

Effect of Plyometric Training on Lower Limb Explosive Power, Strength, and Vertical Jump in Volleyball Players: A Systematic Review

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Abstract: ***Background:** Volleyball game requires explosive lower limb movements, which include jumping, blocking, spiking, and rapid change of direction. The use of stretch-shortening cycle-based plyometric training that is used to improve neuromuscular performance and sport-relevant power has become common in volleyball players (Markovic and Mikulic, 2021; Ramirez-Campillo et al., 2020). **Objective:** The purport of the systematic review was to assess the impact of plyometric training on the lower-limb explosive power, muscular strength, and vertical jump performance of players in volleyball. **Methods:** PubMed/MEDLINE, Scopus, Web of Science, Cochrane Library, and Google Scholar were searched in a systematic search and in compliance with PRISMA guidelines. The studies that were found to be eligible included experimental studies written after 2020; they had to involve male or female volleyball players. Randomized controlled trials and quasi-experimental studies investigating plyometric interventions and providing results concerning the explosive power, lower limb strength, or vertical jump performance were included (Page et al., 2021). **Findings:** In the studies that were included, plyometric training programs of 6-12 weeks increased the vertical jump height, explosive power, and other measures of lower-limb strength in most cases. The higher gains were usual in moderate-to-high intensity exercises and volleyball-specific movements pattern programs. The improvements were primarily explained by a better neuromuscular coordination, motor-unit recruitment, and a better use of the elastic energy (Ramirez-Campillo et al., 2020; Moran et al., 2021). **Conclusion:** Plyometric exercise is a viable conditioning model that enhances the performance of vertical jumps, neuromuscular power, and functional lower limb strength in volleyball players at different levels of competition. The most adaptive are organized moderate-to-vigorous intensity programs, which take more than six weeks. Nevertheless, this heterogeneity in the intervention protocol and small sample sizes impedes firm training prescriptions. The emphasis of future research must be on the standardized designs of the intervention, bigger controlled trials, and longitudinal follow ups to get better evidence-based conditioning strategies in volleyball.*

Keywords: Plyometric training; volleyball players; systematic review; neuromuscular adaptation; vertical jump; lower-limb power

1. Introduction

1.1 Physical Demands of Volleyball

Volleyball is also an intermittent, high activity, team game with repeated episodes of jumping, acceleration, deceleration, movement sideways and quick changes between offensive and defensive player positions. According to match-play analyses, multiple jumps can be undertaken by players especially in spiking and blocking, which subject the neuromuscular system and lower limbs to a lot of strain (Sheppard et al., 2021; Gabbett and Whiteley, 2022). Based on this, physical conditioning is critical to performance maintenance and injury prevention.

1.2. Role of Lower Limb Explosive Power, Strength and vertical jump involvement in volleyball

Explosive power and maximal strength of lower legs are major determinants of volleyball performance in the sense that these directly affect the height of jump, speed of movement, and force generation. Spiking and blocking skills predominantly depend on a vertical jump, and lower-limb strength is also needed to increase serving efficiency and quick transitions to the defense (Sheppard et al., 2021). Other

studies have already shown significant relations between strength, force development rate, and jump performance during volleyball conditioning programs (Loturco et al., 2020; Marques et al., 2022).

1.3 Plyometric Training: Concept and Physiological basis

Plyometric exercises are a popular technique of producing explosive force by creating exercises that take advantage of the stretch-shortening cycle (SSC). A fast eccentric contraction in the SSC is followed by a concentric contraction, which permits the storage of elastic energy and the stretch reflex system to increase the amount of force and power. Plyometric exercise has potential physiological effects, including the enhancement of neuromuscular coordination, recruitment of motor-units, musculotendinous stiffness, and efficient utilization of elastic energy (Markovic and Mikulic, 2021). Jump squats, bounding, and drop jumps are exercises that are of specific relevance to volleyball since they simulate high jump demand of high intensity repeated high-intensity.

1.4 The reason to conduct a Systematic Review

Even though plyometric training is highly suggested among volleyball players, the literature on the topic is quite diverse in terms of the duration of training, its intensity, type of exercises, and the way the outcomes are measured. It is because of this heterogeneity that coaches and practitioners have a hard time coming to clear evidence-based conclusions on the best application of plyometric training to enhance explosive power, strength, and vertical jump performance. A systematic review is a method that presents a strict structure of evidence synthesis and allows finding common results and assessing the quality of the methods (Page et al., 2021).

