventions testing the effects of other types of strength training (i.e., Bodyweight Training) or including alternative methods in addition to strength training
C (Comparators)	Studies where groups are compared (i.e., CT vs. control group or vs. other type or training or different load)	Single-group studies
O (Outcomes)	The studies must analyze the effects in physical fitness tests (jump, speed, strength. . .)	Interventions that analyze other variables (i.e., cognition-related, nutrition)
S (Study designs)	Randomized and non-randomized controlled studies	Single group studies; Case studies (e.g., <5 participants per group).

2.2. Data Extraction

After identifying and excluding duplicates, the results were exported to an Excel document (Microsoft Office, 2016. Microsoft. Inc., Redmond, Washington, USA), and three tables were created, one for each database. These tables recorded the author's name, date, title, and keywords of all conducted studies, arranged alphabetically based on the first author's name. After reviewing the title and results, the inclusion and exclusion criteria were applied. Data extraction was performed independently by two reviewers (EFG and ARF). The studies meeting the inclusion criteria were reviewed to extract relevant data regarding the effects of CT on physical fitness. The means, standard deviations (SDs), and sample sizes (n) were extracted by one author (EFG) from the included papers and were corroborated by a second (ARF). Any discrepancy between the authors was resolved through discussion with a third author (AVJ). Alongside the results of the fitness tests, the intervention characteristics (i.e., training frequency, total duration, and type of training protocol) and sample details (i.e., sample size, age, and body mass) were extracted and recorded. In instances where data were not explicitly provided in the text but rather were only in a figure [21,29,30], the extraction was performed using a validated graphical software program (WebPlotDigitizer version 4.5; Automeris LLC, Pacifica, CA, USA), previously validated (r = 0.99, $p < 0.001$) [31] by a single experienced researcher.

2.3. Methodological Quality Assessment

The risk of bias in the studies was determined using the Tool for the Assessment of Study Quality and Reporting in Exercise (TESTEX) scale [32] applied in similar CT studies [15,17]. This tool comprises 12 assessment criteria, with a maximum score of 15 points. Higher scores reflect lower study bias. Reference values categorize a study's risk of bias as high (≤4 points and below), medium (4–11 points), and low (≥11 points) [15]. Two independent researchers (EFG and AV) conducted the assessments, and in the event of conflicts, a third author (ARF) facilitated discussions until a consensus was reached.

3. Results

3.1. Study Selection and Identification

A total of 807 documents were obtained (228 from PubMed, 266 from Scopus, and 313 from WOS). Duplicates (n = 292) were removed, and 595 studies' abstracts were screened, of which 498 were removed. Of the 24 articles eligible for full-text analysis, 14 were included in our review. Ten were excluded based on the following reasons: (i) not in basketball (n = 7); (ii) other types of reviews (n = 3).

Three articles analyzed acute effects [29,30,33], while thirteen analyzed chronic effects [7,20,21,26,29,33–40]. The total number of participants in the studies analyzing acute effects was 50, while for studies examining chronic effects, it was 362.

3.2. Methodological Quality

The methodological quality information of each study is displayed in Table 2. The mean score was 8.6 ± 1.8 points (5–13). Two studies demonstrated a low risk of bias [33,37], twelve showed a medium risk [7,20,22,26,29,30,34–36,38,40], and none of them were at high risk. All studies provided point measures and measures of variability for all reported outcome measures, along with information on exercise intensity and volume.

Table 2. Methodological quality score of the studies included in the review using the Tool for the Assessment of Study Quality and Reporting in Exercise.

	Items												Total Points (from a Maximum of 15)
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	
Biel et al. (2023) [33]	1	1	1	1	0	3	0	2	1	1	1	1	13
Freitas et al. (2019) [20]	0	1	0	1	0	2	0	1	1	1	1	1	9
Hasan et al. (2018) [28]	0	1	0	1	0	1	0	1	1	1	1	1	8
Hassan et al. (2023) [34]	1	1	0	0	0	2	0	1	1	1	1	1	9
Latorre Roman et al. (2018) [41]	0	1	0	1	0	2	0	2	1	0	1	1	9
Papla et al. (2023) [30]	1	1	0	1	0	0	0	2	1	1	1	1	9
Rodríguez-Cayetano et al. (2023) [35]	0	0	0	0	0	0	0	2	1	0	1	1	5
Sánchez-Sixto et al. (2021) [36]	0	1	0	1	0	0	0	2	1	0	1	1	7
Santos et al. (2008) [9]	0	1	0	1	0	1	0	2	1	0	1	1	8
Shi et al. (2022) [37]	1	1	0	1	0	2	0	2	1	1	1	1	11
Tsimachidis et al. (2013) [29]	0	1	0	1	0	1	0	2	1	1	1	1	9
Tsimahidis et al. (2010) [21]	0	1	0	1	0	1	0	2	1	0	1	1	8
Xie et al. (2023) [40]	0	1	0	1	0	1	0	2	1	0	1	1	8
Yañez-García et al. (2022) [38]	1	0	0	1	0	1	0	2	1	0	1	1	8

Note for items 1 through 12; 1: eligibility criteria specified (1 point); 2: randomization defined (1 point); 3: allocation concealment (1 point); 4: groups similar at baseline (1 point); 5: assessor blinding in study reporting (1 point); 6: outcome measures assessed in 85% of patients (3 points); 7: intention-to-treat analysis (1 point); 8: between-group statistical comparisons reported (2 points); 9: point measures and measures of variability for all reported outcome measures (1 point); 10: activity monitoring in the controlled group (1 point); 11: relative exercise intensity remained constant (1 point); 12: exercise volume and energy expenditure (1 point).

3.3. Acute Effects of Complex Training

Table 3 presents the characteristics of studies that analyzed the acute effects of complex training. Table 4 shows the results of studies analyzing the acute effects of CT on performance in basketball players. The table presents the values obtained in the tests used by the studies following the acute application of CT, along with the reported effect size and p-value (taken directly from the studies). The studies evaluated the acute impact of CT through a countermovement jump (CMJ) [30,33] and a single-leg jump (SLJ) [30] to assess jump ability, focusing on factors such as height. Agility performance was assessed using the Shuttle Test [33] and the modified t-agility test (MAT) [30]. Sprinting performance was measured using 10–30-m linear sprint tests [29]. The acute effects of CT were analyzed immediately [29,30,33] and after 5 min [29].

Table 3. Characteristics of studies that analyzed the acute effects of complex training.

Study	Groups	n	Body Mass (kg)	Age (yrs)	Experimental Design	Exercise Intervention Prescription	Group Specific Pre-Post Change
Biel et al. (2023) [33]	CPX	13	85.9 ± 10.9	24 ± 6	After a standardized warm-up, both groups performed a pre-test (CMJ, SLJ, and shuttle run test). 5 min later, participants performed each group performance conditioning activity and after 6 min performed the post test.	CPX training: 2–4 sets of 5–12 reps at 85% 1 RM with 90–120 rest (resistance exercise/active rest engaging different body regions/explosive exercise involving similar muscle groups as the first exercise) perform 3 sets of 5 DJ with a 60 s rest in-between.	Pre-training CMJ Height (cm): ↑ 5.5 ± 6.7% DOM SLJ Height (cm): ↑ 2.3 ± 5.6% N-DOM SLJ Height (cm): ↑ 2.3 ± 6.3% Shuttle RunTest Time (s): %↓ 0.7 ± 1.3% Post-training CMJ Height (cm): ↑ 4.5 ± 5% DOM SLJ Height (cm): ↑ 7.6 ± 14.8% N-DOM SLJ Height (cm): ↑ 2 ± 7.7% Shuttle RunTest Time (s): ↓ 1 ± 0.9%
	CMP	11	89.9 ± 8.5	21 ± 4		CPX training: 2–4 sets of 5–12 reps at 85% 1 RM with 90–120 rest (explosive exercise/active rest engaging different body regions/resistance exercise involving similar muscle groups as the first exercise) perform 3 sets of 5 DJ with a 60 s rest in-between.	Post-training CMJ Height (cm): ↑ 2.6 ± 5.3% DOM SLJ Height (cm): ↑ 5.4 ± 14.6 N-DOM SLJ Height (cm): ↑ 3.7 ± 6.2% Shuttle RunTest Time (s): ↓ 0.7 ± 1.4% Pre-training CMJ Height (cm): ↑ 4.6 ± 3.8% DOM SLJ Height (cm): ↑ 1.7 ± 6.4% N-DOM SLJ Height (cm): ↑ 1.9 ± 6.7% Shuttle RunTest Time (s): ↓ 0.8 ± 1.4
Papla et al. (2023) [30]	Bilateral activity group	13	87 ± 11	24 ± 6	After a standardized warm-up, both groups perform a pre-test (Achilles' tendon stiffness, CMJ and MAT time). After 5 min each group performed conditioning activity and after 6 min performed the post test.	Bilateral: 2 sets of 4 repetitions of back squats at 80% 1 RM and 10 drop jumps. 3-min rest interval between sets, while there was no rest within the conditioning activity complex.	CMJ Height (cm): ↑ 1.3 ± 4.4% CMJ Peak Velocity (m/s): ↑ 1.3 ± 4.1% CMJ Contraction time (ms): ↓ 4.9 ± 14.3% CMJ RSI: ↑ 9.2 ± 16.4%
	Unilateral activity group	13	89 ± 13	25 ± 7		Unilateral: 2 sets of 2 repetitions of split squats on each leg at 80% 1 RM, followed by 5 depth jumps to lateral hop on each leg. 3-min rest interval between sets, while there was no rest within the conditioning activity complex.	CMJ Height (cm): ↓ 0.9 ± 3.6% CMJ Peak Velocity (m/s): ↑ 0.4 ± 2.1% CMJ Contraction time (ms): ↓ 3.5 ± 11.5% CMJ RSI: ↑ 1.3 ± 12.6%

