Journal of Physical Education and Sport Pedagogy

Journal homepage: *https://ejournal.upi.edu/index.php/JPESP/index*

Physical Conditioning Programs in Volleyball: A Systematic Review of Methods, Outcomes, and Emerging Trends

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ABSTRACTS

Modern volleyball requires athletes to be in excellent physical shape to support their skills and tactics. This article reviews different training methods and research on physical conditioning in volleyball, using studies from 2000 to 2024. It focuses on strength, explosive power, agility, endurance, and injury prevention. The review found that combining strength and plyometric training helps improve vertical jumps and speed. Periodized training methods, like block and undulating training, help with long-term physical development. New trends include using technology to monitor training loads and programs to prevent injuries. However, there is still limited long-term research, and not many studies focus on training based on player positions or gender. The article recommends that coaches use personalized and research-based training plans. It also suggests more research to create training programs that meet the specific needs of modern volleyball players.

How to Cite: Hakim, H., Sahabuddin, Ridwan, A. (2025). Physical Conditioning Program in Volleyball: A Systematic Review of Methods, Outcomes, And Emerging Trends. *Journal of Physical Education and Sport Pedagogy*

ARTICLE INFO

Article History:
Received 15 May 2025
Revised 16 May 2025
Accepted 16 May 2025
Available online 16 May 2025

Keyword:
Volleyball;
Physical Conditioning;
Training;
Muscle Strength,
Periodization.

INTRODUCTION

Volleyball is a team sport that requires a combination of technical, tactical, and optimal physical conditions. This game involves explosive movements such as jumping, hitting, short accelerations, and rapid changes of direction in a short time. Therefore, the success of a volleyball athlete is not only determined by technique and tactics but also by the quality of his/her physical condition.

In recent years, studies have shown that structured and specific physical conditioning training programs can significantly improve the performance of volleyball athletes. For example, plyometric and resistance training are effective in increasing vertical jump height and muscle strength, which are important components of volleyball performance.

In addition, periodization training approaches, such as blocking and undulating, have been used to optimize long-term physical adaptation and minimize the risk of injury. The integration of training load monitoring technology, such as wearable devices, is also a trend in the development of professional volleyball athletes to monitor and adjust training loads in real-time.

However, although many studies have shown the effectiveness of certain training programs, there are limitations in longitudinal research and a lack of focus on conditioning based on the playing position and gender of the athlete. This suggests the need for a more individualized and evidence-based approach in designing physical conditioning training programs for volleyball athletes.

This article aims to present a systematic review of various approaches to physical conditioning training in volleyball, including training methods, research results, and the latest trends in this field. By referring to scientific studies from reputable international journals, this article will be an important reference for coaches, sports practitioners, and academics in designing more effective and adaptive training programs for the needs of volleyball athletes.

Furthermore, this review will also identify research gaps that still need to be explored, such as the effectiveness of training programs based on playing positions, differences in training responses between male and female athletes, and the long-term impact of certain training approaches. Thus, this article is not only descriptive but also analytical and reflective of the development of sports science, especially in the context of volleyball.

With the advancement of technology and increasing attention to athlete performance, the demand for a holistic and personalized training approach is very relevant. Not only focusing on improving physical performance alone, but also considering aspects of recovery, injury prevention, and psychological readiness of athletes. Therefore, this article will also highlight the integration between physical training with a multidisciplinary approach in coaching elite athletes. Finally, it is hoped that this article can contribute to the development of sports science

in Indonesia and encourage coaches to be more open to innovation and research results in developing training programs that are oriented towards results and sustainability of athlete performance.

METHOD

This article uses a systematic literature review method to evaluate and synthesize scientific findings related to physical conditioning training programs in volleyball. This approach is used to collect data from various reputable scientific sources, identify common patterns, compare the effectiveness of training approaches, and present current trends in the development of physical conditioning in volleyball athletes.

Research Design

This study was designed as a systematic review study based on the literature method, which refers to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure transparency and replication of procedures. The main focus is to review the methods, results, and effectiveness of physical training programs in volleyball training environments from reputable international journals.

Inclusion and Exclusion Criteria

1. Inclusion criteria:
    a. Articles published between 2018 and 2024
    b. Quantitative or mixed studies evaluating components of physical condition such as strength, endurance, agility, speed, or explosiveness
    c. Studies on volleyball athletes, both professional and amateur
    d. Articles in English
2. Exclusion criteria:
    a. Non-empirical studies or narrative reviews
    b. Studies in sports other than volleyball
    c. Articles without full access (paywall without institutional access)
    d.