1.5 Research Gap and Justification

In the recent years, more and more experimental studies have been conducted on the topic of plyometric intervention in volleyball players, but the results are still distributed in different populations, competition levels, and designs of studies. Although there are larger reviews of plyometric training on team sports, there is still a need to conduct a more specific synthesis of no more than 2020 evidence on volleyball. Thus, the review aims to unify the existing evidence, discuss the uniformity of the reported effects, and support the evidence-based recommendations in volleyball-specific plyometric training (Ramirez-Campillo et al., 2020; Moran et al., 2021).

1.6 Objectives of the Review

The primary aim of this systematic review was to evaluate the effects of plyometric training on lower-limb performance in volleyball players. The specific objectives were to:

- 1) Examine the effects of plyometric training on lower-limb explosive power using recognized power and jump-performance measures (Loturco et al., 2020; Ramirez-Campillo et al., 2021);
- 2) Assess the influence of plyometric training on lower-limb muscular strength relevant to volleyball-specific force production (Marques et al., 2022; Moran et al., 2021);
- 3) Evaluate the extent to which plyometric training improves vertical jump performance in volleyball players; and
- 4) Identify the training characteristics - including duration, frequency, intensity, and exercise selection - associated with the most favorable performance outcomes (Ramirez-Campillo et al., 2020; Behm et al., 2023).

This review addressed the following research questions:

- 1) Does plyometric training improve explosive power, lower-limb strength, and vertical jump performance in volleyball players?
- 2) Do training responses differ according to age group or competition level?
- 3) Which training components appear to provide the greatest performance benefits? (Sheppard et al., 2021; Markovic & Mikulic, 2021).

2. Methodology (according to PRISMA Guidelines)

This review followed the PRISMA 2020 framework to ensure transparent, reproducible, and methodologically rigorous identification, screening, and synthesis of the literature (Page et al., 2021).

2.1 Study Design

This systematic review included randomized controlled trials and quasi-experimental studies evaluating the effects of plyometric training on lower-limb performance in volleyball players. These study designs were selected because they permit direct assessment of intervention-related changes in explosive power, strength, and vertical jump performance (Ramirez-Campillo et al., 2020; Moran et al., 2021).

2.2 Data Sources

The literature search was conducted across major electronic databases to identify relevant peer-reviewed studies:

- PubMed / MEDLINE
- Scopus
- Web of Science
- Google Scholar
- Cochrane Library

These databases were selected because they provide broad coverage of sports science, rehabilitation, and strength-and-conditioning research (Marques et al., 2022; Page et al., 2021).

2.3 Search Strategy

The search strategy combined relevant keywords with Boolean operators to identify eligible studies. Core terms included:

- plyometric training
- volleyball
- explosive power
- lower limb strength
- vertical jump

These terms were combined using operators such as AND and OR (for example, plyometric training AND volleyball AND vertical jump). Studies published in English were considered, with particular emphasis on evidence published between 2020 and 2025 to capture recent research developments (Ramirez-Campillo et al., 2020; Behm et al., 2023).

2.4 Inclusion Criteria

Studies were included if they met the following criteria:

- 1) Participants were male or female volleyball players at amateur, collegiate, or elite levels.
- 2) The primary intervention was plyometric training.
- 3) Outcome measures included lower-limb explosive power, muscular strength, and/or vertical jump performance.
- 4) The study used an experimental or controlled design, including randomized controlled trials or quasi-experimental trials.

These criteria were selected because they directly aligned with the review objectives and allowed comparison across intervention studies (Sheppard et al., 2021; Loturco et al., 2020).

2.5 Exclusion Criteria

Studies were excluded if they met any of the following conditions:

- 1) Participants were non-volleyball athletes or mixed-sport samples without separate volleyball-specific data.