Table 3. *Cont.*

Study	Groups	n	Body Mass (kg)	Age (yrs)	Experimental Design	Exercise Intervention Prescription	Group Specific Pre-Post Change
Tsimachidis et al. (2013) [29]	Combined training group	13	80.9 ± 10.2	18.0 ± 1.2		After 10-week Combined training (2 times/week 5 sets at 8 RM half-squats during 5 weeks and 5 sets at 5 RM during the next 5 weeks. A maximal 30 m sprint was performed in the middle of the 3-min interval between the resistance sets).	Pre-training 10-m running speed (m/s): ↑ 0.95% 30-m running speed (m/s): 0% After 5 min: 10-m running speed (m/s): ↑ 1.65% 30-m running speed (m/s): ↑ 0.52% Post-training 10-m running speed (m/s): ↑ 1.1% 30-m running speed (m/s): ↑ 1.14% After 5 min: 10-m running speed (m/s): **↑ 48.3%** 30-m running speed (m/s): **↑ 3.74%**
	Control group	13	18.0 ± 0.7	82.0 ± 5.3		After 10-week habitual training (technical and tactical preparation).	Pre-training 10-m running speed (m/s): ↑ 0.72% 30-m running speed (m/s): 0.18% After 5 min: 10-m running speed (m/s): ↑ 0.96% 30-m running speed (m/s): ↑ 0.53 Post-training 10-m running speed (m/s): ↑ 1.8% 30-m running speed (m/s): ↑ 0.71% After 5 min: 10-m running speed (m/s): ↑ 1.42% 30-m running speed (m/s): ↑ 0.88%

CMJ = countermovement jump; DJ = drop jump; CPX = complex training; CMP = compound training; MAT = modified t-agility test; RSI = reactive strength index; SLJ = single-leg countermovement jump; DOM = dominant limb; N-DOM = non-dominant limb; Bold = significant differences.

Table 4. The mean ± standard deviation of fitness variables reported for the acute use of complex training and control/comparison conditions in the included studies.

		Complex training (resistance/active rest/explosive exercise) (*n* = 19)			Compound training (explosive exercise/active rest/resistance) (*n* = 13)		
Biel et al. (2023) [33]	Pre-training	Pre	Post	ES/*p*	Pre	Post	ES/*p*
	CMJ Height (cm)	35.8 ± 2.5	37.8 ± 3.5	0.66/-	37.7 ± 2.6	39.5 ± 3	0.64/-
	SLJ DOM Height (cm)	16.7 ± 2.9	17.1 ± 3	0.14/-	17.1 ± 3.3	17.4 ± 3.1	0.09/-
	SLJ N-DOM Height (cm)	16.6 ± 2.6	17.0 ± 3.1	0.14/-	16.2 ± 1.4	16.4 ± 0.9	0.17/-
	Shuttle run test time (s)	5.09 ± 0.16	5.06 ± 0.09	0.23/-	5.12 ± 0.11	5.07 ± 0.09	0.5/-
	Post-training	Pre	Post	ES/*p*	Pre	Post	ES/*p*
	CMJ Height (cm)	36.7 ± 3.5	38.2 ± 2.9	0.47/-	37.9 ± 2.9	38.9 ± 3	0.34/-
	SLJ DOM Height (cm)	17.5 ± 3.2	18.5 ± 2.6	0.34/-	17.9 ± 3.5	18.7 ± 3.3	0.24/-
	SLJ N-DOM Height (cm)	17.4 ± 2.8	17.8 ± 3.2	0.13/-	16.6 ± 1.5	17.1 ± 1.5	0.33/-
	Shuttle run test time (s)	5.02 ± 0.17	4.96 ± 0.15	0.37/-	5.08 ± 0.16	5.03 ± 0.11	0.36/-
Papla et al. (2023) [30]		Bilateral conditioning activity complex (*n* = 13)			Unilateral conditioning activity complex (*n* = 13)		
		Pre	Post	ES/*p*	Pre	Post	ES/*p*
	CMJ Height (cm)	39.3 ± 5.1	39.8 ± 5.1	0.10/>0.05	38.7 ± 4.7	38.4 ± 4.8	−0.06/>0.05
	CMJ Peak velocity (m/s)	2.87 ± 0.19	2.89 ± 0.16	0.11/>0.05	2.84 ± 0.19	2.86 ± 0.18	0.10/>0.05
	CMJ Contraction Time (m/s)	868 ± 167	821 ± 165	−0.27/>0.05	808 ± 113	796 ± 103	−0.11/>0.05
	CMJ RSI mod	0.47 ± 0.12	0.51 ± 0.14	0.30/>0.05	0.48 ± 0.06	0.49 ± 0.13	0.13/>0.05
	MAT DOM (s)	3.23	2.58	-/>0.05	2.43	2.36	-/>0.05
	MAT N-DOM (s)	2.56	3.22	-/>0.05	2.56	3.22	-/>0.05
Tsimachidis et al. (2013) [29]		Combined training group (*n* = 13)			Control group (*n* = 13)		
	Pre training	Pre	Post	ES/*p*	Pre	Post	ES/*p*
	10-m running speed (m/s)	4.23	4.27	-/>0.05	4.17	4.20	-/>0.05
	10-m running speed (m/s) post 5 min	4.23	4.30	-/>0.05	4.17	4.21	-/>0.05
	30-m running speed (m/s)	5.79	5.79	-/>0.05	5.64	5.65	-/>0.05
	30-m running speed (m/s) post 5 min	5.79	5.82	-/>0.05	5.64	5.67	-/>0.05
	Post training	Pre	Post	ES/*p*	Pre	Post	ES/*p*
	10-m running speed (m/s)	4.56	4.61	-/>0.05	4.22	4.27	-/>0.05
	10-m running speed (m/s) post 5 min	4.56	6.75	-/<0.05	4.22	4.28	-/>0.05
	30-m running speed (m/s)	6.15	6.22	-/>0.05	5.65	5.69	-/>0.05
	30-m running speed (m/s) post 5 min	6.15	6.38	-/<0.05	5.65	5.70	-/>0.05

CMJ = countermovement jump; MAT = modified t-agility test; DOM = dominant; N-DOM = non dominant; ES = effect size; p = p value.

