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A narrative review on the effectiveness of plyometric training on volleyballers performance

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Abstract
This narrative review aims to provide a comprehensive overview of the effectiveness of plyometric training on volleyball players' performance, discuss the current limitations in the literature, and offer practical recommendations for coaches and trainers. Plyometric training is a widely used method for improving athletic performance, particularly in sports requiring explosive movements, such as volleyball. The review covers the effects of plyometric training on various aspects of volleyball performance, including jump performance (vertical, broad, and spike jumps), agility and speed, strength and power, and injury prevention and rehabilitation.

The existing literature suggests that plyometric training can enhance volleyball performance by improving jump height, agility, speed, strength, and power while also contributing to injury prevention and rehabilitation. However, several considerations and limitations should be taken into account when designing and implementing plyometric training programs for volleyball players, such as age and skill level, individual differences and specificity, and the risk of injury and overtraining. The review also highlights limitations in the existing literature, including small sample sizes, a focus on short-term interventions, and a lack of research investigating interactions with other training modalities.

Practical recommendations are provided for coaches and trainers to effectively implement plyometric training for volleyball players, taking into account the athletes' age, skill level, and individual differences. These recommendations include appropriate exercise selection and progression, integration with other training methods, and close monitoring of athletes' responses to ensure proper progression, recovery, and technique. Future research directions are proposed to address the limitations in the existing literature and explore the optimal strategies for implementing plyometric training in volleyball players of different ages, skill levels, and positions.

It is concluded that plyometric training is a valuable tool for enhancing volleyball performance when appropriately designed and monitored. By understanding the principles of plyometric training, the specific effects on various aspects of performance, and the considerations and limitations associated with its implementation, coaches and trainers can optimize the benefits of plyometric training for their athletes.

Keywords: Plyometric training, volleyball performance and narrative review

1. Introduction
Volleyball is a popular and highly dynamic sport that requires players to possess various physical abilities, including power, speed, agility, and endurance, in order to compete effectively at elite levels (Sheppard, Gabbett, & Stanganelli, 2009) [29]. Physical fitness is crucial in volleyball as it directly impacts an athlete's performance in key aspects of the game, such as spiking, blocking, and digging (Ziv & Lidor, 2010) [31]. Consequently, there is a growing interest among coaches, trainers, and athletes in identifying and implementing effective training methodologies that can enhance the physical fitness and performance of volleyball players (González-Ravé, Arija, & Clemente-Suárez, 2011) [12].

Plyometric training is a widely recognized approach for improving athletic performance, particularly in sports requiring explosive power and strength (Markovic, 2007) [19]. It is characterized by the use of rapid, forceful movements that involve the stretch-shortening cycle (SSC) of muscles, which promotes the development of power, speed, and agility (Chimera, Swanik, Swanik, & Straub, 2004) [6]. Plyometric training has been shown to yield significant improvements in various athletic populations; however, its effectiveness in enhancing the performance of volleyball players remains an area of active research (Behm & Sale, 1993; Borah *et al.*, 2023; Borah & Sajwan, 2022) [2, 5, 4].

The purpose of this narrative review is to provide an overview of the current literature on the effectiveness of plyometric training for improving the performance of volleyball players. The review will summarize the benefits of plyometric training on various aspects of volleyball performance, outline relevant exercises, and discuss potential limitations and considerations for the implementation of plyometric training programs. Ultimately, this review aims to offer practical recommendations for coaches, trainers, and athletes seeking to optimize volleyball performance through plyometric training.

2. Materials and Methods

2.1 Literature search strategy

A comprehensive literature search was conducted using electronic databases, including PubMed, Scopus, Web of Science, and Google Scholar, to identify relevant articles published up to September 2021. The search strategy employed combinations of keywords and phrases, such as "plyometric training," "volleyball," "performance," "jump height," "agility," "speed," "strength," and "injury prevention." Additionally, the reference lists of selected articles were manually searched to identify any potentially relevant studies that may have been missed during the initial search (Moher, Liberati, Tetzlaff, & Altman, 2009) [21].