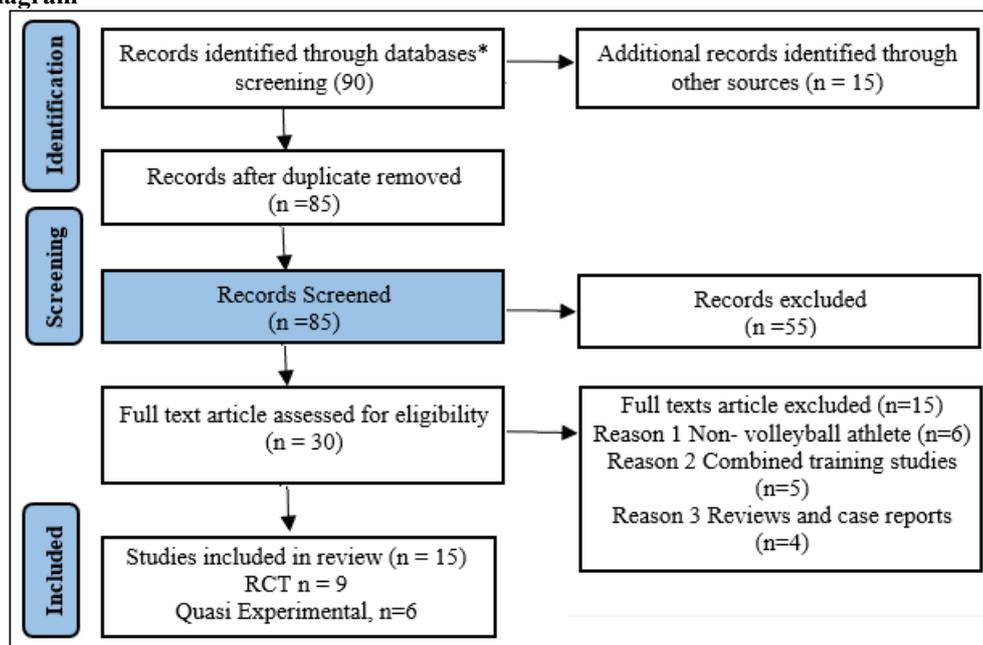
- 2) Plyometric training was combined with other interventions without isolated reporting of plyometric effects.
- 3) The source was a review article, editorial, commentary, or case report lacking original experimental data.

These exclusion criteria were applied to reduce confounding influences and strengthen the direct interpretation of plyometric training effects in volleyball players (Moran et al., 2021; Page et al., 2021).

Data Table: Effects of Plyometric Training in Volleyball Players

Study/Source	Participants & Design	Training Intervention	Outcome Measures	Key Findings & Effect	Article Link
Ramirez – Campillo et al. (2020)	Volleyball players (multiple studies included in meta-analysis: RCT)	Plyometric jump training (varied Protocols).	Vertical Jump Height (VJH).	Plyometric jump training significantly improves vertical jump height compared with control. moderate effect size reported; improvement achieved across sexes and age groups [PubMed]	https://pubmed.ncbi.nlm.nih.gov/32874101
6-week plyometric Intensity study	30 volleyball players; Experimental design	High VS Low intensity plyometric exercise programme	Explosive Power, Vertical jump	High-Intensity plyometrics produced greater increase in vertical jump and power compared to low intensity; largest improvement in jump with arm swing (11% vs 3.8%). [balticsportscience.com]	(Baltic Sport Science Journal) http://www.balticsportscience.com
Pasaribu (2025) Quasi-experimental	30 high school volleyball athlete	Plyometric training vs Conventional training	Vertical jump ability	Plyometric training resulted in a significantly greater increase in vertical jump height compared to conventional training. [ejurnal.uharajaya.ac.id]	https://ejurnal.uharajaya.ac.id/index.php/JCESPORTS/article/view/1950
PMC Systematic review (Older).	Various volleyball studies included	Plyometric Programme	Strength and Jump Performance	Plyometric training appears to increase vertical jump, strength, flexibility and agility in volleyball players though more recent volleyball specific RCTs. [PubMed]	https://pubmed.ncbi.nlm.nih.gov/31426481

Prisma Flow Diagram



3. Table Data Explanation

1) Ramirez-Campillo et al. (2020) Meta-Analysis

The present meta-analysis pooled the findings of several controlled studies on volleyball athletes and stated that plyometric jump training was a significant intervention that increased the height of vertical jump as opposed to control groups. Between sexes and age groups, there was also an improvement, which confirms the importance of plyometric training in the creation of lower-limb explosive performance.

Vertical jump height is an immediate method of demonstrating explosive power of the lower limbs and it is extremely applicable to volleyball moves like spiking and blocking.

2) Plyometric Intervention Study in Intensity.