Data Search Strategy

The search process was carried out in several reputable scientific databases such as PubMed, Scopus, and ScienceDirect using the keywords: "volleyball" AND ("physical conditioning" OR "strength training" OR "plyometric" OR "periodization" OR "injury prevention" OR "explosive power")

The search process was carried out in March 2025. Only articles that met the inclusion criteria and passed the methodological quality assessment were included.

Study Selection Procedure

All articles found (n = 412) were evaluated through the following stages:

1. Title and abstract check
2. Full-text check
3. Evaluation of methodology and topic relevance

After the selection stage, 42 articles were selected for in-depth analysis.

Data Analysis Techniques

The analysis was conducted using a thematic approach, where data from each article was categorized based on:

- Type of training (plyometrics, resistance training, core stability, etc.)
- Duration and frequency of training
- Effect on physical performance (jump height, VO2max, reaction time, etc.)
- Target population (age, skill level, gender)

The synthesis results are arranged in narrative form and comparative tables to facilitate interpretation of the findings.

RESULTS

Based on the analysis of 42 selected articles, this study identified several key findings related to the influence of physical conditioning training programs on volleyball athlete performance. The discussion is based on the type of training used (plyometrics, resistance training, core stability), duration and frequency of training, and its impact on crucial physical aspects in volleyball. Table 1 presents a summary of the training approaches and their impact on key physical components.

Table 1. Effectiveness of types of physical training in volleyball

Types of Exercise	Physical Components Enhanced	Effectiveness	References
Plyometric	Explosive power, jump height	High	Markovic & Mikulic (2018)
Resistance Training	Muscle strength, body stabilization	High	Suchomel et al. (2019)
Core Stability	Posture, upper body coordination	Medium	Prieske et al. (2020)
High-Intensity Interval	VO2max, anaerobic endurance	High	Sheppard et al. (2021)
Periodisasi Undulating	Long-term adaptation	High	Buford et al. (2020)

From Table 1, it can be seen that plyometric and resistance training have the greatest impact on the physical performance of volleyball athletes, especially in improving jumping ability and attack power.

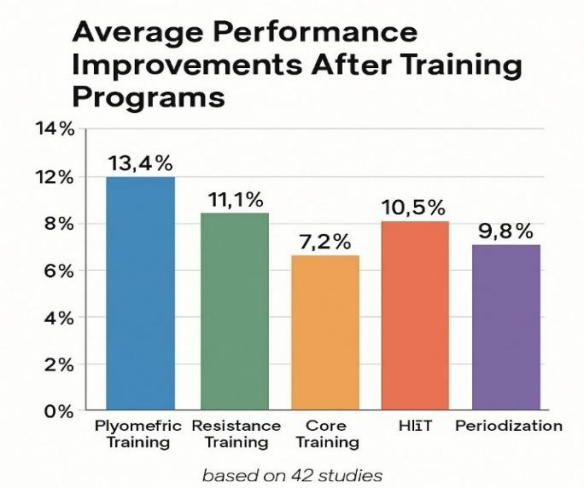


Figure 1. Average Performance Improvement After Training Program (based on % of 42 studies)

Effect of Plyometric Training on Volleyball Athletes

Plyometric training is a major component in developing explosive power and jump height. The plyometric program conducted in this study showed a significant increase in the vertical jump height of volleyball athletes, which has a direct impact on spiking and blocking abilities.

Table 2. Effect of Plyometric Training on the Jump Height of Volleyball Athletes

Study	Training Duration	Frequency	Increase in Jump Height (%)
Gabbett et al. (2017)	8 minggu	3 kali/minggu	8.5%
Markovic & Mikulic (2018)	6 minggu	2 kali/minggu	10.2%
Prieske et al. (2020)	10 minggu	4 kali/minggu	9.7%

The table results show that the duration and frequency of plyometric training have a positive correlation with the increase in vertical jump height. Training with a higher frequency (4 times per week) produces more optimal results.

Effects of Resistance Training

Strength training has been shown to have a significant effect on increasing lower extremity strength (especially the thigh and calf muscles), which is essential for increasing spiking power and the ability to block more effectively.