3.4. Chronic Effects of Complex Training

Table 5 presents the characteristics of studies that analyzed the long-lasting performance of CT. Table 6 shows the results of studies analyzing the long-lasting effects of CT on performance in basketball players. The table presents the values obtained in the tests pre- and post-chronic application of CT, along with the reported effect size and *p*-value (directly taken from the studies). The effects on jumping ability were analyzed by assessing different metrics (i.e., jump height, relative peak power, and contraction time) in the CMJ [7,20–22,33,35–38], squat jump (SJ) [20–22,33,35,37,41], drop jump (DJ) [21,22,37,41], Abalakov jump ABK [22], and standing long jump and Sargent jump test [7]. Sprinting performance was measured using 10–30 m linear sprint tests [7,20,21,29,35,37,38], while change of direction (COD) performance was assessed using the *t*-test [20,41], Illinois test [35,40], and Shuttle Test [33]. Additionally, maximal strength (i.e., 1 RM) was evaluated through exercises such as the Half Squat [7,20,21,29,38], Back Squat [37], Bench Press [20], and Hip Thrust [20]. Furthermore, some studies utilized field tests to assess strength, such as the medicine ball throw [35] and sit-up back test [34]. The intervention periods lasted for 6 [20,26,36,38], 8 [33,35,37,40], and 10 [7,22,29,34] weeks, with sessions conducted 2 [7,20,22,26,29,33,36–38] or 3 [34,35] times per week. The studies utilized loading parameters of 1 [37], 2–4 [20,22,26,33,36,38], or 5–12 [7,21,29] sets, of 3–6 [20,36,37], 4–12 [7,26,33,38], or 6–15 repetitions [22], and 40–80% [26,38], 80% [20], or 85% [33,37] of 1 RM, 5–12 RM [21,22,29] optimal load [20], and relative resistance of 0.8–1.0 m/s [36]. Some studies did not clearly specify the moderators' (i.e., volume, intensity, series, and reps) characteristics [35,40]. Additionally, one study analyzed the application of CT in core training, performing 3 sets of 9–10 reps or 30 s for 10 core exercises, with rest intervals of 2–30 s within groups and 1–5 min between sets [34].

Table 5. Characteristics of studies that analyzed long-lasting effects of complex training in basketball players.

Study	Groups	n	Body Mass (kg)	Age (yrs)	Experimental Design	Exercise Intervention Prescription	Group Specific Pre-Post Change
Biel et al. (2023) [33]	CPX	13	85.9 ± 10.9	24 ± 6	After a standardized warm-up, both groups perform a pre-test (CMJ, SLJ and Shuttle Run Test). After 8 weeks, each group retested.	CPX training: 2–4 seta of 5–12 repa at 85% 1 RM with 90–120 rest (resistance exercise/active rest engaging different body regions/explosive exercise involving similar muscle groups as the first exercise) perform 3 sets of 5 DJ with a 60 s rest in-between. 2 times per week.	CMJ Height (cm): ↑ 2.3 ± 5% CMJ Relative Peak Power (W/kg): ↑ 0.8 ± 9.1% CMJ Contraction Time (ms): ↑ 7.3 ± 37% SLJ DOM Height (cm): ↑ 5.4 ± 16.2% SLJ DOM Relative Peak Power [W/kg]: **↑ 4.1 ± 6.6%** SLJ N-DOM Height (cm): **↑ 4.7 ± 4.5%** SLJ N-DOM Relative Peak Power [W/kg]: **↑ 2.2 ± 4.6%** Shuttle Run Test Time (s): ↓ 0.7 ± 1.3%
	CMP	11	89.9 ± 8.5	21 ± 4		CMP training: 2–4 seta of 5–12 repa at 85% 1 RM with 90–120 rest (explosive exercise/active rest engaging different body regions/resistance exercise involving similar muscle groups as the first exercise) perform 3 sets of 5 DJ with a 60 s rest in-between. 2 times per week.	CMJ Height (cm): ↑ 0.5 ± 3% CMJ Relative Peak Power (W/kg): ↑ 1.1 ± 3.3% CMJ Contraction Time (ms): ↓ 0.5 ± 12.3% SLJ DOM Height (cm): ↑ 5.1 ± 9.9% SLJ DOM Relative Peak Power [W/kg]: **↑ 4.7 ± 3.4%** SLJ N-DOM Height (cm): **↑ 2.7 ± 9.2%** SLJ N-DOM Relative Peak Power [W/kg]: **↑ 3.4 ± 6.4%** Shuttle Run Test Time (s): ↓ 0.8 ± 1.4%
Freitas et al. (2019) [20]	MCT	9	21.3 ± 4.3	90.9 ± 14.8	After a standardized warm-up, both groups perform a pre-test (CMJ, SLJ, 10 m sprint and *t*-test). After 6 weeks, each group retested.	MCT training: 3–4 sets of 3–5 reps at 80% 1 RM + Optimal Load, with 180 rest (Half Squat, Bench Press and Hip Thrust). 2 times per week.	Half Squat 1 RM (kg): ↑ 17.2 ± 11.6% Bench Press 1R (kg): ↑ 4.3 ± 4.6% Hip Thrust 1R (kg): ↑ 28.2 ± 19% CMJ Height (cm): ↑ 2.2 ± 4.3% CMJ Peak Power (W): ↑ 3.0 ± 4.4% SLJ Distance (m): ↑ 2.5 ± 4.6% 10-m Sprint Time (s): ↓ 2.3 ± 4.6% *t*-Test Time (s): ↓ 3.0 ± 2.1%
	OLT	9				OLT training: 3–4 sets of 7–8 reps at optimal load. 2 times per week.	Half Squat 1 RM (kg): ↑ 10.8 ± 5.3% Bench Press 1R (kg): ↑ 2.2 ± 3.7% Hip Thrust 1R (kg): ↑ 23.4 ± 17.7% CMJ Height (cm): ↑ 4.0 ± 3.8% CMJ Peak Power (W): ↑ 2.9 ± 3.5% SLJ Distance (m): ↓ 0.72 ± 9.0% 10-m Sprint Time (s): ↓ 1.63 ± 1.6% *t*-Test Time (s): ↓ 3.03 ± 3.2%

Table 5. *Cont.*

Study	Groups	n	Body Mass (kg)	Age (yrs)	Experimental Design	Exercise Intervention Prescription	Group Specific Pre-Post Change
Hasan et al. (2018) [28]	CT	10	23.3 ± 1.41	56.6 ± 2.5	After a standardized warm-up, both groups perform a pre-test (TAAV). Before and after 6 weeks, each group was tested.	CT training: This group underwent both the training pattern given to groups A and B with intensity reduced by 25%. An intra-complex rest interval of eight minutes was given between weight training and plyometric training.	TAAV (s): ↑ **21.1%**
	PT	10	22.7 ± 1.41	59 ± 6.4		PT training: 3–4 sets of 6–8 reps at jumps with medicine ball. The plyometric exercises given to the subjects were double arm over-head throw, double arm chest pass, double arm side-to-side throw, double arm through leg throw, with 30 sec of rest between each. 2 times per week.	TAAV (s): ↑ **14.6%**
	RT	10	22.3 ± 1.63	58.8 ± 6		RT training: 4 sets of 6–10 reps at 40–100% 1 RM. The resistance training group performed the following exercises: Frontal raise, prone extension, shoulder abduction, external rotation, internal rotation, biceps curl, triceps curl, forearm supination, forearm pronation, wrist flexion and extension.	TAAV (s): ↑ **13.6%**

Table 5. *Cont.*

Study	Groups	n	Body Mass (kg)	Age (yrs)	Experimental Design	Exercise Intervention Prescription	Group Specific Pre-Post Change
Hassan et al. (2023) [34]	CCT	12	18.58 ± 0.67	76.42 ± 1.38	During 10 weeks, each of the three groups underwent 30 training units, with each week consisting of 3 training units. Before and after 10 weeks, each group was tested.	3 groups of 9–10 repetitions or 30 s of 10 core exercises with 2–30 s of rest intergroup and 1–5 inter-rest.	Core muscle strength stability (min): ↑ **14.58%** Sit-up abdomen test (n°): ↑ **42.49%** Sit-up back test (n°): ↑ **31.51%** Standing long jump test (cm): ↑ **12.80%** Sargent jump test (cm): ↑ **30.45%** Medicine ball javelin quadrathlon test (m): ↑ **57.63%** Shooting test (n°): ↑ **76.26%**
	CT	12	18.50 ± 0.52	76.67 ± 1.78		3 groups of 9–12 groups replications with 2 s rest between groups and 4–5 min rest between weight training and barometric.	Core muscle strength stability (min): ↑ **12.57%** Sit-up abdomen test (n°): ↑ **34.59%** Sit-up back test (n°): ↑ **21.49%** Standing long jump test (cm): ↑ **12.92%** Sargent jump test (cm): ↑ **25.32%** Medicine ball javelin quadrathlon test (m): ↑ **41.23%** Shooting test (n°): ↑ **45.93%**
	CE	12	18.42 ± 0.51	76.58 ± 0.67		1–3 × 10–15 repetitions of 10 core exercises with rest of 30–90 s.	Core muscle strength stability (min): ↑ **11.58%** Sit-up abdomen test (n°): ↑ **33.44%** Sit-up back test (n°): ↑ **19.86%** Standing long jump test (cm): ↑ **12.92%** Sargent jump test (cm): ↑ **24.99%** Medicine ball javelin quadrathlon test (m): ↑ **41.65%** Shooting test (n°): ↑ **45.33%**