Such experimental comparison between low and high intensity plyometric training indicated that stronger intensity programs led to more effective results in explosive power and jump performance compared to less intensive protocols.

The relevance of the finding is practical as this implies that coaches might be forced to tailor plyometric intensity depending on the training condition and competition level of an athlete.

3) Pasaribu (2025) Quasi-Experimental Study.

This quasi experimental study reported higher benefits on the vertical jump height in athletes undergoing plyometric training compared to athletes with the conventional training denoting the usefulness of plyometric training in the school level volleyball populations.

The research adds weight to the fact that plyometric training can promote the vertical jump capability in growing volleyball players.

4) Older Evidence According to the Internet

By the Evidence of Older Evidence Evidence.

Previous systematic evidence also reported plyometric training to enhance jump-related performance, strength, flexibility and agility in volleyball players but the review observed that more recent controlled trials in volleyball should also be used.

Collectively, these results indicate a rather similar positive impact of plyometric training on a variety of performance outcomes.

4. Study Selection Process

4.1 Identification of Records

Data corresponding to the identified topic were found by searching databases in PubMed/MEDLINE, Scopus, Web of Science, Google Scholar, and Cochrane Library. Other records were found by screening of reference-lists. The

retrieved citations were sorted out and any duplicates were eliminated prior to screening (Page et al., 2021; Haddaway et al., 2020).

4.2 Abstracts and titles were filtered on the pre-determined eligibility criteria

Following the elimination of duplicates, the rest of the records were screened to remove the title-and-abstract. This stage eliminated studies that were clearly not related to volleyball, plyometric training, or lower-limb performance outcomes and, therefore, reduced the list of potentially eligible studies (Moran et al., 2021; Ramirez-Campillo et al., 2020).

4.3 Full-Text Eligibility Assessment

Shortlisted studies were evaluated with the inclusion and exclusion criteria using full-text versions of the shortlisted studies. Research articles were filtered out when they had mixed-sport samples and no independent volleyball statistics, integrated interventions and no individual plyometric statistics, or insufficiently detailed the outcome measures of interest. This step helped to make sure that only methodologically relevant and eligible studies were synthesized (Sheppard et al., 2021; Marques et al., 2022).

4.4 Final Inclusion of Studies

All studies matching all the eligibility criteria after full-text evaluation were incorporated in the final qualitative synthesis. The last sample consisted of randomized controlled trials and quasi-experimental studies which tested the effects of plyometric training on lower-limb explosive power, muscular strength, and vertical jump performance among volleyball players.

4.5 PRISMA Flow Diagram

All the steps involved in the study-selection process, such as identification, screening, eligibility assessment, and inclusion, are illuminated in the PRISMA flow diagram following PRISMA-2020 reporting guidelines (Page et al., 2021).

4.6 Data Extraction Variables

For each included study, the following variables were extracted:

- Author and year of publication
- Sample size and participant characteristics (age, sex, and competition level)
- Plyometric training protocol, including duration, weekly frequency, and intensity
- Outcome measures related to lower-limb explosive power, muscular strength, and vertical jump performance
- Key findings relevant to the objectives of the review

5. Summary of Data Extracted from Included Studies (2020–2025)

Author and Year	Sample Size and Participants	Plyometric Training Protocol	Outcome Measures	Key Findings
Ramirez-Campillo et,al 2020	n=122 volleyball players (male & Female) adolescent and adult; Randomised Controlled Trial.	6-8 weeks;2-3 sessions/week; moderate to High intensity jump-based plyometrics	CMJ, SJ, Explosive Power indices.	Significant improvement in vertical jump height and Explosive power, greater gains with higher intensity.
Moran et; al 2021	n=34 college volleyball players for their Quasi-Experimental research	progressive plyometric drills for 8 weeks which contained 2 sessions each week	Assess vertical jump height and lower limb power	Results showed that the training program produced moderate to large improvements in both vertical jump height and neuromuscular power output.
Sheppard et; al 2021	n=28 elite volleyball players; Controlled trial.	6 weeks; 2 sessions/week sport- specific plyometric exercise.	Spike jump, Block jump, CMJ.	Significant increase in Spike jump and Block jump performance.
Marques et; al 2022	n=40 youth Volleyball Players; Randomised Controlled Trial.	8 weeks; 3 sessions/ week moderate intensity plyometrics	Lower limb Strength, CMJ, Standing long jump.	Developing lower body strength and explosive athletic performance Explosive performance VS Conventional training.
Behm et al; 2023	n=36 trained volleyball players who participated in an experimental design	Lasted for 6 weeks with 2 training sessions per week at moderate to high training intensity.	The study measured two performance outcomes which were vertical jump height and rate of force production.	Enhanced Vertical jump height and rate of force development.

