The effect of electromyostimulation training on recovery and athlete performance in the sport of volleyball: a review of recent literature

El efecto del entrenamiento con electroestimulación en la recuperación y el rendimiento del deportista de voleibol: una revisión de la literatura reciente

Authors

Dedi Iskandar [1]
Herman Subarjah [2]
Yunyun Yudiana [3]
Gilang Ramadan [4]

[1] Universitas Pendidikan Indonesia (Indonesia)
[2] Universitas Pendidikan Indonesia (Indonesia)
[3] Universitas Pendidikan Indonesia (Indonesia)
[4] Universitas Muhammadiyah Gorontalo (Indonesia)

Corresponding author:
Dedi Iskandar
dediiskandar@upmk.ac.id

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Abstract

Introduction: Electromyostimulation (EMS) training has become a popular method to improve muscle strength and speed up athletes' recovery, especially in the sport of volleyball. However, although many studies support the effectiveness of EMS in individual athletes, its application in volleyball sport, is still not widely researched. Objective: This study aimed to evaluate the effects of EMS on muscle recovery and specific performance in the sport of volleyball. Methodology: The research sought to identify potential benefits and challenges in integrating EMS into volleyball training programmes to maximise overall team performance. The research method involved a comprehensive literature review, with reference to articles published in databases such as PubMed and Scopus. The literature search followed PRISMA guidelines, and only articles relevant to the topic of EMS in volleyball sport were considered. Of the total 220 publications found, only five articles met all inclusion criteria and were further analysed. Results: The results showed that EMS can significantly improve muscle strength and accelerate recovery after intense training, especially in explosive movements such as jumping and change of direction. Discussion: The study also showed that combining EMS with functional training can improve VO2max capacity, muscle strength and physical endurance. However, the application of EMS in the sport of volleyball requires customisation to ensure that it does not disrupt team dynamics and coordination. Conclusions: EMS has the potential to be an effective tool in improving athlete performance and muscle recovery in volleyball sports. However, further research is needed to understand how EMS can be optimally integrated into team training programmes without disrupting team balance. Future research should also evaluate the long-term impact of EMS on team athlete performance.

Keywords

Electromyostimulation (EMS); athlete recovery; team sports; muscle strength; performance enhancement.

Resumen

Introducción: El entrenamiento con electroestimulación muscular (EMS) se ha convertido en un método popular para mejorar la fuerza muscular y acelerar la recuperación de los atletas, especialmente en el deporte del voleibol. Sin embargo, aunque muchos estudios respaldan la eficacia de la EMS en atletas individuales, su aplicación en el deporte del voleibol aún no se ha investigado ampliamente. Objetivo: Este estudio tuvo como objetivo evaluar los efectos de la EMS en la recuperación muscular y el rendimiento específico en el deporte del voleibol.
Metodología: La investigación trató de identificar los posibles beneficios y desafíos de integrar la EMS en los programas de entrenamiento de voleibol para maximizar el rendimiento general del equipo. El método de investigación consistió en una revisión exhaustiva de la literatura, con referencia a artículos publicados en bases de datos como PubMed y Scopus. La búsqueda bibliográfica siguió las directrices de PRISMA, y solo se consideraron los artículos relevantes para el tema de la EMS en el deporte del voleibol. Del total de 220 publicaciones encontradas, solo cinco artículos cumplieron todos los criterios de inclusión y fueron analizados con más detalle.
Resultados: Los resultados mostraron que la EMS puede mejorar significativamente la fuerza muscular y acelerar la recuperación después de un entrenamiento intenso, especialmente en movimientos explosivos como saltar y cambiar de dirección.
Discusión: El estudio también mostró que la combinación de EMS con entrenamiento funcional puede mejorar la capacidad de VO2max, la fuerza muscular y la resistencia física. Sin embargo, la aplicación de EMS en el deporte del voleibol requiere personalización para garantizar que no perturbe la dinámica y la coordinación del equipo. Conclusiones: La EMS tiene el potencial de ser una herramienta eficaz para mejorar el rendimiento de los atletas y la recuperación muscular en los deportes de voleibol. Sin embargo, es necesario seguir investigando para comprender cómo se puede integrar de forma óptima la EMS en los programas de entrenamiento en equipo sin perturbar el equilibrio del equipo. Las futuras investigaciones también deberían evaluar el impacto a largo plazo de la EMS en el rendimiento de los atletas de equipo.