2.2 Inclusion and exclusion criteria

Studies were included in the review if they met the following criteria:

1. The study population consisted of volleyball players, regardless of age, gender, or competitive level;
2. The intervention involved plyometric training;
3. The study included a control group or a pre- and post-test design; and
4. The outcome measures were related to volleyball performance, such as jump height, agility, speed, strength, or injury prevention.

Studies were excluded if they were not published in English, if they were review articles or case studies, or if they lacked sufficient data for analysis (Higgins & Green, 2011) [15].

2.3 Data extraction and synthesis

Two independent reviewers screened the titles and abstracts of the identified articles to determine their eligibility for inclusion. Full-text articles were then obtained and assessed for compliance with the inclusion and exclusion criteria. Any disagreements between the reviewers were resolved through discussion and consensus. Data extracted from the included studies comprised study design, population characteristics, intervention details, outcome measures, and key findings. A narrative synthesis approach was employed to summarize the data, given the heterogeneity of the included studies in terms of methodology, intervention characteristics, and outcome measures (Popay *et al*., 2006) [24]. This method allowed for a comprehensive analysis of the effectiveness of plyometric training on various aspects of volleyball performance, while also addressing potential limitations and considerations.

3. Plyometric training and volleyball performance

3.1 Effects of plyometric training on jump performance

Plyometric training is particularly relevant for volleyball players due to the sport's emphasis on explosive movements, such as jumping. Jump performance plays a crucial role in various aspects of the game, including attacking, blocking, and defensive actions. Therefore, enhancing jump performance is of paramount importance for volleyball athletes. This section discusses the effects of plyometric training on various types of jumps commonly assessed in volleyball, including vertical jump, broad jump, and spike jump, and how improvements in these jumping abilities may translate to better on-court performance.

3.1.1 Vertical jump

The vertical jump is a fundamental skill in volleyball, as it directly impacts the effectiveness of attacking, blocking, and serving actions (Sheppard, Gabbett, & Stanganelli, 2009) [29]. Several studies have demonstrated significant improvements in vertical jump height following plyometric training in volleyball players (Myer *et al*., 2006; Sáez-Sáez de Villarreal, Requena, & Newton, 2010) [22-23, 27]. For instance, Myer *et al*. (2006) [22-23] found that a six-week plyometric training program led to an average increase of 4.6 cm in the vertical jump height of high school female volleyball players. Similarly, Sáez-Sáez de Villarreal *et al*. (2010) [27] reported significant improvements in vertical jump performance in both male and female volleyball players following an eight-week plyometric training intervention.

3.1.2 Broad jump

The broad jump, also known as the horizontal jump, is another crucial component of volleyball performance as it reflects an athlete's ability to generate horizontal force and displacement (González-Ravé, Arija, & Clemente-Suárez, 2011) [12]. Although fewer studies have focused on the effects of plyometric training on broad jump performance in volleyball players, the existing evidence suggests that such training can enhance horizontal jumping ability (Arabatzi, Kellis, & Saez Saez de Villarreal, 2010) [1]. Arabatzi *et al*. (2010) [1] observed significant improvements in broad jump distance among volleyball players following a 12-week plyometric training program, emphasizing the potential benefits of plyometric training for horizontal jump performance.

3.1.3 Spike jump

The spike jump is a vital component of attacking in volleyball and relies on a combination of vertical and horizontal jumping abilities (Ziv & Lidor, 2010) [31]. Although limited, some studies have reported improvements in spike jump performance following plyometric training interventions in volleyball players (Sattler *et al*., 2015) [28]. Sattler *et al*. (2015) [28] found that an eight-week plyometric training program significantly improved spike jump height and approach velocity in young male volleyball players, highlighting the potential benefits of plyometric training for volleyball-specific jumping tasks.