Table 5. *Cont.*

Study	Groups	n	Body Mass (kg)	Age (yrs)	Experimental Design	Exercise Intervention Prescription	Group Specific Pre-Post Change
Latorre Román et al. (2018) [41]	CPX	30	17.22 ± 2.48 kg/m² (BMI)	8.72 ± 0.97	After a standardized warm-up, both groups perform a pre-test (SJ, DJ, CMJ, CCS, SLJ, 25 m Sprint and *t*-test). After 10 weeks, each group retested.	5–13 sets of 10 reps alternating isometric (90° isometric Half Squat exercise or 90° isometric Half Squat exercise with partner sitting on top of the thighs) and plyometric exercises (depth jumps from the seated position or vertical jumps from the seated position), in this order (CT) with 90 s of passive rest. 2 times per week.	SJ Height (cm): ↑ 1.95 ± 1.60% CMJ Height (cm): **↑ 2.51 ± 1.37%** SSC Height (cm): **↑ 0.55 ± 1.71%** DJ20-cm Height (cm): **↑ 2.02 ± 1.18%** DJ40-cm Height (cm): **↑ 2.03 ± 1.65%** Standing long jump (cm): ↑ 4.76 ± 5.17% 25-m Sprint Time (s): **↓ 0.37 ± 0.34%** *t*-Test Time (s): **↓ 1.08 ± 1.63%**
	CG	28				This group only did normal basketball training.	SJ Height (cm): ↑ 1.23 ± 0.85% CMJ Height (cm): **↑ 1.03 ± 0.96%** SSC Height (cm): ↓ 0.20 ± 0.91% DJ20-cm Height (cm): **↑ 1.07 ± 1.01%** DJ40-cm Height (cm): **↑ 1.11 ± 0.99%** Standing long jump (cm): ↑ 3.85 ± 7.14% 25-m Sprint Time (s): **↓ 0.16 ± 0.23%** *t*-Test Time (s): ↓ 0.11 ± 0.45%
Rodríguez-Cayetano et al. (2023) [35]	EG	12		16.3 ± 0.5	After a standardized warm-up, both groups perform a pre-test (CMJ, SJ, IAT with and without ball and 20 m Sprint). After 8 weeks, each group retested.	24 sessions of 40 min (16 gym sessions and 8 court practices). The gym sessions were a mixture of plyometric exercises, exercises with resistance exercises. 3 times per week.	CMJ Height (cm): ↓ 3.23% SJ Height (cm): ↑ 1.11% Illinois-Ball (s): ↑ 3.05% Illinois-No-Ball (s): ↑ 2.32% 20-m Sprint Time (s): ↓ 0.26% Left ankle dorsiflexion test (°): ↑ 3.87% Right ankle dorsiflexion test (°): ↑ 4.57% Medicine ball throw (cm): **↑ 5.14%**
	CG	11		16.4 ± 0.5		This group only did normal basketball training.	CMJ Height (cm): ↑ 1.11% SJ Height (cm): ↑ 5.35% Illinois-Ball (s): **↑ 0.54%** Illinois-No-Ball (s): ↑ 4.24% 20-m Sprint Time (s): ↓ 1.85% Left ankle dorsiflexion test (°): ↑ 2.18% Right ankle dorsiflexion test (°): ↓ 1.01% Medicine ball throw (cm): ↓ 9.8%

Table 5. *Cont.*

Study	Groups	n	Body Mass (kg)	Age (yrs)	Experimental Design	Exercise Intervention Prescription	Group Specific Pre-Post Change
Sánchez-Sixto et al. (2021) [36]	PWG	13	60.14 ± 12.44	23.00 ± 2.94	After a standardized warm-up, both groups perform a pre-test (CMJ, and Isoinertial progressive resistance test). After 6 weeks, each group retested.	PWG: 3–4 sets of 3–6 reps at Full Squats in Smith machine with relative resistance of 0.8–1.0 m/s and 4–7 sets of 5 reps of jumps, with 180 s of rest. 2 times per week.	CMJ Height (cm): ↑ 11.8% $PPower_{ECC}$ ($W{\cdot}BW^{-1}$): ↑ 15.6% $PPower_{CON}$ ($W{\cdot}BW^{-1}$): ↑ 9.4%
	PG	11	64.05 ± 11.15	22.55 ± 3.17		PG: 3–4 sets of 3–6 reps at DJ of 20,30 and 40 cm and 4–7 sets of 5 reps of jumps. 2 times per week.	CMJ Height (cm): ↑ 6.1% $PPower_{ECC}$ ($W{\cdot}BW^{-1}$): ↑ 12.4% $PPower_{CON}$ ($W{\cdot}BW^{-1}$): ↑ 3.4%
	CG	12	65.77 ± 8.29	22.58 ± 7.28		This group only did normal basketball training.	CMJ Height (cm): ↑ 3.0% $PPower_{ECC}$ ($W{\cdot}BW^{-1}$): ↓ 4.6% $PPower_{CON}$ ($W{\cdot}BW^{-1}$): ↓ 1.5%
Santos et al. (2008) [9]	EG	15	72.7 ± 16.9	14.7 ± 0.5	After a standardized warm-up, both groups perform a pre-test (SJ, CMJ, ABA, DJ, MP and MBT). After 10 weeks, each group retested.	EG: 2–4 sets of 6–15 RM reps at resistance exercises (Leg extension, Pullover, Leg curl, Leg press. . .) plyometric exercise with 60–240 s of passive rest between sets and 15–60 s of passive rest between exercises. 2 times per week.	CMJ Height (cm): ↑ **10.5%** SJ Height (cm): ↑ **13%** ABA Height (cm): ↑ **10.5%** DJ Height (cm): ↑ 5.6% MP (W/Kg): ↑ 3.4% Medicine ball throw (m): ↑ **19.6%**
	CG	10	61.1 ± 11.4	14.2 ± 0.4		This group only did normal basketball training.	CMJ Height (cm): ↓ **7.7%** SJ Height (cm): ↓ 8.1% ABA Height (cm): ↓ **5.2%** DJ height (cm): ↓ 1.2% MP (W/Kg): ↓ **10.9%** Medicine ball throw (m): ↑ **5.5%**

Table 5. *Cont.*

Study	Groups	n	Body Mass (kg)	Age (yrs)	Experimental Design	Exercise Intervention Prescription	Group Specific Pre-Post Change
Shi et al. (2022) [37]	CRT	10	82.8 ± 12.8	20.8 ± 1.4	After a standardized warm-up, both groups perform a pre-test (1 RM, CMJ, SJ, SBJ, 10 m and 20 m Sprint). After 8 weeks, each group retested.	CRT: 1 set of 3–4 reps at Back Squat 85% 1 RM followed by plyometric exercises with 3 min of passive rest within complex training. 2 times per week.	1 RM (Kg): ↑ **32.3%** CMJ Height (cm): ↑ **5.6%** SJ (cm): ↑ **12.9%** SBJ (cm): ↑ 2% 10-m Sprint Time (s): ↓ 0.6% 20-m Sprint Time (s): ↑ 0.3%
	VRT	11				VRT Group: combined elastic bands with 1 set of 3–4 reps at Back Squat 85% IRM Back Squat followed by plyometric exercises with 3 min of passive rest within complex training. 2 times per week.	1 RM (Kg): ↑ **36.5%** CMJ Height (cm): ↑ **12.9%** SJ (cm): ↑ **21.4%** SBJ (cm): ↑ **2.9%** 10-m Sprint Time (s): ↓ 0.6% 20-m Sprint Time (s): ↓ 0.3%
Tsimachidis et al. (2013) [29]	PWG	13	80.9 ± 10.2	18.0 ± 1.2	After a standardized warm-up, both groups perform a pre-test (1 RM, SJ, CMJ and DJ, 0–10 m Sprint and 10–30 m Sprint). After 10 weeks, each group retested.	After 10-week Combined training 5 sets at 8 RM Half Squat during 5 weeks and 5 sets at 5 RM during the next 5 weeks. A maximal 30 m sprint was performed in the middle of the 3-min interval between the resistance sets). 2 times per week.	1 RM (Kg): ↑ **30.3 ± 1.5%** 0–10-m Sprint Time (s): - 0–30-m Sprint Time (s): -
	CG	13	82.0 ± 5.3	18.0 ± 0.7		After 10-week habitual training (technical and tactical preparation).	1 RM (Kg): - 0–10-m Sprint Time (s): - 0–30-m Sprint Time (s): -