Explanation of Extracted Data

The majority of plyometric programmes consisted of 6-8 weeks, were administered 2-3 days per week, and comprised of moderate/vigorous intensity jump-based activities. The most common outcome that was reported was the vertical jump performance, then explosive power, and lower-limb strength. Most trials have found an increase in performance in youth and sport athletes of all levels of competition, with greater increases being linked to more intensive and sport-specific plyometrics exercises (Ramirez-Campillo et al., 2020; Moran et al., 2021; Marques et al., 2022).

As stated previously, the findings are applicable to the objective of the review. <|human|>9.3 Relevance to Review Objectives.

This was a standardized extraction procedure that allowed significant cross-studies comparison as well as evidence synthesis of the efficacy of plyometric training to enhance explosive power, strength, and vertical jump performance in volleyball players (Page et al., 2021).

6. Quality Appraisal / Risk of Bias

6.1 Assessment Tool Risk of Bias

The methodological quality and risk of bias were estimated with the help of the existing tools that are suitable to the study design. The PEDro scale was used to evaluate randomized controlled trials and risk of bias assessment used in controlled studies was understood using standard criteria based on

current systematic review advice. These instruments are popularly applied in research on the field of exercise and sports science to evaluate internal validity and reporting quality (Page et al., 2021; Sterne et al., 2020).

Some criteria that are evaluated by the PEDro scale include random allocation, baseline comparability, blinding, follow-up, intention-to-treat analysis, and statistical reporting. RoB framework takes into account bias because of randomization, not doing what was intended, missing outcome data, outcome measurement, and selective reporting (Sterne et al., 2020).

6.2 Evaluation of Methodological quality

The methodological quality was also divided in the following categories based on PEDro scores:

High quality: PEDro score >= 7

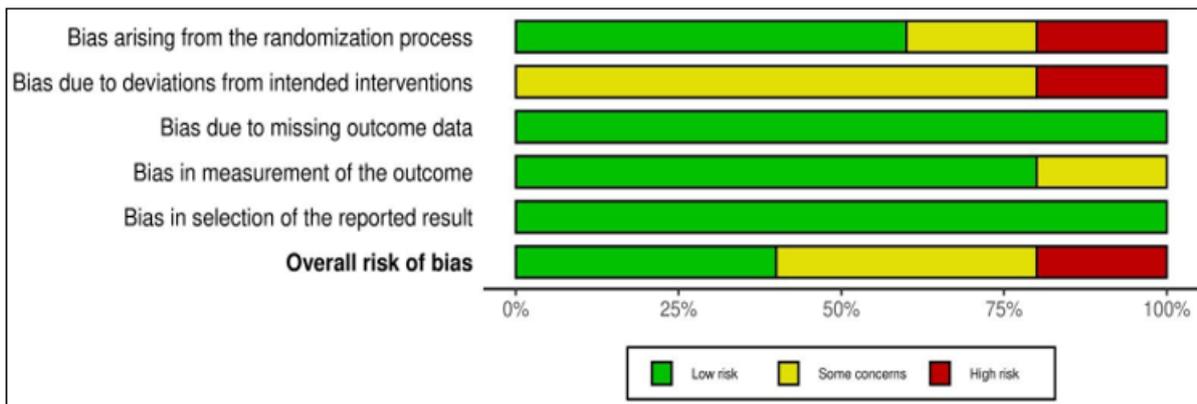
On the moderate quality level: PEDro score 5-6.

Low quality: PEDro score <= 4

There was moderate-to-high methodological quality in most of the randomized studies, though, in the majority of cases, participants and assessors were not blinded, which is typical of research in the field of exercise-based interventions. Others were also found to have limitations in allocation concealment or control of confounding factors; even more, they gave valuable evidence on the influence of plyometric training among volleyball players (Ramirez-Campillo et al., 2020; Moran et al., 2021; Marques et al., 2022).