Palabras clave

Electromioestimulación (EMS); recuperación del deportista; deportes de equipo; fuerza muscular; mejora del rendimiento.

Introduction

Electromyostimulation (EMS) training has become a prominent topic in sports due to its potential in enhancing muscle strength and accelerating recovery in volleyball players. Numerous studies have shown that EMS can positively impact various aspects of athletic performance. For example, Sadeghipour et al. (2021) found a significant increase in maximal strength after 3 to 6 weeks of EMS application. This finding is consistent with the research by (Li et al., 2023) which also supports the effectiveness of EMS in increasing strength. Furthermore, Samsonova et al. (2023) demonstrated that combining functional training with full-body EMS could improve running performance, further reinforcing the benefits of EMS in athletic training. However, despite EMS being extensively studied in individual sports, its application in volleyball has been relatively unexplored. Volleyball is characterized by strong team coordination, endurance, strength, and high speed. The dynamics in this sport require a different training approach than in individual sports. While previous research has linked EMS with improved individual performance, there is still a gap in the literature regarding how EMS can be effectively integrated into training programs to maximize overall performance in volleyball.

One of the main challenges in applying EMS to volleyball is determining how it can contribute to team performance without compromising coordination and strategy. In volleyball, where each player has a specific and interdependent role, improving individual performance through EMS must be evaluated in the context of the overall team strategy. EMS has been shown to effectively improve lower limb strength and explosive power in volleyball players, which are important physical attributes in this sport, especially for dynamic movements such as jumping and rapid changes of direction (Li et al., 2023). However, these benefits must be carefully considered to ensure that the application of EMS does not disrupt the balance and harmony within the team. Additionally, Wirtz et al. (2019) emphasize the importance of training specifications and EMS application tailored to the specific needs of volleyball, which requires training methods aligned with the sport's physical demands. Therefore, further research is needed to address how EMS can be adapted to meet the unique needs of volleyball.

Previous research also highlights the potential of integrating EMS into training routines, particularly in combination with other types of exercises. For instance, Pregelj & Šimunič (2019) found that combining plyometric training with EMS significantly increased muscle strength in adolescent girls, including volleyball players. These findings suggest that integrating EMS with plyometric training may provide additional benefits in developing strength and explosive power in volleyball athletes.

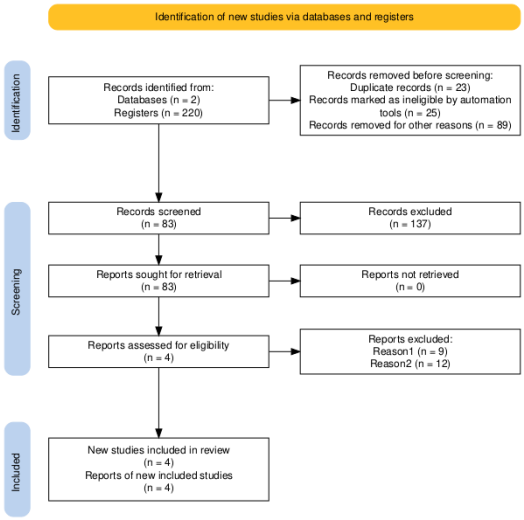
From a performance improvement perspective, it is also essential to consider EMS's role in muscle recovery and injury prevention in volleyball. Given the high physical demands of volleyball, where players often face muscle injury risks due to fast and explosive movements, EMS can play a crucial role in speeding up the recovery process and reducing injury risks. As shown by Micke et al. (2022), EMS can influence physiological parameters relevant to muscle recovery, such as body composition and muscle strength, which, in turn, can enhance physical endurance and reduce recovery time after intense training or competition. In this context, integrating EMS into volleyball training programs should be carefully designed to maximize its benefits without disrupting the main training program or increasing injury risks. Kale & Gürol (2019) demonstrated that EMS, when combined with voluntary muscle movements specific to a sport, could improve muscle strength and jumping ability in soccer players. A similar approach could be adapted for volleyball, where EMS is used as a supplementary training tool focused on developing core and lower limb strength, which is essential for on-court performance.

This study aims to evaluate the effects of EMS training on muscle recovery and specific performance in the sport of volleyball. The research will conduct a review of recent literature to identify the potential benefits and challenges of integrating EMS into volleyball training programmes and provide recommendations for practical application and further research. As such, this research will not only provide a deeper understanding of the potential of EMS in improving volleyball team performance, but also help identify gaps in the existing literature and guide future research in a more specific and applicable direction. This research is expected to contribute to developing more effective training strategies in the sport of volleyball, utilising EMS technology to improve athletic performance and competitiveness at the elite level.