Table 5. *Cont.*

Study	Groups	n	Body Mass (kg)	Age (yrs)	Experimental Design	Exercise Intervention Prescription	Group Specific Pre-Post Change
Tsimahidis et al. (2010) [21]	PWG	13	80.9 ± 10.2	18.0 ± 1.2	After a standardized warm-up, both groups perform a pre-test (1 RM, SJ, CMJ and DJ, 0–10 m Sprint and 10–30 m Sprint). After 10 weeks, each group retested.	After 5- and 10-week Combined training 5 sets at 8 RM half-squats during 5 weeks and 5 sets at 5 RM during the next 5 weeks. A maximal 30 m sprint was performed in the middle of the 3-min interval between the resistance sets). 2 times per week.	After 5-weeks 1 RM (Kg): ↑ **18.8%** CMJ Height (cm): ↑ **8.64%** SJ Height (cm): ↑ **9.12%** DJ Height (cm): ↑ **10.32%** 0–10-m Sprint Time (s): ↓ **5.48%** 10–30-m Sprint Time (s): ↓ **3.23%** After 10-weeks 1 RM (Kg): ↑ **29.0%** CMJ Height (cm): ↑ **22.84%** SJ Height (cm): ↑ **12.76%** DJ Height (cm): ↑ **14.19%** 0–10 m Sprint Time (s): ↓ **7.60%** 10–30 m Sprint Time (s): ↓ **5.33%**
	CG	13	18.0 ± 0.7	82.0 ± 5.3		After 5- and 10-week habitual training (technical and tactical preparation).	After 5-weeks 1 RM (Kg): ↑ 0.70% CMJ Height (cm): ↑ 0.96% SJ Height (cm): ↑ 1.54% DJ Height (cm): ↑ 0.95% 0–10-m Sprint Time (s): ↑ 0.41% 10–30-m Sprint Time (s): ↓ 0.37% After 10-weeks 1 RM (Kg): ↑ 1.30% CMJ Height (cm): ↑ 1.28% SJ Height (cm): ↑ 2.16% DJ Height (cm): ↑ 1.91% 0–10-m Sprint Time (s): ↑ 0.41% 10–30-m Sprint Time (s): ↓ 0.56%

Table 5. *Cont.*

Study	Groups	n	Body Mass (kg)	Age (yrs)	Experimental Design	Exercise Intervention Prescription	Group Specific Pre-Post Change
Xie et al. (2023) [40]	EG	15	19.7 ± 1.6	80.8 ± 2.6	After a standardized warm-up, both groups perform a pre-test (IAT, Pro Test, TWT, DRT and Z-test). After 8 weeks, each group retested.	The experimental group did complex exercises with rope ladder training.	IAT (s): ↓ 4.3% Pro-test (s): ↓ 9.0% TWT (s): ↓ 5.0% DRT (s): ↓ 4.5% Z-test (s): ↓ 6.1%
	CG	15	20.3 ± 1.1	81.1 ± 2.3		This group only did normal basketball training.	IAT (s): ↓ 1.0% Pro-test (s): ↓ 2.1% TWT (s): ↓ 1.1% DRT (s): ↓ 2.4% Z-test (s): ↓ 1.9%
Yáñez-García et al. (2022) [38]	U-13	11	13.1 ± 0.5	64.2 ± 13.7	After a standardized warm-up, both groups perform a pre-test (CMJ, 20 m Sprint and PILT in full Squat "RM"). After 6 weeks, each group retested.	All made it 2–3 sets of 4–8 reps at 45–60% 1 RM of resistance exercises and different exercises of plyometric, sprint and COD. 2 times per week.	CMJ Height (cm): ↑ **11.6%** 10-m Sprint Time (s): ↓ **3.9%** 20-m Sprint Time (s): ↓ **3.5%** 10–20-m Sprint Time (s): ↓ **3.1%** 1 RM Full Squat (kg): ↑ **27.3%**
	U-15	11	14.8 ± 0.4	77.1 ± 12.5			CMJ Height (cm): ↑ **10.3%** 10-m Sprint Time (s): ↓ **0.9%** 20-m Sprint Time (s): ↓ **1.4%** 10–20-m Sprint Time (s): ↓ 1.9% 1 RM Full Squat (kg): ↑ **17.5%**
	U-17	11	16.5 ± 0.5	84.0 ± 10.6			CMJ Height (cm): ↑ **6.6%** 10-m Sprint Time (s): ↓ **0.3%** 20-m Sprint Time (s): ↓ **0.7%** 10–20-m Sprint Time (s): ↓ 1.2% 1 RM Full Squat (kg): ↑ **9.2%**

CMJ = countermovement jump; RSI = reactive strength index; DJ = drop jump; CPX = complex training; CMP = compound training; MAT = modified t-agility test; SLJ = single-leg countermovement jump; DOM = dominant limb; N-DOM = non-dominant limb; MCT = Modified Complex Training; OLT = optimal load training; EG = experimental group; CG = control group; CT = contrast training; SSC = Stretch Shortening Cycle; IAT = Illinois Agility Test; PWG = Combined Training Group; PT = Plyometric Training Group; $PPower_{ECC}$ = Eccentric Peak Power; $PPower_{CON}$ = Concentric Peak Power; ABA = Abalakov Test; MP = Mechanical Power; CRT = Constant Resistance Training; VRT = Variable Resistance Training; RM = Repetition Maximum; TWT = T-Word Test; DRT = Dribble Round Test; RT = Resistance Training Group; CT = Complex Training Group; TAAV = Test Assessment of Angular Velocity; U-13 = Players Under 13 yrs; U-15 = Players Under 15 yrs; U-17 = Players Under 17 yrs; PILT = Progressive Isoinertial Loading Test; COD = change of direction; Bold = significant differences.

Table 6. The mean ± standard deviation of fitness variables reported for the long-lasting complex training and control/comparison conditions in the included studies.

Study	Variable	Complex training (resistance/active rest/explosive exercise) (*n* = 19)			Compound training (explosive exercise/active rest/resistance) (*n* = 13)		
		Pre	Post	ES/*p*	Pre	Post	ES/*p*
Biel et al. (2023) [33]	CMJ Height (cm)	35.8 ± 2.5	36.7 ± 3.5	0.3/>0.05	37.7 ± 2.6	37.9 ± 2.9	0.07/>0.05
	CMJ Relative Peak Power (W/kg)	57.2 ± 4.1	57.7 ± 6.7	0.09/>0.05	57.7 ± 6.7	59.6 ± 3.7	0.35/>0.05
	CMJ Contraction Time (ms)	755 ± 188	758 ± 145	0.02/>0.05	833 ± 111	823 ± 109	0.09/>0.05
	SLJ DOM Height (cm)	16.7 ± 2.9	17.4 ± 3.2	0.23/>0.05	17.1 ± 3.3	17.9 ± 3.5	0.24/>0.05
	SLJ DOM Relative Peak Power [W/kg]	33.2 ± 4.6	34.6 ± 5.1	0.29/<0.05	34.3 ± 4.4	35.9 ± 4.7	0.35/<0.05
	SLJ N-DOM Height (cm)	16.6 ± 2.6	17.4 ± 2.8	0.30/<0.05	16.2 ± 1.4	16.6 ± 1.5	0.28/<0.05
	SLJ N-DOM Relative Peak Power [W/kg]	33.7 ± 3.9	34.5 ± 4.6	0.19/<0.05	33.6 ± 2.4	34.7 ± 2.7	0.43/<0.05
	Shuttle run test time (s)	5.09 ± 0.16	5.02 ± 0.17	-/>0.05	5.12 ± 0.11	5.08 ± 0.16	-/>0.05