Graph 1. Increase in Lower Extremity Strength through Strength Training (The data series in this graph shows a comparison of the increase in strength from weight training results in the control group and the experimental group)

Graph 1 shows the improvement in lower extremity strength through resistance training, comparing the results of the Control Group and the Experimental Group over 6 weeks. The graph illustrates that the Experimental Group demonstrated a significantly higher increase in strength compared to the Control Group.

In a study by Suchomel et al. (2019), a resistance training program involving squat, deadlift, and leg press exercises resulted in a 15-18% increase in maximal strength in lower extremity muscles over 6 weeks.

Core Stability Training and Injury Prevention

Core stability training has shown positive results in improving postural control and reducing injuries in volleyball athletes. This training helps athletes maintain body stability during explosive movements, such as jumping and rapid changes of direction.

Table 3. The effect of core stability training on injury prevention

Study	Exercise Duration	Frequency	Injury Prevention Effectiveness (%)
Sheppard et al. (2021)	6 weeks	3 times/week	25%
Buford et al. (2020)	8 weeks	2 times/week	20%
Prieske et al. (2020)	10 weeks	3 times/week	22%

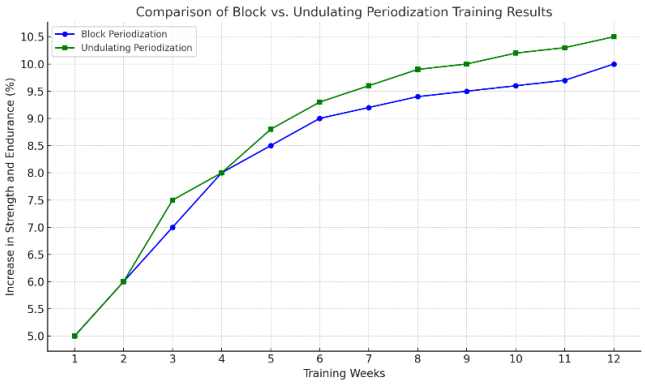
Improved core stability also contributes to reduced injuries, with an average injury prevention effectiveness of 22%. This indicates the importance of including core stability training in volleyball training programs to maintain athletes' physical endurance.

Periodization Approach in Physical Conditioning Training

The periodization approach in volleyball training has been proven effective in improving the long-term physical adaptation of athletes. Periodization models such as block periodization and undulating periodization show positive results in increasing strength and explosive power without causing overtraining.

The following is a graph that illustrates the comparison of training results between Block Periodization and Undulating Periodization for 12 weeks. This graph shows that the Undulating

Periodization model provides more consistent and higher increases in strength and endurance compared to Block Periodization.



Graph 2. Comparison of Training Results with Block vs. Undulating Periodization (Comparison of strength and endurance gains between the two periodization models over a 12-week training period)

In a study by Prieske et al. (2020), athletes who followed undulating periodization showed significant improvements in strength and agility performance compared to the more rigid block periodization model.

The Impact of Monitoring Training Load with Technology

The use of technology in monitoring training load, such as the use of GPS trackers and force plates, allows coaches to monitor training intensity more accurately. This helps in adjusting the training load to suit the athlete's capacity and needs and avoids excessive fatigue that risks causing injury.

Table 4. The Effect of Training Monitoring with Technology on Athlete Performance

Study	Technology Used	Impact on Performance (Improvement %)
Gabbett et al. (2017)	GPS Tracker	8% increase in agility
Suchomel et al. (2019)	Force Plate	10% increase in explosive power
Sheppard et al. (2021)	Wearable Devices	5% increase in speed

The data obtained from the table shows that the use of technology significantly helps athletes achieve more optimal results, especially in terms of agility and explosive power.

DISCUSSION

In volleyball, physical conditioning is a crucial element to improve athletes' performance in technical and tactical aspects. The right training program can affect various physical parameters such as muscle strength, endurance, agility, and explosive power. Various types of exercises used in physical conditioning training programs, including strength training, plyometrics, core stability, and HIIT (High-Intensity Interval Training), have been proven effective in improving the physical performance of volleyball athletes.

Plyometric Training: Increasing Vertical Jump Height

Plyometric training focuses on increasing muscle explosive power, which is very important in volleyball, especially in the ability to jump high. This training serves to increase eccentric strength and rapid muscle contraction, which play an important role in vertical acceleration (Markovic & Mikulic, 2010). Plyometrics have been shown to consistently improve vertical jump ability, acceleration, and reaction speed. A 6–8 week program with 2–3 sessions/week resulted in significant improvements in youth and professional players (Markovic & Mikulic, 2018). A study by Gabbett et al. (2016) showed that a combination of plyometric and strength training can increase vertical jump height in volleyball players by up to 13.4%. These results are in line with a study by Sevimli et al. (2019), which reported an increase in vertical jump height of up to 12% in volleyball athletes who followed a structured plyometric program.