Method

The research method involved a systematic literature search through various trusted databases, the databases used in this study were PubMed and Scopus. The search process focused on topics related to Electromyostimulation (EMS), athlete recovery, athlete performance and volleyball. The main focus in the selection of sources was the quality of the articles, the relevance of the topic and the completeness of the data presented. The exclusion criteria applied in the selection process included several key aspects. Firstly, only articles published in journals indexed by Scimago Journal Rank (SJR) and PubMed were considered for further analysis, this could be excluded if the same article contained in the 2 databases would be selected one of them. Published articles must be in English. Keywords used in the literature search included “EMS to recovery”, and “use of EMS for athlete performance”.

Figure 1 Selection process of articles used to utilize PRISMA guidelines



The initial search process successfully identified a total of 220 publications relevant to the research topic. Of these, 129 articles were found through the PubMed database, while 91 others were found through Scopus. After applying the established exclusion criteria, the number of relevant articles was significantly reduced. Many articles were eliminated because they did not explicitly mention the relationship between EMS training and athlete recovery and performance in the context of team sports. After a rigorous screening process, only five articles met all inclusion criteria and were considered relevant for further analysis. After the initial selection, all selected articles were extracted and analyzed using Mendeley software. Mendeley was used to manage references and ensure no duplication in the selected articles, thus ensuring the integrity of the data to be analyzed. With only five articles remaining after a rigorous selection process, this study recognises the limited number of studies that explicitly address EMS in the context of athlete recovery and performance in the sport of volleyball. However, the selected articles provide in-depth insights and sufficient data for a comprehensive analysis of the potential impact of EMS on improving recovery and performance in team sports. The analysis of these articles will form the basis for the conclusions drawn in this research, as well as the recommendations to be provided for practical applications in the field and future research.

Results

Electromyostimulation (EMS) training has been associated with athlete recovery and performance enhancement, particularly in the context of the sport of volleyball. Previous studies (Li et al., 2023) have shown that EMS can help accelerate muscle recovery, increase strength, and reduce fatigue after matches or intense training sessions. Although there are some variations in research findings, influenced by factors such as the type of intervention, training duration, and individual participant characteristics, most studies agree that EMS has positive effects on athletic performance. Most studies reveal

improvements in performance and faster recovery following the incorporation of EMS into training programs (Miranda-Mendoza et al., 2023). Table 1 from the literature review outlines the results of various studies, which are then discussed in detail in this article to explore the impact of EMS on athlete recovery and performance in team sports.

Table 1. Characteristics of the analysed studies

Name and Year	Title	Research methodology	Characteristics of the study sample	Research findings
(Voelzke et al., 2012)	Promoting lower extremity strength in elite volleyball players: Effects of two combined training methods	The study involved 16 elite volleyball players from Germany's first division, randomly assigned to two groups: resistance plus plyometric training (RT+P) and electromyostimulation plus plyometric training (EMS+P). Both groups followed a 5-week program with bi-weekly sessions integrated into their regular training. Pre- and post-tests assessed jump and sprint performance using force plates, sprint timing, and custom measurement tools. Statistical analysis included Wilcoxon Tests and Mann-Whitney U Tests.	Participants were 16 healthy, elite volleyball players (mean age: 23.8–26 years) competing at the national level. The RT+P group had an average body mass of 81.9 kg, while the EMS+P group averaged 79.6 kg. All participants consented to the study, which adhered to ethical guidelines.	RT+P training improved squat jump (SJ) height by 2.3% and reach height (RH) by 0.4%, favoring explosive strength. Conversely, EMS+P training enhanced countermovement jump (CMJ) by 3.8%, drop jump (DJ) index by 6.4%, RH by 1.6%, and sprint times (5m, 10m straight/lateral) by 2.6%–7.3%, showcasing broader agility benefits. Statistical analysis revealed RT+P's superior SJ improvements ($p = 0.023$), while EMS+P excelled in 5m sprint time reduction ($p = 0.006$). The findings suggest RT+P is optimal for jump performance, whereas EMS+P offers advantages for agility and speed, highlighting the value of combining these training methods in elite volleyball preseason preparation.
(Keskin et al., 2024)	Effects of different pre-exercise strategies on jumping performance in female volleyball players	This experimental study compared the effects of three pre-exercise strategies 5 repetition maximum knee extension, electromyostimulation (EMS), and ischemic preconditioning (IPC) against a control condition involving standardized warm-up on jumping performance in female volleyball players. Fifteen participants completed squat jumps and 15-second repeated countermovement jumps following each condition. Performance measures and ratings of perceived exertion (RPE) were collected and statistically analyzed to determine the effectiveness of each strategy.	The study included 15 healthy female volleyball players (mean age: 18 ± 0.6 years, height: 164.8 ± 5.4 cm, body mass: 57.2 ± 8.1 kg) with an average training experience of 7.3 ± 1.4 years. All participants were experienced athletes and voluntarily participated in the study, which adhered to ethical standards and included a standardized warm-up as the control condition for comparison.	The findings indicated that a standardized warm-up was sufficient to optimize jumping performance in female volleyball players. Neither EMS nor IPC pre-exercise strategies improved performance; in fact, both resulted in performance decrements compared to the control condition ($P < 0.05$). Ratings of perceived exertion were consistent with these results, suggesting that additional pre-exercise protocols may not provide added benefit. The study concludes that a properly executed standardized warm-up is adequate for preparing athletes for jumping tasks. Further research should investigate alternative pre-exercise strategies that can complement standardized warm-ups to enhance performance in volleyball-specific actions.