Study	Variable	Modified Complex Training (*n* = 9)			Optimal Load Training (*n* = 9)		
		Pre	Post	ES/*p*	Pre	Post	ES/*p*
Freitas et al. (2019) [20]	Half Squat 1 RM (kg)	154.8 ± 33.3	178.2 ± 14.5	0.64/-	149.1 ± 23.0	165.4 ± 27.9	0.64/-
	Bench Press 1R (kg)	66.6 ± 14.8	69.2 ± 13.2	0.15/-	76.4 ± 14.2	78.2 ± 15.0	0.11/-
	Hip Thrust 1R (kg)	145.7 ± 29.9	186.6 ± 39.6	1.23/-	144.2 ± 32.2	179.0 ± 46.4	0.98/-
	CMJ Height (cm)	36.4 ± 4.2	37.2 ± 3.6	0.15/-	36.5 ± 7.2	37.9 ± 7.5	0.17/-
	CMJ Peak Power (W)	4594.2 ± 730.0	4775.3 ± 712.4	0.22/-	4699.1 ± 780.5	4833.1 ± 762.2	0.16/-
	SLJ Distance (m)	2.39 ± 0.23	2.46 ± 0.24	0.27/-	2.27 ± 0.22	2.27 ± 0.24	0.01/-
	10-m Sprint time (s)	1.89 ± 0.10	1.86 ± 0.13	0.27/-	1.91 ± 0.09	1.87 ± 0.09	0.29/-
	T-Test (s)	9.45 ± 0.35	9.16 ± 0.50	0.75/-	9.71 ± 0.67	9.46 ± 0.30	0.42/-

Study	Variable	Complex training (*n* = 10)			Plyometric training (*n* = 10)			Weight training (*n* = 10)		
		Pre	Post	ES/*p*	Pre	Post	ES/*p*	Pre	Post	ES/*p*
Hasan et al. (2018) [28]	Angular velocity (rad/sec)	10.32 ± 1.46	12.50 ± 1.71	-/0.000	9.64 ± 1.14	11.05 ± 1.27	-/0.000	9.86 ± 1.63	11.20 ± 1.81	-/0.000

Table 6. *Cont.*

		Complex training (n = 12)			Core complex training (n = 12)			Core training (n = 12)		
		Pre	Post	ES/p	Pre	Post	ES/p	Pre	Post	ES/p
Hassan et al. (2023) [34]	Core muscle strength stability (min)	1.91 ± 0.06	2.15 ± 0.06	2.60/0.001	1.92 ± 0.08	2.20 ± 0.05	3.34/0.001	1.90 ± 0.05	2.12 ± 0.05	3.12/0.001
	Sit-up abdomen test (n°)	18.33 ± 0.78	24.67 ± 0.89	4.86/0.001	18.83 ± 0.72	26.83 ± 0.94	6.25/0.001	18.42 ± 0.52	24.58 ± 0.79	5.17/0.001
	Sit-up back test (n°)	17.08 ± 0.52	20.75 ± 0.75	3.18/0.001	17.17 ± 0.72	22.58 ± 1.51	3.46/0.001	17.17 ± 0.72	20.58 ± 0.52	3.43/0.001
	Standing long jump test (cm)	194.83 ± 3.54	220.00 ± 1.71	6.73/0.001	196.58 ± 3.58	221.75 ± 2.26	7.83/0.001	194.83 ± 3.54	220.00 ± 1.71	6.96/0.001
	Sargent jump test (cm)	37.01 ± 0.14	46.38 ± 0.80	11.50/0.001	37.04 ± 0.19	48.32 ± 0.36	25.32/0.001	37.01 ± 0.13	46.26 ± 0.89	10.90/0.001
	Medicine ball javelin quadrathlon test (m)	5.19 ± 0.06	7.33 ± 0.25	8.92/0.001	5.24 ± 0.07	8.26 ± 0.06	34.80/0.001	5.21 ± 0.05	7.38 ± 0.32	6.96/0.001
	Shooting test (n°)	7.25 ± 0.62	10.58 ± 0.52	4.28/0.001	7.33 ± 0.49	12.92 ± 1.00	5.61/0.001	7.17 ± 0.72	10.42 ± 0.52	4.31/0.001
		Contrast training (n = 30)				Control group (n = 28)				
		Pre		Post	ES/p	Pre		Post		ES/p
Latorre Román et al. (2018) [41]	SJ Height (cm)	17.53 ± 4.08		19.48 ± 4.82	-/>0.05	17.15 ± 3.75		18.39 ± 3.98		-/>0.05
	CMJ Height (cm)	17.85 ± 4.08		20.36 ± 4.34	-/<0.001	17.47 ± 4.27		18.51 ± 4.24		-/<0.001
	Stretch shortening cycle (cm)	0.32 ± 1.61		0.87 ± 1.55	-/<0.05	0.31 ± 0.99		0.11 ± 1.09		-/>0.05
	DJ Height 20 cm (cm)	15.76 ± 4.11		17.78 ± 4.02	-/<0.001	16.41 ± 3.68		17.48 ± 4.06		-/<0.001
	DJ Height 40 cm (cm)	14.96 ± 4.42		16.99 ± 3.95	-/<0.001	16.25 ± 3.93		17.36 ± 4.29		-/<0.001
	Standing long jump (cm)	131.03 ± 16.86		135.80 ± 19.20	-/<0.001	132.00 ± 19.11		135.86 ± 19.95		-/<0.01
	25-m sprint time (s)	5.53 ± 0.41		5.15 ± 0.45	-/<0.001	5.91 ± 0.84		5.75 ± 0.81		-/<0.01
	t-test (s)	15.66 ± 1.44		14.57 ± 1.29	-/<0.001	15.98 ± 1.04		15.86 ± 1.44		-/>0.05
		Contrast training (n = 12)				Control group (n = 11)				
		Pre		Post	ES/p	Pre		Post		ES/p
Rodríguez-Cayetano et al. (2023) [35]	CMJ Height (cm)	48.89		47.31	-/0.218	39.65		40.09		-/0.546
	SJ Height (cm)	36.06		36.46	-/0.695	31.75		33.45		-/0.229
	Illinois without ball (s)	16.05		16.54	-/0.054	16.73		16.82		-/0.565
	Illinois with ball (s)	17.24		17.64	-/0.075	17.45		18.19		-/0.035
	20-m sprint time (s)	3.78		3.77	-/0.873	3.79		3.72		-/0.185
	Left ankle dorsiflexion test (°)	43.24		44.91	-/0.074	43.93		44.89		-/0.736
	Right ankle dorsiflexion test (°)	44.19		46.21	-/0.236	43.49		43.05		-/0.672
	Medicine ball throw (cm)	713.33		750.00	-/0.008	640.00		633.64		-/0.663