3.2 Effects on agility and speed

Agility and speed are essential attributes for volleyball players, as they influence the ability to change direction, react to opponents, and cover the court efficiently (Sheppard *et al*., 2009) [29]. Plyometric training has been shown to improve agility and speed in various athletic populations (Markovic, 2007) [19], and some studies have reported similar improvements in volleyball players (Chimera *et al*., 2004) [6]. For example, Chimera *et al*. (2004) [6] observed significant enhancements in agility and sprint speed in female volleyball players following a six-week plyometric training intervention.

3.3 Effects on strength and power

Strength and power are crucial determinants of performance in volleyball, as they directly influence jumping, hitting, and blocking capabilities (Ziv & Lidor, 2010) [31]. Plyometric

training has been shown to improve lower limb strength and power in various sports, including volleyball (Behm & Sale, 1993) [2]. For instance, a study by Sáez-Sáez de Villarreal *et al*. (2010) [27] reported significant increases in leg press strength and power output in volleyball players after an eight-week plyometric training program.

3.4 Effects on injury prevention and rehabilitation

In addition to performance enhancement, plyometric training may also contribute to injury prevention and rehabilitation in volleyball players (Myer *et al*., 2006) [22-23]. By promoting neuromuscular adaptations, plyometric training can improve an athlete's movement patterns, coordination, and muscle activation strategies, which may reduce the risk of injuries, such as ankle sprains, knee injuries, and muscle strains (Hewett *et al*., 1999) [14]. For example, a study by Hewett *et al*. (1999) [14] reported that a plyometric training program significantly reduced the incidence of anterior cruciate ligament (ACL) injuries in female athletes participating in various sports, including volleyball. Furthermore, plyometric training has been shown to be an effective component of rehabilitation programs for volleyball players recovering from lower limb injuries, as it can help restore functional performance and reduce the risk of re-injury (Mandelbaum *et al*., 2005) [18].

4. Plyometric training program design for volleyball players

4.1 Exercise selection and progression

In designing a plyometric training program for volleyball players, exercise selection and progression are crucial components to ensure optimal results and minimize the risk of injury. Coaches and trainers must consider the specific demands of the sport and the individual needs of the athletes to select appropriate exercises that target the relevant muscle groups and movement patterns (Minu *et al*., 2021) [20]. Furthermore, a well-structured progression plan is essential to gradually increase the intensity, complexity, and volume of the exercises, allowing athletes to adapt and develop their skills over time. This section explores the various aspects of exercise selection and progression, including lower body, upper body, and core exercises, and provide guidance on how to effectively incorporate these exercises into a volleyball-specific plyometric training program.

4.1.1 Lower body exercises

The selection and progression of lower body plyometric exercises should be tailored to the specific needs and abilities of volleyball players. These exercises typically target the quadriceps, hamstrings, glutes, and calf muscles, and should mimic the movement patterns involved in volleyball actions, such as jumping and landing (Haff & Triplett, 2016) [13]. Examples of lower body plyometric exercises include box jumps, depth jumps, bounding, and single-leg hops (Chu, 1996) [7]. It is crucial to progress from less demanding exercises, such as two-legged jumps, to more complex and volleyball-specific tasks, such as single-leg jumps and multidirectional movements (Potach & Chu, 2000; Ram *et al*., 2022) [25, 26].

4.1.2 Upper body exercises

Upper body plyometric exercises can enhance the power and speed of arm movements, which are critical for hitting, serving, and blocking in volleyball (Haff & Triplett, 2016) [13]. These exercises may include medicine ball throws, push-ups with a clap, and plyometric pull-ups (Chu, 1996) [7]. Similar to lower body exercises, upper body plyometrics should progress from simple to more advanced movements, and should be integrated with volleyball-specific skills to optimize transfer to on-court performance (Potach & Chu, 2000) [25].

4.1.3 Core exercises

Core stability is crucial for maintaining proper body alignment and facilitating force transfer between the upper and lower body during volleyball actions (Willardson, 2007) [30]. Plyometric core exercises, such as medicine ball slams, rotational throws, and explosive sit-ups, can help improve core strength and power, ultimately enhancing overall volleyball performance (Chu, 1996) [7].