(Malatesta et al., 2003)	Effects of electromyostimulation training and volleyball practice on jumping ability	This study investigated the effects of a 4-week electromyostimulation (EMS) training program on vertical jump performance in volleyball players. Twelve participants completed EMS sessions targeting knee extensor and plantar flexor muscles, incorporated into regular volleyball training three times weekly. Each EMS session lasted approximately 12 minutes, involving 20–22 muscle stimulations. Squat jump (SJ), countermovement jump (CMJ), and 15-second consecutive CMJ tests were conducted pre-training, post-training, and 10 days after the training period to assess performance changes.	The study involved 12 volleyball players who participated in a 4-week EMS training program. All participants were actively training and completed three EMS sessions per week alongside their volleyball practices. The study included athletes experienced in volleyball to ensure consistency in skill and neuromuscular responses during the assessment of vertical jump performance.	The study found no significant changes in squat jump (SJ) and countermovement jump (CMJ) performance immediately after the 4-week EMS training program. However, the mean jump height and power during 15-second consecutive CMJs increased by approximately 4% ($p < 0.05$). Interestingly, ten days after the conclusion of EMS training, significant improvements in single jump heights were observed (SJ +6.5%, CMJ +5.4%). These delayed enhancements suggest that EMS training can improve neuromuscular adaptations when combined with sport-specific workouts. The findings highlight the importance of allowing time for the central nervous system to optimize neuromuscular control following EMS training to maximize its benefits for vertical jump performance.
(Maffiuletti et al., 2002)	Effect of combined electrostimulation and plyometric training on vertical jump height	This study evaluated the effects of a 4-week combined electromyostimulation (EMS) and plyometric training program on the vertical jump performance of volleyball players. Ten participants underwent training three times weekly, with each session comprising EMS for the knee extensors (48 contractions), EMS for the plantar flexors (30 contractions), and 50 plyometric jumps. Testing was conducted at baseline (week 0), mid-program (week 2), post-program (week 4), and after 2 weeks of regular volleyball training (week 6). Assessments included various vertical jump tests and maximal voluntary contraction (MVC) measurements for targeted muscle groups.	The sample consisted of 10 volleyball players who participated in a structured 4-week combined EMS and plyometric training program. All athletes were actively engaged in volleyball training and committed to a tri-weekly training schedule. The participants' performances were evaluated using standardized strength and jump tests, ensuring consistency and reliability in the data collection process.	The study demonstrated significant improvements in muscle strength and jump performance. By week 2, MVC increased significantly for both the knee extensors (+20%) and plantar flexors (+13%) compared to baseline ($P < 0.05$). After 4 weeks, vertical jump performance improved markedly, with relative gains ranging from 8-10% for the spike-countermovement jump to 21% for the squat jump ($P < 0.001$). These enhancements were sustained after an additional 2 weeks of volleyball training, indicating the durability of strength and explosive adaptations. The findings highlight the effectiveness of combining EMS and plyometric exercises to rapidly boost strength and jump ability in volleyball players, which is critical for in-game performance. For optimal results, EMS should be paired with specific training like plyometrics to maximize neuromuscular adaptations and jump development.