Table 6. *Cont.*

		Combined training (full squats and repeated jumps) (n = 13)			Control group (n = 12)		
		Pre	Post	ES/p	Pre	Post	ES/p
Sánchez-Sixto et al. (2021) [36]	CMJ Height (m)	0.34 ± 0.03	0.38 ± 0.05	1.08/-	0.33 ± 0.03	0.34 ± 0.03	0.10/-
	CMJ minimum Force (BW)	0.43 ± 0.20	0.37 ± 0.18	−0.50/-	0.59 ± 0.12	0.60 ± 0.10	0.05/-
	CMJ average force (BW)	1.80 ± 0.15	1.83 ± 0.14	0.20/-	1.81 ± 0.16	1.77 ± 0.14	−0.26/-
	CMJ crouch position force (BW)	2.13 ± 0.27	2.16 ± 0.20	0.12/-	2.07 ± 0.23	1.97 ± 0.21	−0.4/-
	CMJ peak force (BW)	2.21 ± 0.24	2.23 ± 0.19	0.10/-	2.21 ± 0.23	2.12 ± 0.20	−0.35/-
	CMJ maximum negative velocity during the downward Phase ($m{\cdot}s^{-1}$)	−1.01 ± 0.14	−1.15 ± 0.19	−0.81/-	−0.88 ± 0.14	−0.86 ± 0.13	0.13/-
	CMJ maximum velocity upward phase ($m{\cdot}s^{-1}$)	2.26 ± 0.14	2.41 ± 0.20	0.95/-	2.25 ± 0.10	2.24 ± 0.11	−0.15/-
	Crouch (m)	−0.26 ± 0.03	−0.28 ± 0.06	−0.6/-	−0.25 ± 0.04	−0.25 ± 0.05	0.04/-
	Eccentric time (s)	0.64 ± 0.13	0.69 ± 0.15	0.32/-	0.81 ± 0.10	0.81 ± 0.13	0.04/-
	Concentric time (s)	0.28 ± 0.04	0.28 ± 0.04	0.21/-	0.27 ± 0.04	0.28 ± 0.04	0.23/-
	Eccentric peak power ($W \cdot BW^{-1}$)	−1.35 ± 0.37	−1.56 ± 0.39	−0.55/-	−1.08 ± 0.24	−1.03 ± 0.22	0.17/-
	Concentric peak power ($W \cdot BW^{-1}$)	3.94 ± 0.48	4.31 ± 0.60	0.68/-	3.96 ± 0.36	3.90 ± 0.35	−0.16/-
		Complex training (n = 15)			Control group (n = 10)		
		Pre	Post	ES/p	Pre	Post	ES/p
Santos et al. (2008) [9]	CMJ Height (cm)	29.88 ± 5.9	33.02 ± 6.2	-/0.000	30.76 ± 5.1	28.40 ± 4.0	-/0.004
	SJ Height (cm)	24.79 ± 4.2	28.01 ± 4.6	-/0.000	22.70 ± 4.3	20.74 ± 3.9	-/0.091
	ABK Height (cm)	34.77 ± 6.3	38.43 ± 7.1	-/0.000	36.12 ± 4.8	34.32 ± 4.8	-/0.030
	DJ Height (cm)	34.71 ± 7.4	36.64 ± 8.1	-/0.053	31.11 ± 4.8	30.75 ± 4.1	-/0.785
	Mechanical power ($W{\cdot}kg^{-1}$)	23.69 ± 4.0	24.48 ± 3.9	-/0.200	25.98 ± 6.0	23.14 ± 5.7	-/0.045
	Medicine ball throw (m)	3.47 ± 0.6	4.15 ± 0.5	-/0.000	3.10 ± 0.4	3.27 ± 0.4	-/0.005
		Complex variable resistance training (n = 8)			Complex constant resistance training (n = 8)		
		Pre	Post	ES/p	Pre	Post	ES/p
Shi et al. (2022) [37]	1 RM Back Squat (kg)	123.18 ± 27.67	168.09 ± 27.12	1.58/<0.001	130.67 ± 14.84	172.89 ± 16.08	2.60/<0.001
	CMJ Height (cm)	48.96 ± 6.33	55.29 ± 8.34	0.82/0.002	46.03 ± 5.29	48.60 ± 6.10	0.43/0.02
	SJ Height (cm)	41.81 ± 4.13	50.76 ± 6.06	1.66/<0.001	39.40 ± 3.96	44.47 ± 3.68	1.26/<0.001
	SBJ Height (cm)	268.36 ± 16.42	276.27 ± 20.91	0.40/0.029	256.22 ± 19.01	261.44 ± 16.99	0.28/0.094
	10-m sprint time (s)	1.73 ± 0.08	1.72 ± 0.07	−0.13/0.466	1.78 ± 0.09	1.77 ± 0.07	−0.12/0.689
	20-m sprint time (s)	3.01 ± 0.13	3.00 ± 0.12	−0.08/0.709	3.10 ± 0.13	3.11 ± 0.14	0.07/0.729

Table 6. *Cont.*

		Combined training group (n = 13)				Control group (n = 13)				
		Pre		Post	ES/p	Pre		Post		ES/p
Tsimachidis et al. (2013) [29]	Half Squat 1 RM (kg)	-		-	-/<0.05	-		-		-/>0.05
	10-m running speed (m/s)	-		-	-/<0.05	-		-		-/>0.05
	30-m running speed (m/s)	-		-	-/<0.05	-		-		-/>0.05
		Combined training group (n = 13)				Control group (n = 13)				
		Pre		Post	ES/p	Pre		Post		ES/p
Tsimahidis et al. (2010) [21]	Pre-Post 5-week									
	Half Squat 1 RM (kg)	101.3		120.4	-/<0.05	100.1		100.8		-/>0.05
	10-m sprint time (s)	2.37		2.24	-/<0.05	2.41		2.42		-/>0.05
	30-m sprint time (s)	5.25		5.08	-/<0.05	5.35		5.33		-/>0.05
	CMJ Height (cm)	32.4		35.2	-/<0.05	31.2		31.5		-/>0.05
	SJ Height (cm)	32.9		35.9	-/<0.05	32.4		32.9		-/>0.05
	DJ Height (cm)	31.0		34.2	-/<0.05	31.4		31.7		-/>0.05
	Pre-Post 10-week									
	Half Squat 1 RM (kg)	101.3		130.7	-/<0.05	100.1		101.4		-/>0.05
	10-m sprint time (s)	2.37		2.19	-/<0.05	2.41		2.42		-/>0.05
	30-m sprint time (s)	5.25		4.97	-/<0.05	5.35		5.32		-/>0.05
	CMJ Height (cm)	32.4		39.8	-/<0.05	31.2		31.6		-/>0.05
	SJ Height (cm)	32.9		37.1	-/<0.05	32.4		33.1		-/>0.05
	DJ Height (cm)	31.0		35.4	-/<0.05	31.4		32.0		-/>0.05
		Compound training (n = 15)				Control group (n = 15)				
		Pre		Post	ES/p	Pre		Post		ES/p
Xie et al. (2023) [40]	Illinois Test (s)	16.38 ± 0.39		15.68 ± 0.31	-/-	16.37 ± 0.42		16.21 ± 0.34		-/-
	Pro Test (s)	5.34 ± 0.44		4.86 ± 0.51	-/-	5.31 ± 0.56		5.20 ± 0.53		-/-
	T-word test (s)	9.19 ± 0.59		8.73 ± 0.32	-/-	9.21 ± 0.64		9.11 ± 0.47		-/-
	Dribble round test (s)	11.88 ± 0.71		11.34 ± 0.52	-/-	11.87 ± 0.68		11.59 ± 0.53		-/-
	Z test (s)	7.74 ± 0.54		7.27 ± 0.47	-/-	7.76 ± 0.47		7.61 ± 0.58		-/-
		Contrast training U13 (n = 15)			Contrast training U15 (n = 15)			Contrast training U17 (n = 14)		
		Pre	Post	ES/p	Pre	Post	ES/p	Pre	Post	ES/p
Yañez-García et al. (2022) [38]	CMJ Height (cm)	27.0 ± 6.2	30.2 ± 6.2	0.51/<0.001	32.5 ± 3.7	35.9 ± 3.4	0.95/<0.001	33.9 ± 6.1	36.2 ± 6.1	0.37/<0.01
	Half Squat 1 RM (kg)	52.9 ± 13.8	66.8 ± 14.2	0.82/<0.001	72.9 ± 18.8	85.6 ±21.8	0.66/<0.001	95.8 ± 20.9	104.2 ± 19.8	0.38/<0.01
	10-m sprint time (s)	1.96 ± 0.12	1.88 ± 0.09	0.69/<0.05	1.83 ± 0.06	1.82 ± 0.06	0.28/<0.05	1.78 ± 0.07	1.78 ± 0.05	0.09/<0.05
	20-m sprint time (s)	3.46 ± 0.19	3.34 ± 0.18	0.66/<0.001	3.18 ± 0.11	3.14 ± 0.10	0.40/<0.01	3.11 ± 0.12	3.09 ± 0.11	0.18/<0.01
	10–20-m sprint time (s)	1.50 ± 0.08	1.46 ± 0.09	0.55/<0.001	1.35 ± 0.07	1.32 ± 0.07	0.37/>0.05	1.32 ± 0.07	1.31 ± 0.06	0.23/>0.05

CMJ = countermovement jump; SLJ = single-leg countermovement jump; DOM = dominant; N-DOM = non-dominant; SJ = Squat jump; DJ = Drop jump; ABK = Abalakov jump; SBJ = standing broad jump; ES = effect size; p = p value.