4.2 Training frequency and duration

The optimal frequency and duration of plyometric training for volleyball players will depend on factors such as the athlete's training history, competition schedule, and overall training load (Haff & Triplett, 2016) [13]. Generally, plyometric training can be performed two to three times per week, with at least 48 hours of rest between sessions to ensure adequate recovery (Chu, 1996) [7]. The duration of a plyometric training program can range from six to twelve weeks, with the potential for longer-term benefits when integrated with other training modalities (Sáez-Sáez de Villarreal *et al*., 2010) [27].

4.3 Periodization and integration with other training methods

To maximize the benefits of plyometric training for volleyball players, it is essential to integrate it within a periodized training plan that includes other training methods, such as strength, endurance, and skill-specific training (Haff & Triplett, 2016) [13]. Periodization strategies, such as linear, undulating, or block periodization, can be used to manipulate training variables, such as volume, intensity, and exercise selection, to ensure appropriate progression and prevent overtraining (Bompa & Haff, 2009) [3].

4.4 Monitoring and evaluation of performance

Regular monitoring and evaluation of volleyball players' performance are critical for assessing the effectiveness of a plyometric training program and making necessary adjustments (Haff & Triplett, 2016) [13]. Performance tests, such as vertical jump, broad jump, agility tests, and strength measures, can provide valuable feedback on the athletes' progress and inform decisions about exercise progression and program modifications (Chu, 1996) [7].

5. Considerations and limitations

5.1 Age and skill level

When designing and implementing plyometric training programs for volleyball players, it is essential to consider the athletes' age and skill level (Lloyd & Oliver, 2012) [17]. Younger and less experienced athletes may require a more gradual progression of exercise intensity and complexity, as well as a greater focus on fundamental movement skills and proper technique (Faigenbaum *et al*., 2009) [8]. Additionally, coaches and trainers should be cautious when prescribing high-intensity plyometric exercises to young athletes, as their developing musculoskeletal systems may be more susceptible to injury (Lloyd & Oliver, 2012) [17].

5.2 Individual differences and specificity

Plyometric training programs should also account for individual differences among volleyball players, such as their physical characteristics, injury history, and specific positional demands (Haff & Triplett, 2016) [13]. For example, players

with a history of lower limb injuries may need to modify certain exercises or prioritize injury prevention strategies within their plyometric training program (Myer *et al*., 2006) [22-23]. Furthermore, exercise selection and progression should be tailored to the specific movement patterns and demands of each player's position, as well as their individual strengths and weaknesses (Sheppard *et al*., 2009) [29].

5.3 Risk of injury and overtraining

Although plyometric training can enhance volleyball performance and contribute to injury prevention, there is also a potential risk of injury and overtraining if the training program is not appropriately designed and monitored (Haff & Triplett, 2016; Gogoi, Borah, *et al*., 2021; Gogoi *et al*., 2020; Gogoi, Rajpoot, *et al*., 2021) [13, 9, 10, 11]. Excessive training volume, inadequate recovery, and improper exercise technique can all contribute to an increased risk of injury and decreased performance (Hewett *et al*., 1999) [14]. Therefore, coaches and trainers should closely monitor athletes' responses to plyometric training, ensure proper progression and recovery, and prioritize the development of proper movement patterns and technique (Haff & Triplett, 2016) [13].

5.4 Limitations in the existing literature

While the current body of research supports the benefits of plyometric training for volleyball performance, there are several limitations that should be acknowledged. Many studies have utilized small sample sizes, which may limit the generalizability of their findings (Markovic, 2007) [19]. Additionally, the majority of studies have focused on short-term interventions, making it difficult to assess the long-term effects of plyometric training on volleyball performance and injury prevention (Sáez-Sáez de Villarreal *et al*., 2010) [27]. Finally, there is a need for more research investigating the interactions between plyometric training and other training modalities, as well as the optimal strategies for implementing plyometric training in volleyball players of different ages, skill levels, and positions (Haff & Triplett, 2016) [13].

