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Do Warm-Up Strategies Impact the Jumping Performance of Young Female Volleyball Players?

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Abstract

Objectives. The aim of this study was to assess whether a warm-up routine incorporating plyometric exercises promotes greater improvements in jumping performance, power output, and neuromuscular responsiveness compared with warm-up strategies commonly used in volleyball practice.

Materials and Methods. Twenty-four sub-elite female volleyball players (age: 16.3 ± 0.6 years; body mass: 58.7 ± 3.8 kg; height: 165.6 ± 6.8 cm) from a regional club performed three different warm-up protocols, each lasting 20 minutes: traditional warm-up (TWU), neuromuscular warm-up (NWU), and isometric warm-up (IWU). To minimize fatigue effects, three experimental sessions were conducted with 48-hour intervals. Following each warm-up protocol, participants were randomly assessed using the Squat Jump (SJ), Countermovement Jump (CMJ), Standing Long Jump (SLJ), Squat Jump–Block Jump (SJ–BJ), Repeated Countermovement Jump (RCMJ), and Drop Jump (DJ) tests.

Results. Jump performance outcomes demonstrated significantly higher values ($p < 0.001$) following the NWU protocol. Compared with IWU, TWU resulted in higher performance values in SLJ, SJ–BJ, RCMJ, and shorter ground contact time during the DJ test.

Conclusions. Neuromuscular warm-up appears to be particularly effective in sports requiring explosive, high-speed actions, as it may directly enhance training quality and jumping performance during competition. The findings indicate that post-activation performance enhancement (PAPE) can be observed in Under-17 female volleyball players when appropriate warm-up exercises are applied. This study provides practical insights into warm-up strategies for youth volleyball clubs with limited access to resistance training equipment.

Keywords: jump, volleyball, PAPE, neuromuscular integrative exercise, plyometric.

Introduction

Recently, novel approaches and innovative training methodologies have increasingly been developed within the context of team sports (Esposito et al., 2024a; Altavilla et al., 2023; D'Elia, 2023).

Researchers and strength and conditioning coaches have progressively shifted their focus towards scheduling training sessions that reflect performance profiles across different sports (Giardullo et al., 2025; Shalom et al., 2025; Altavilla et al., 2022).

Furthermore, new methodologies have been proposed to enhance physical efficiency (Keoliya, et al., 2024; Esposito et al., 2024b; Deng et al., 2023) and improve the monitoring of training sessions (Hernandez-Martinez et al., 2023; Pawlik & Mroczek, 2022).

The warm-up represents one of the most important phases of a training session and has increasingly attracted attention from both researchers and practitioners (Keskin et al., 2025; Villalon-Gasch et al., 2022; Petisco et al., 2019).

Typically performed at the beginning of the session, the warm-up should include a variety of exercises tailored to the training objectives and the functional requirements of the sport (Villalon-Gasch et al., 2022; Seitz et al., 2016).

A well-designed warm-up is widely used in sport environments, as it aims to improve physical performance and reduce the injury risk prior to the main training phase (Keskin et al., 2025; Pérez-Gomez et al., 2022).

Previous studies have highlighted the benefits of appropriately designed warm-up protocols in improving performance (Papagiannis et al., 2024; Foqha et al., 2023; Andrade et al., 2015) and reducing injury risk across various sports (Althomali et al., 2025; Emery et al., 2022; Stojanović et al., 2023).

Despite, the effectiveness of injury prevention programmes has led to the widespread integration of specific warm-up protocols, particularly in team sports characterized by a high incidence of non-contact injuries (Magaña-Ramírez et al., 2024; Lopes et al., 2020).

Although the development of appropriate warm-up protocols has been shown to significantly reduce the injury risk, few studies have investigated their effects on sport-specific performance (Pérez-Gomez et al., 2022).