Discussion

The research results displayed in Table 1 provide important insights into the effect of Electrical Muscle Stimulation (EMS) on athlete performance, particularly volleyball players. From the various studies analysed, EMS showed great potential in improving athletes' muscle strength, vertical jump and explosive

ability. In addition, EMS proved to be an effective tool for muscle recovery, reducing the risk of injury and improving physiological parameters such as muscle mass and tissue regeneration.

In the study of Voelzke et al. (2012), EMS combined with plyometric training (EMS+P) resulted in significant improvements in countermovement jump (CMJ) ability by 3.8% and 5-metre sprint by 7.3%. This suggests that EMS can improve speed and explosivity parameters that are important for volleyball performance. This study highlights that the integration of EMS with specific training methods, such as plyometrics, is capable of providing optimal results for elite athletes.

The research results of Keskin et al. (2024) highlighted that pre-exercise strategies such as EMS and ischemic preconditioning (IPC) do not provide an advantage over standard warm-ups in improving springboard performance. In fact, EMS and IPC conditions resulted in a decrease in performance. This confirms that the application of EMS as a pre-exercise strategy should be carefully designed so as not to interfere with physiological adaptations during the main exercise.

In the study by Malatesta et al. (2003), the use of EMS for 4 weeks increased the average CMJ jump height for 15 consecutive seconds by 4% and showed an increase in single jumps such as squat jump (SJ) up to 6.5% after a 10-day pause period. These results support that EMS provides neuromuscular adaptations that take time to fully manifest in athlete performance.

The study of (Maffiuletti et al., 2002), showed remarkable improvements in muscular maximal strength (+20% in knee extensors) and vertical springboard up to 21% after a combination of EMS with plyometrics for 4 weeks. This study provides important evidence that EMS is highly effective when combined with specific exercises to develop explosive strength.

In the context of injury prevention, EMS has the potential to strengthen injury-prone muscles, such as the hamstrings and plantar flexors, as noted in some previous literature (Carragher et al., 2019; Malliaropoulos et al., 2012). Muscle strengthening through EMS can reduce the risk of injury that often occurs due to explosive movements in volleyball, such as spikes and blocks. In addition, EMS also increases blood flow and the elimination of metabolites such as lactic acid, thus accelerating recovery after intense physical activity (Sañudo et al., 2020).

However, the effectiveness of EMS largely depends on the design of the programme, including intensity, duration and frequency. As an additional training tool, EMS should not interfere with the main programme, and its application requires expert supervision to prevent injuries or adverse side effects (Johannsen & Krogh, 2019). Therefore, coaches and medical teams should ensure that the use of EMS is appropriate to the athlete's specific needs and training goals.

Going forward, further research is needed to explore the long-term impact of EMS on athletes, including its effects on motor coordination, aerobic endurance and other physiological parameters. In addition, research on the integration of EMS in injury rehabilitation programmes may provide new insights to accelerate recovery and prevent recurrent injuries. With proper application, EMS has great potential to become an integral part of volleyball athletes' training and recovery programmes.

Conclusions

The conclusions from the results show that Electrical Muscle Stimulation (EMS) has great potential in improving the performance and recovery of volleyball athletes, but its effectiveness is highly dependent on the proper design and implementation of the programme. In the studies analysed, EMS was shown to improve players' muscle strength, vertical jump and explosive power. For example, the combination of EMS with plyometric training provided significant improvements in squat jump (up to 21%) and countermovement jump (3.8%).

In addition, EMS also plays a role in muscle recovery by increasing blood flow and reducing metabolites such as lactic acid, which accelerates the process of tissue regeneration. However, other studies have shown that EMS as a pre-workout strategy does not always provide an advantage over a standard warm-up and may even reduce performance if not designed properly.

For optimal results, EMS should be integrated with sport-specific exercises, such as plyometrics, to develop explosive strength without disrupting the balance of the main programme. Going forward, more

research is needed to explore the long-term impact of EMS, including its effects on motor coordination and injury prevention. With a wise approach, EMS can be an integral tool in the training and recovery of volleyball players.

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Authors' and translators' details:

Dedi Iskandar	dediiskandar@upmk.ac.id	Author
Herman Subarjah	hermansubarjah@upi.edu	Author
Yunyun Yudiana	yunyunyudiana@upi.edu	Author
Gilang Ramadan	gilangramadan@umgo.ac.id	Author
Delta Rahwanda	rahwanda_delta@yahoo.com	Translator