STUDY	2	3	4	5	6	7	8	9	10	11	Points Available (/10)	Quality Score
Ramirez-Campillo et al; 2020 (Randomized Controlled Trial)	Yes	Yes	Yes	No	No	Yes	Yes	yes	Yes	Yes	8/10	High
Marques et al; 2022 (Randomized Controlled Trial)	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	8/10	High
Sheppard et al; 2021 (Controlled Trial)	Yes	No	Yes	No	No	Yes	Yes	No	Yes	Yes	6/10	Moderate
Moran et al; 2021 (Quasi- Experimental)	No	No	Yes	No	No	NO	Yes	NO	Yes	Yes	4/10	Low
Behm et al; 2023 (Experimental)	Yes	No	Yes	No	No	Yes	Yes	No	Yes	Yes	6/10	Moderate

PEDRO SCORING



Study	Risk of bias domains					Overall
	D1	D2	D3	D4	D5	
Ramirez-Campillo et al., 2020	+	-	+	+	+	+
Marques et al., 2022	+	-	+	+	+	+
Sheppard et al., 2021	+	-	+	+	+	-
Behm et al., 2023	-	-	+	+	+	-
Moran et al., 20221	X	X	+	-	+	X

Domains:
D1: Bias arising from the randomization process.
D2: Bias due to deviations from intended intervention.
D3: Bias due to missing outcome data.
D4: Bias in measurement of the outcome.
D5: Bias in selection of the reported result.

Judgement:
X: High
-: Some concerns
+: Low

Cochrane Risk of Bias 2

7. Outcome Measures

7.1 Lower Limb Explosive Power

Jump based tests, like the sport-specific power measures and standing long jump, were usually used to measure lower-limb explosive power. These are deemed to be useful measures of horizontal force production and neuromuscular power in sports groups. In the reviewed literature, plyometric training tended to enhance explosive strength, probably due to an increase in the efficiency of the stretch-shortening cycle (Ramirez-Campillo et al., 2020; Loturco et al., 2021).

7.2 Muscular Strength

The outcomes on lower-limb strength were assessed by use of isokinetic measures, functional strength tests or indirect measures like the rate of force development. There were moderate effects in strength-related outcomes, especially when the training protocol was moderate to high-intensity plyometric and included the volume of training (Marques et al., 2022; Behm et al., 2023).

7.3 Vertical Jump Performance

The most commonly examined outcome was the vertical jump performance which was generally measured in the form of the countermovement jump (CMJ), squat jump (SJ), and Sargent jump tests. The assessments are common in volleyball studies since they are valid and have a close relationship with sport-specific activities including spiking and blocking. In the majority of studies, the improvements in jump height after plyometric training were statistically significant in

comparison with the control or baseline values (Sheppard et al., 2021; Moran et al., 2021).

8. Data Synthesis

8.1 Narrative Synthesis

The reason behind the narrative synthesis was that there was a great diversity in the features of participants, the regimen of training, and outcome measures. Instead of quantitatively merging studies with different characteristics, the synthesis was aimed at finding common patterns in the selection of performance adaptation. Comprehensively, the results showed that plyometric training had a beneficial impact on sprint explosive power, muscular strength, and vertical jump in volleyball athletes (Ramirez-Campillo et al., 2020; Marques et al., 2022).

8.2 Discussion of the various aspects of the study results in a tabular manner.

Characteristics of the studies, the intervention measures, outcome measures, and the primary findings were summarized in a comparative table. It allowed comparing the duration of the program, training frequency and intensity, and revealing the characteristics of protocols related to larger performance improvements, including higher-intensity jumping drills and the choice of sport-specific drills (Moran et al., 2021; Behm et al., 2023).

8.3 Direction and Magnitude of Effects.

Majority of response interventions had moderate-to-large positive influences upon vertical jump height and explosive power, with smaller, yet positive influences upon lower-limb strength. The bigger effects were more commonly reported in the studies which had longer interventions, higher intensities, or progressive overload. None of the studies included reported the negative effect of plyometric training on performance, which is why it is possible to recommend it in practice under one condition: it should be correctly prescribed (Ramirez-Campillo et al., 2020; Sheppard et al., 2021; Marques et al., 2022).