In light of this, the existing body of evidence supports the development of novel warm-up designs aimed at enhancing the activation of both central and peripheral mechanisms associated with performance improvement. Several authors have emphasized the performance benefits of warm-up routines that elicit Post-Activation Potentation (PAP) and Post-Activation Performance Enhancement (PAPE) across athletes from different sports (Villalon-Gasch et al., 2022; Jarosz et al., 2025; dos Santos Silva et al., 2021) and age groups (Sun et al., 2025; Isla et al., 2021).

The aforementioned neuromuscular phenomena, which are induced by high-intensity voluntary contractions, have been shown to improve players' performance. Although PAP and PAPE provide similar benefits, their underlying mechanisms differ. Notably, PAP is primarily determined by improved actin-myosin coupling, whereas PAPE is more strongly associated with increased muscle temperature and greater motor unit recruitment (Blazevich & Babault, 2019).

Most warm-up protocols have traditionally been prescribed for sports characterized by sprinting and high-intensity running; however, their applicability to sports involving repeated vertical jumping is not well documented (Althomali et al., 2025; dos Santos Silva et al., 2021).

For several decades, the traditional approach has consisted of a general cardiovascular phase lasting 10–20 minutes, followed by stretching exercises and sport-specific tasks (van den Tillar et al., 2019; Falch et al., 2021; Altavilla et al., 2023).

This general approach has been easily applied to sports characterized by different energy systems, bout durations and highly complex sport-specific skills, such as shooting, jumping, sprinting, throwing (Sannicandro et al., 2021).

Previous investigations have examined on isometric exercise within warm-up routines, given their effectiveness in recruiting a large number of motor units and promoting greater muscle fibres activation (Jarosz et al., 2025). Conversely, other studies have investigated warm-up protocols based on sport-specific technical skills performed by high-level athletes (dos Santos Silva et al., 2021).

However, volleyball presents unique performance that clearly differentiate it from other team sports; therefore, each phase of training competitive match should be carefully designed according to its specific performance demands.

A recent study has investigated the effectiveness of different warm-up protocols in volleyball players, by comparing ischemic preconditioning exercises and electromyostimulation of selected lower limb muscles on vertical jump performance (Keskin et al., 2025).

However, neither protocol elicited significant changes in vertical jump performance compared with a traditional warm-up.

Furthermore, other studies have examined the performance benefits elicited by particular warm-up protocols in international-level volleyball players (Villalon-Gasch et al., 2022), including overload-based strategies (Ah Sue et al., 2016; Sygulla & Fountaine, 2014).

In volleyball, muscle power plays a crucial role in key actions such as jumping during both offensive and defensive phases. Therefore, it is essential to identify the most effective warm-up strategy. Therefore, it is essential to identify the most effective warm-up protocol.

Further investigation related to pre-exercise activation is warranted, as improved understanding may help practitioners to optimise performance in both elite and young volleyball players.

Addressing this gap in the literature should be considered a priority for the youth population, as this may contribute to the development of evidence-based guidelines for youth volleyball practitioners.

Moreover, the findings related to PAPE in high-level athletes using free weights and maximal loads may not be transferable to younger players, given the limited availability of heavy-load equipment in youth women's volleyball settings.

Accordingly, warm-up protocols should incorporate strategies based on well-established and easily implementable tasks, considering the limited duration of the preparatory phase (approximately 20 minutes).

Based on the limited evidence currently available, the aim of the present study was to assess the effectiveness of different warm-up protocols on muscle power, vertical and horizontal jump performance in Under-17 volleyball players.

We hypothesized that a warm-up routine incorporating plyometric exercises would promote greater improvements in jumping performance, power output, and neuromuscular responsiveness compared with those commonly performed in the volleyball context.