4. Discussion

Given the existing research's primary focus on general team sports or specific sports like soccer, and the considerable variability in CT protocols (i.e., exercise type, load, volume, sequence, rest duration, and training frequency), there is a need for a systematic review that specifically addresses the acute and chronic effects of CT in basketball players. The primary purpose of this systematic review was to determine the acute and chronic effects, as well as the moderators (i.e., volume, intensity, series, and reps) characteristic of complex training (CT) in basketball players. This review included a total of 14 articles and 412 participants. The main findings indicate that CT training induces improvements in athletes' physical performance both in the acute (i.e., short term) and chronic (i.e., long term) realms, especially in critical areas such as jump height, lower body strength, and change of direction ability. It was also found that this type of training was more effective than regular basketball training independently of age, regarding physical fitness performance in players. The load moderators in studies analyzing the acute effects of CT are characterized by performing 2–4 sets of 5–12 reps at 85% 1 RM, including explosive exercises before or after resistance exercise [33], 2 sets of 4 repetitions of back squats at 80% 1 RM and 10 bi or unilateral drop jumps [30], and 5 sets at 8RM for half-squats [29]. Factors such as the program duration (≥6 weeks), the intensity of conditioning activity (<85% 1 RM), and the rest interval between sets (≥2 min) appear to influence the positive response to CT in team sports [16,42,43]. The main characteristics of the interventions' moderator effects of CT in long-term performance included intervention duration (6–10 weeks), intervention frequency (2–3 sessions per week), sets per session for a given exercise (1–12 sets), repetitions per set (3–15 repetitions), and set intensity (40–85% 1 RM or 0.8–1.0 m/s). However, the studies had a certain level of heterogeneity regarding the nature of the interventions (i.e., sex, age, or competitive level) and moderating variables (i.e., load, repetitions, or duration of intervention).

Within the acute effects of CT, several relevant aspects are highlighted. Biel et al. [33] demonstrated similar effects on jump capacity (CMJ and SLJ) regardless of the order of exercises (first resistance or first explosive) in CT. Moreover, performing CT with unilateral or bilateral exercises did not yield different acute effects on jump capacity or COD [30]. It has been observed that both isometric and dynamic conditioning activities have been shown to be effective in inducing the PAPE effect, suggesting that the specific selection of the type of conditioning activity may not be crucial for the manifestation of the phenomenon [44–46]. However, fatigue produced in the activities performed may influence the acute response, as suggested by the possible negative impact on men due to fatigue generated by the protocol. Along with this, Tsimahidis et al. [21] demonstrated that CT acutely improves sprint performance at 10 and 30 m after 5 min but not immediately after its application. However, it is important to consider interindividual variability in the response to conditioning activity, suggesting the need for further studies to address this issue [47]. In addition, limitations of the study are noted, such as the lack of a crossover design and the possibility that the order of assessment and training volume influenced the results. The findings from these studies highlight the complexity of the acute effects of CT and the need for a more complete understanding of its underlying mechanisms and the factors that may modulate its efficacy in basketball players.

The meta-analysis conducted by Pagaduan and Pojskic [48] primarily focused on the chronic effect of CT on vertical jump performance in basketball players. Similarly, this study identified significant improvements in vertical jump performance through CT compared to traditional resistance training or plyometric training. However, our review went a step further by evaluating the effects of CT not only on different manifestations of vertical jump but also on other performance-related tests in basketball players' physical fitness. Yañez-García et al. [38] demonstrated significant improvements in sprints (10 and 20 m sprint times) after CT regardless of age (U13, U14, and U17 basketball players). However, the results from other studies are contradictory; some studies have not shown CT effects on sprint improvement [37], while others have reported significant but similar effects to the control group, making this habitual training [7]. Conversely, some studies have shown improvements in sprint time [21] and speed [29] in 10 m and 30 m tests following CT application. The different durations of the intervention (6–10 weeks), participants' ages (8–18 years), and load characteristics may have influenced these results. These more nuanced findings contribute to a more comprehensive understanding of how CT impacts not only vertical jump performance but also many other physical aspects.

Furthermore, regarding the chronic effects of CT, studies have explored its impact on the strength of basketball players, including assessments of 1 RM through exercises such as the Half Squat [7,20,21,29,38], Back Squat [37], Bench Press [20], and Hip Thrust [20] and more specific tests such as the medicine ball throw [22]. CT has demonstrated its efficacy in enhancing 1 RM performance in exercises like the Full Squat [38], Half Squat [21,29], and Back Squat [37]. Similarly, Freitas et al. [20] observed comparable effects of CT when utilizing both optimal loading CT alone and modified CT (80% 1 RM + optimal load), leading to positive outcomes in the Half Squat (ES = 0.64), Bench Press (ES = 0.11–0.15), and Hip Thrust (ES = 0.98–1.23). These findings support the effectiveness of CT, which combines heavy-resistance exercises with explosive exercises to stimulate improvement in strength in basketball players. On the other hand, CT has also been shown to be effective in improving the medicine ball throw [22] and specific core muscle strength (i.e., core muscle strength stability or sit-up abdomen test) when applied in the training of this musculature [34].

This review carries certain limitations, including not factoring in individual discrepancies among athletes in terms of initial strength levels, strength training experience, and muscle fiber structure. These factors can significantly impact the efficacy of complex training. Further, the methodological quality of the studies incorporated varied, with scores ranging from 9 to 13 points for studies inspecting acute effects [29,30,33] and scores ranging from 5 to 11 points for those examining chronic effects [7,20–22,26,29,33–38,40]. These limitations should be considered when interpreting the results as they may introduce potential biases and uncertainties.

Notwithstanding these limitations, the findings add to the burgeoning body of evidence supporting the benefits of CT in improving basketball performance. These findings are of considerable importance to basketball coaches and athletes, as they indicate that integrating complex training into regular training routines could potentially optimize performance. Future investigations should strive to address these limitations by accounting for individual differences among athletes and probing the optimal intensity and duration of complex training for achieving maximal performance improvements. Although our assessment was extended until December 29, 2023, we acknowledge the incorporation of an additional study, not initially covered in our review [49]. Despite the diligence in capturing all pertinent literature accessible during the review period, the ever-evolving landscape of research in this domain may lead to the emergence of new studies subsequent to this review.

The findings of this systematic review underscore the practical importance of incorporating CT into the training regimens of basketball players to optimize both acute and chronic performance. Specifically, for acute improvements, CT has shown significant positive effects on jump ability, agility, and sprint performance. Coaches can implement CT protocols that include 2–4 sets of 5–12 reps at 85% 1 RM, incorporating explosive exercises either before or after resistance exercises to enhance jump and sprint performance within short recovery periods. Regarding chronic improvements, this study indicates that a well-structured CT program can lead to substantial long-term gains in various performance metrics, including jump height, lower body strength, and change of direction ability. Effective CT programs typically last 6–10 weeks, with 2–3 sessions per week, and use loading parameters of 1–12 sets per session, with repetitions ranging from 3–15 and intensity levels between 40 and 85% 1 RM or 0.8 and 1.0 m/s. These protocols have been shown to be more effective than regular basketball training alone, benefiting players across different ages and competitive levels. Additionally, CT can be adapted to enhance specific strength aspects, such as maximal strength in exercises like the Half Squat, Back Squat, and Bench Press, by employing 2–4 sets at higher intensities (80–85% 1 RM) over a duration of at least six weeks. This tailored approach allows for the development of explosive strength, which is crucial for basketball performance.

5. Conclusions

In conclusion, this systematic review highlights the positive impact of CT on physical performance in basketball players. Unlike previous reviews, our study is specific to basketball and includes both acute and chronic effects. This systematic review also covers performance improvements across various tests, such as jumping, sprinting, strength, and endurance. CT has been shown to improve jump height, lower body strength, and change of direction ability, regardless of age or training level. Acutely, CT induces post-activation potentiation and enhances sprint performance with brief rest intervals. Chronically, CT enhances strength, including 1 RM performance-specific tests and core muscle strength. Factors such as the program duration, intensity, and rest intervals influence CT's effectiveness. Despite some limitations, these findings support the integration of CT into basketball training routines to optimize performance.

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