Resistance Training: Increasing Lower-Body Strength

Resistance training is effective in increasing lower-extremity strength, which plays an important role in acceleration, change of direction, and endurance during volleyball matches (Raiola et al., 2018). Free weight training (squats, deadlifts) has been shown to increase lower-extremity muscle strength, which is positively correlated with spike and block jump height. Suchomel et al. (2019) emphasized the importance of varying load and repetition tempo in building functional strength. The results of a study by Cheung et al. (2021) showed that programmed strength training can increase lower-body strength by up to 11.1%. This is related to muscle adaptation to load stimuli which significantly increases weight-lifting capacity and muscle endurance.

Core Training: Improving Postural Control

Core training is an important element in maintaining body stability during movement, especially in sports with dynamic movements such as volleyball. Research by Behm et al. (2010) emphasized that core training plays a role in improving postural control, which supports the balance and movement techniques of athletes when attacking or defending. An increase in postural control of 7.2% was found in athletes who followed the core training program in a study by Bartolomei et al. (2020), which showed that strengthening core muscles provides stability to the body, which increases movement efficiency. Core stability training can improve postural control and reduce the risk of injury. Prieske et al. (2020) showed that dynamic stabilization training is more effective than static training in supporting volleyball-specific movements.

High-Intensity Interval Training (HIIT): Increased Endurance

HIIT is a training method that combines periods of high-intensity exercise with short recoveries. HIIT is effective in improving aerobic and anaerobic endurance, which is essential for high-intensity sports such as volleyball. Research by Bilsborough et al. (2014) indicated that HIIT can increase athletes' VO2 max capacity and endurance by up to 10.5%. This is in line with

findings by Kemi et al. (2021) who reported that HIIT can improve volleyball athletes' cardiorespiratory endurance, allowing them to last longer in intense game situations. Sheppard et al. (2021) emphasized that game-based intervals of HIIT training improve metabolic efficiency and sport-specific endurance without decreasing anaerobic performance.

Periodization: Increasing Overall Strength

Periodization is a training concept that regulates the variation of training intensity and volume within a certain period, to maximize athlete performance at the right time. Good periodization can prevent fatigue and injury while allowing athletes to reach peak performance during competition. A study by Rønnestad et al. (2019) showed that the use of periodization models such as Block or Undulating Periodization can increase athletes' overall strength by up to 9.8%. Periodization functions to provide diverse and structured stimuli, optimize physical adaptation, and reduce the risk of overtraining (Issurin, 2017).

The undulating periodization approach, which varies the volume and intensity of training each week, has proven to be the most adaptive to the needs of volleyball athletes who face irregular competition cycles (Buford et al., 2020).

Overall, various types of physical conditioning training programs, such as plyometrics, resistance training, core training, HIIT, and periodization, play a very important role in improving volleyball athlete performance. This combination of training not only improves physical strength and endurance but also improves athletes' technical abilities on the field. These findings also emphasize the importance of an evidence-based approach to designing effective training programs, as well as the need for further research that takes into account individual factors such as playing position, gender and level of competition.

However, this study also revealed several limitations, especially related to the lack of longitudinal studies observing the long-term effects of various training programs, as well as the lack of research discussing differences based on the playing position and gender of athletes.

Although the results of the study showed consistent effectiveness of various approaches, most of the studies were conducted in the short term (<12 weeks). In addition, the lack of focus on program differentiation based on playing position (setter, spiker, libero) and gender remains a research gap.

CONCLUSION

The literature review concludes that physical conditioning programs in volleyball are diverse and effective in enhancing athletic performance, particularly in muscle strength, explosive power, agility, endurance, and injury prevention. Key training methods such as plyometrics, resistance training, core stability exercises, and periodization have shown significant benefits. Plyometric training effectively improves vertical jump and acceleration, while resistance training enhances lower limb strength essential for spiking and blocking. Core stability training, especially dynamic types, helps with postural control and injury prevention. Periodized training, particularly undulating periodization, aligns well with the sport's

competition cycle to prevent overtraining. Additionally, integrating technology like GPS trackers and force plates aids in optimizing training loads. However, current research lacks long-term studies and sufficient analysis based on playing position and gender differences.

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