Materials and Methods

Sample

Prior to the recruitment procedure, a sample size estimation was conducted using G*Power analysis (Düsseldorf, Germany) for a repeated-measures ANOVA design (effect size = 0.31; power = 0.90; $\alpha = 0.05$). Twenty-four sub-elite female volleyball players (age: 16.3±0.6 years, 58.7±3.8 kg, 165.6±6.8 cm, training age 7.7±1.9 years) belonging to a regional club were involved in the present study. Four participants were excluded from the final sample because they did not complete all three experimental sessions.

The eligibility criteria for this study were: i) participation in at least 90% of training sessions during the month preceding the study; ii) absence of injuries or neuromuscular or musculoskeletal disorders during the same period; iii) regular participation in volleyball training, including jump-specific training, and competitive match during the four weeks prior to the study; iv) no consumption of alcoholic beverages within 72 hours prior to each experimental session; v) participation in all experimental sessions. The study was approved by the club's manager and was conducted according to the principles expressed in the Declaration of Helsinki. Written informed consent was obtained from the parents or legal guardians, and all participants provided written assent.

Experimental Design

Participants performed three different warm-up protocols, each lasting 20 minutes To minimise potential fatigue effects, three experimental sessions were conducted with 48-hour interval between sessions. All assessments and warm-up protocols were carried out during a mid-season break in the competitive season.

The traditional warm-up (TWU) consisted of an 8-minutes cardiovascular phase, followed by 4 minutes of dynamic stretching and mobility exercises, and 8 minutes of sport-specific drills.

The neuromuscular warm-up (NWU) constisted of an 8-minutes cardiovascular phase, followed by 4 minutes of dynamic stretching and mobility exercises, and 8 minutes of neuromuscular phase including 4 x 3 countermovement jumps (CMJ; 30 s recovery), 4 x 4 pogo jumps (30 s recovery) and 3 x 3 split jumps per leg (45 s recovery)

The isometric warm-up (IWU) consisted of an 8-minutes cardiovascular phase, followed by 4 minutes of dynamic stretching and mobility exercise, and a isometric phase including 4 x 30 s half-squat at 90° holds knee flexion (30 s recovery), 4 x 30 s isometric exercises targeting triceps surae (30 s recovery) and 3 x 30 sec isometric lunges at 90° knee flexion (30 s recovery).

At the end of each warm-up protocol, participants were randomly assessed using the following tests:

- Squat jump (SJ): performed on a force platform (Globus Treviso, Italy), to assess explosive strength through elevation of the centre of mass using exclusively concentric muscle contraction.
- Countermovement Jump (CMJ): performed on a force platform (Globus Treviso, Italy), to assess explosive strength through plyometric contractions.
- Standing long jump (SLJ): used to assess explosive strength in its horizontal component.
- Squat Jump – Block Jump (SJ-BJ): used to assess sport-specific vertical jump performance. Block jump consisted of a two-legged vertical jump with arm swing, simulating a volleyball blocking action (Dopsaj et al., 2012).
- Repeated countermovement jump (RCMJ): performed on a force platform (Globus Treviso, Italy) to assess average jump height (MJH, cm), peak power (PP, W) and average power (MP, W) during jumps measured over 15 second period.
- Drop jump (DJ): performed on a force platform (Globus Treviso, Italy) to assess the elevation of the centre of mass. Participants dropped from a 45 cm box and performed a rebound jump with minimal knee flexion during ground contact (GCT) (Dopsaj et al., 2012).

Statistical Analysis

Descriptive statistics are presented as mean ± standard deviation (SD). Data normality was checked using Shapiro Wilk test. As the variables did not meet the assumption of normality, Friedman test (non-parametric ANOVA for repeated measures) was applied to detect significant differences among conditions. When a significant main effect was observed, Conover's post hoc test with Bonferroni correction was used for pairwise comparisons. Kendall's W effect sizes (WKendall) along with 95% confidence interval (95% CI) were reported. Effect sizes were interpreted according to the following thresholds (Tomczak et al., 2014): 0.1 – < 0.3 (small), 0.3 – < 0.5 (moderate) and ≥ 0.5 (large). Statistical significance was set at p<0.05. Statistical analyses were conducted using JASP software (version 0.19.2, Amsterdam, The Netherlands).