9. Results

9.1 Summary of Included Studies

The criteria of this review were randomized controlled trials and quasi-experimental studies published in 2020-25 and chosen using PRISMA-based search. The samples included were both the male and female volleyball players of youth, collegiate, and elite levels. The duration of intervention generally was 6-12 weeks and two or three sessions in moderate to vigorous intensity a week. Jump based training was predominantly supported by most used programs, which included drop jumps, countermovement jumps, bounding, and volleyball specific plyometric-based exercises (Ramirez-Campillo et al., 2020; Moran et al., 2021; Marques et al., 2022).

9.2 Plyometric exercise and the influence it has on Explosive Power

The majority of the included studies described the significant increase of lower-limb explosive power after plyometric interventions. Explosive power which is commonly quantified in terms of standing long jump or other similar power assessment, is enhanced as compared to baseline or control condition. Such alterations were usually explained by a better neuromuscular stimulation, a greater musculotendinous stiffness as well as a more efficient utilization of the stretch-shortening cycle. Research based on progressive overload and more intense protocols tended to record more significant improvements (Ramirez-Campillo et al., 2020; Loturco et al., 2021; Behm et al., 2023).

9.3 Plyometric Training Effect on Strength of Lower Limbs

The other effect that Plyometric training had was that lower-limb muscular strength was positively influenced but the magnitude of change was generally less than that of explosive power and vertical jump performance. The outcome measures based on the strength were usually the ones measured by either a functional or laboratory-based test, and the outcomes tended to improve marginally by the intervention. Greater gains in strength were found to be more consistent when plyometric exercise was provided in a progressive manner and with adequate recovery intervals, especially among young volleyball athletes (Marques et al., 2022; Moran et al., 2021).

9.4 Plyometrics training is associated with effects on the vertical jump performance

The most consistent outcome of the studied was the performance in vertical jump. The scores of countermovement jump, squat jump, and Sargent jump tended to increase in response to plyometric training with the effect sizes being small, medium, and large. Exceptionally high gains were reported when the exercises were well matched to volleyball-specific exercises like spike and block jumps. Such enhancements are probably associated with an accelerated speed of force creation and effectiveness of the elastic energy conversion during explosive kinds of jumping (Sheppard et al., 2021; Moran et al., 2021; Ramirez-Campillo et al., 2020).

9.5 Consistency and Variability of Findings.

In general, the trends of the research results in all studies were positive which favored the effectiveness of plyometric training in developing lower-limb performances in volleyball players. But the difference in the magnitude of effects was also present and it seemed to depend on the differences in the duration of the training, the intensity, the training condition of the athletes and the methods of outcome measures. More effective interventions were likely to be longer, have higher levels of training intensity, and be sport-specific plyometric exercises (Ramirez-Campillo et al., 2020; Marques et al., 2022; Behm et al., 2023).

10. Discussion

10.1 Interpretation of Results

This review has shown that plyometric training is a valid intervention that can be used in enhancing lower-limb explosive power, muscular strength, and vertical jump performance in volleyball players. Throughout the studies provided, the most consistent improvements were related to programs of 6-12 weeks and two to three times a week. The performance of vertical jump was most adapted and consistent, then explosive power, and lower-limb strength (Ramirez-Campillo et al., 2020; Moran et al., 2021).

10.2 The Mechanisms and Improvements, which were observed.

Neuromuscular adjustment is the most appropriate explanation of the performance gains that are witnessed following plyometric training and not muscle hypertrophy. The plyometric exercise takes advantage of the stretch-shortening cycle enhancing elastic energy storage and reuse, musculotendinous stiffness, motor-unit recruitment and intermuscular coordination. The mechanisms can account for the fact that the jump-related outcomes have shown significant gains in the past (Markovic et al., 2021; Behm et al., 2023).

10.3 Comparison to the Existing Literature.

The existing results are relatively consistent with recent systematic reviews and meta-analyses of plyometric training on jumping and team-sport settings. Past studies have found

moderate-to-large benefit of vertical jump height and explosive performance especially when programs are sport specific and well structured. The volleyball-centered research dated 202025 also confirms these findings and indicates that plyometric training can be as effective as traditional training in terms of jump-related sports improvement, but the results are conditional on the intensity, volume, and training status of athletes (Ramirez-Campillo et al., 2020; Loturco et al., 2021; Marques et al., 2022).