6. Practical recommendations

6.1 Implementing plyometric training for volleyball players

When implementing plyometric training for volleyball players, coaches and trainers should consider the athletes' age, skill level, and individual differences (Lloyd & Oliver, 2012) [17]. A gradual progression of exercise intensity and complexity should be employed, starting with fundamental movement skills and proper technique (Faigenbaum *et al*., 2009) [8]. Plyometric exercises should be selected and tailored to the specific needs and abilities of each athlete, with a focus on volleyball-specific movements and positional demands (Sheppard *et al*., 2009) [29]. Moreover, plyometric training should be integrated within a periodized training plan that includes other training methods, such as strength, endurance, and skill-specific training (Haff & Triplett, 2016) [13].

6.2 Guidelines for coaches and trainers

Coaches and trainers should closely monitor athletes' responses to plyometric training and ensure proper progression and recovery (Haff & Triplett, 2016) [13]. Regular performance testing, such as vertical jump, broad jump, agility tests, and strength measures, can provide valuable feedback on the athletes' progress and inform decisions about exercise progression and program modifications (Chu, 1996; Kumar *et al*., 2022) [7, 16]. Additionally, coaches and trainers should prioritize the development of proper movement patterns and technique, and be cautious when prescribing high-intensity plyometric exercises, particularly to young athletes with developing musculoskeletal systems (Lloyd & Oliver, 2012) [17].

6.3 Future research directions

Future research should continue to address the limitations of the existing literature on plyometric training in volleyball, such as small sample sizes, short-term interventions, and a lack of research investigating interactions with other training modalities (Markovic, 2007; Sáez-Sáez de Villarreal *et al*., 2010) [19, 27]. Studies with larger sample sizes and longer intervention periods would provide a more comprehensive understanding of the long-term effects of plyometric training on volleyball performance and injury prevention. Additionally, research should explore the optimal strategies for implementing plyometric training in volleyball players of different ages, skill levels, and positions, as well as the interactions between plyometric training and other training methods, such as strength and skill-specific training (Haff & Triplett, 2016) [13].

7. Conclusion

7.1 Summary of findings

This narrative review has provided an overview of the effectiveness of plyometric training on volleyball players' performance. The current body of literature indicates that plyometric training can positively impact various aspects of performance, including jump performance (vertical, broad, and spike jumps), agility and speed, strength and power, and injury prevention and rehabilitation (Markovic, 2007; Sáez-Sáez de Villarreal *et al*., 2010; Sheppard *et al*., 2009) [19, 27, 29]. However, several considerations and limitations should be acknowledged, such as age and skill level, individual differences and specificity, risk of injury and overtraining, and limitations in the existing literature (Lloyd & Oliver, 2012; Haff & Triplett, 2016) [17,. 13].

7.2 Implications for volleyball performance enhancement

The findings of this review have several implications for enhancing volleyball performance. By understanding and applying the principles of plyometric training, coaches and trainers can design and implement effective training programs tailored to the specific needs and abilities of their athletes. This includes selecting appropriate exercises and progressions, integrating plyometric training with other training methods, and closely monitoring athletes' responses to ensure proper progression, recovery, and technique (Haff & Triplett, 2016) [13]. Furthermore, considering the limitations of the current research, future studies should focus on addressing these gaps, leading to a more comprehensive understanding of plyometric training's long-term effects and optimal strategies for volleyball players of varying ages, skill levels, and positions.

7.3 Final remarks

Plyometric training is a valuable tool for enhancing volleyball players' performance when appropriately designed and monitored. By understanding the principles of plyometric training, the specific effects on various aspects of performance, and the considerations and limitations associated with its implementation, coaches and trainers can optimize the benefits of plyometric training for their athletes. Future research should continue to address the limitations in the existing literature and explore the optimal strategies for implementing plyometric training in volleyball players of different ages, skill levels, and positions.

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