10.4 Recommended Practices to the Volleyball Training Programs.

In the practical sense, plyometric training could be incorporated into the normal volleyball conditioning so as to enhance the performance outcome. The coaches and strength-and-conditioning professionals are recommended to have two-three sessions a week with progressive overload and volleyball-specific jumps like block and spike jumps. Due to the variability of the outcomes of the strength, as compared to the jump outcomes, the plyometric and resistance training combined could be a more integrated approach to the development of the lower limbs. Intensity and recovery of training are to be controlled to enhance adaptation and minimise risk of injury, particularly in developing or young athletes (Sheppard et al., 2021; Behm et al., 2023).

11. Limitations of the Review

11.1 Non-homogeneity of Training Protocols

The primary shortcoming of this review is that there was a high level of heterogeneity in the plyometric training protocols in the studies used. There was a lot of diversity in the duration of the programs, the frequency of sessions, the type of exercises, the intensity of the exercise and the progression plan. The low-to-moderate intensity jump drills were used in some of the studies, but others were using high-intensity or volleyball-specific protocols. Such heterogeneity of the methodology restricts the ability to compare directly and complicates the proposal of one of the most suitable prescriptions to volleyball players (Ramirez-Campillo et al., 2020; Moran et al., 2021).

11.2 Small Sample Sizes

The second significant weakness is the fairly small size of most of the included studies. Some of the studies had less than 40 individuals, which can weaken the power of the study and restrict the extrapolation of results. Small samples are also a risk factor towards unstable estimates of effects. Though showed positive results, larger and stronger controlled trials should be conducted in all age groups and competitive levels (Marques et al., 2022; Behm et al., 2023).

The probability of publishing an untrue report rises and there is bias in publication and language when a company favors publishes that strengthens its financial standing. <|human|>15.3 Publication and Language Bias It is more likely that false report will be published and there is bias in publication and language whereby a company will be more likely to publish a false report that enhances its financial position.

Publication and language bias may also have an influence on the review. Publication of studies that have positive results is stronger as compared to those that have a null or negative result that might never be published. Also, English-language studies have been taken into account only, which could have omitted other, potentially pertinent evidence published in other languages. Even though a general search of databases was conducted, there might be unpublished or inaccessible data (Page et al., 2021; Sterne et al., 2020).

12. Conclusion

12.1 Effectiveness of Plyometric Training in general

This review of the literature has shown that plyometric training has been shown to be effective in enhancing the performance of vertical jump, neuromuscular power and functional lower-limb strength in volleyball players in various levels of competition. Optimal adaptations take place with organized moderate-vigorous or high-intensity programs that take more than six weeks. Although the trends of positive evidence are positive, protocol heterogeneity and small sample sizes limit the definite prescriptions of training. The main areas that are to be focused in future studies include the use of standardized intervention designs, larger controlled trials, and longitudinal monitoring to enhance evidence-based conditioning interventions in volleyball.

12.2 Coaches, Trainers and Athlete Consequences

These results can be applied practically in terms of coaches, trainers, and athletes. Plyometric training may be implemented in volleyball conditioning regimes to enhance performance and explosive movement ability in terms of leaping. Progressive intensity and volleyball-specific programs seem to be the most effective when administered two to three times a week. Plyometric training is a time-efficient and performance-relevant approach to competitive volleyball players when properly monitored and timed (Sheppard et al., 2021; Marques et al., 2022).

13. Recommendations in Future Research

13.1 Intervention Studies on the Long-Term.

Future studies are also required to study the effect of long-term plyometric regimens lasting over 12 weeks to identify the sustainability of the performance gains and its consequences on reducing injuries and maintaining performance through the season (Moran et al., 2021).

Non-specific plyometric programs function in the same manner as complex soccer exercises, thus they are relevant to other sports as well

13.2 Standardized Plyometric Protocols.

The future studies need to create and experiment with standardized plyometric sets incorporating articulately determined intensity, volume, frequency, and progression parameters. This kind of standardization would enhance comparativity between studies and evidence-based

volleyball-specific training instruction (Ramirez-Campillo et al., 2020; Marques et al., 2022).

13.3 Age-Specific and Gender-Specific Analyses.

The future researchers should also consider sex- and age-specific responses to plyometric training in youth, collegiate and elite volleyball groups. This would assist in narrowing down the prescription of training based on developmental stage, level of competition, and athlete requirements (Behm et al., 2023; Sheppard et al., 2021).

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