Results

Table 1 and 2 report mean values±SD for descriptive statistics and significant differences through non-parametric ANOVA for repeated measures, respectively.

SJ showed significant differences among warm-up conditions, with higher values observed after NWU (29.91±1.64 cm) compared with both TWU (27.92±1.47 cm) and IWU (27.16±1.33 cm) (p<0.001 for both comparisons).

SLJ demonstrated significant differences among warm-up conditions. NWU produced significantly greater values (204.28±3.64 cm) compared with TWU (198.07±3.85 cm) and IWU (187.21±5.20 cm), while TWU elicited significantly higher values than IWU (p<0.001 for all comparisons).

CMJ reported significant differences among warm-up conditions, with NWU showing significantly greater values (32.98±0.83 cm) than TWU (31.01±1.10 cm) and IWU (30.62±1.9 cm) (p<0.001 for both comparisons).

SJ-BJ showed significant differences among warm-up conditions. NWU elicited significantly greater values (37.02±0.88 cm) than TWU (35.54±0.80 cm) and IWU (32.23±3.12 cm), while TWU determined significantly higher values compared with IWU (p<0.001 for all comparisons).

No significant differences were found in the number of jumps performed during RCMJ among warm-up conditions, with values of 12.7±0.8 jumps, 12.8±0.9 jumps and 12.5±0.6 jumps following TWU, NWU and IWU, respectively.

MJH recorded during RCMJ significantly differed among warm-up conditions. NWU produced significantly greater values (25.88±1.73 cm) compared with TWU (24.91±1.70 cm) and IWU (24.10±1.66 cm), while TWU reported significantly higher results than IWU (p<0.001 for all comparisons).

PP recorded during RCMJ demonstrated significant differences among warm-up conditions. NWU showed significantly greater values (2399.35±269.32 W) compared with both TWU (2389.50±83.33 W) and IWU (2198±107.14 W), while TWU determined significant benefits than IWU (p<0.001 for all comparisons).

MP recorded during RCMJ showed significant differences among warm-up conditions, with both TWU (2141.1±176.6 W) and NWU (2241.9±285.9 W) showing higher results than IWU (2002.9±207.9 W) (p<0.001 for both comparisons)

Table 1. Mean±SD are reported for descriptive statistics in jump performances

Variable	NWU	TWU	IWU
SJ (cm)	29.91 ± 1.64	27.92 ± 1.47	27.16 ± 1.33
SLJ (cm)	204.28 ± 3.64	198.07 ± 3.85	187.21 ± 5.20
CMJ (cm)	32.98 ± 0.83	31.01 ± 1.10	30.62 ± 1.9
SJ-BJ (cm)	37.02 ± 0.88	35.54 ± 0.80	34.47 ± 0.86
RCMJ (counts)	12.78 ± 0.89	12.85 ± 0.94	12.57 ± 0.64
RCMJ-MJH (cm)	25.88 ± 1.66	24.91 ± 1.70	24.10 ± 1.66
RCMJ-PP (W)	2399.35 ± 269.32	2389.50 ± 83.33	2198.00 ± 107.14
RCMJ-MP (W)	2241.90 ± 285.95	2141.10 ± 176.6	2002.9 ± 207.921
DJ height (cm)	24.58 ± 1.86	22.51 ± 0.92	21.41 ± 0.79
GCT (ms)	259.85 ± 9.67	287.35 ± 16.02	307.78 ± 19.5

Note. SJ: squat jump; SLJ: standing long jump; CMJ: countermovement jump; SJ-BJ: squat jump – block jump; RCMJ: repeated countermovement jump; MJH: average jump height; PP: peak power; MP: average power; DJ: drop jump; GCT: ground contact time

DJ height showed significant differences among warm-up conditions. NWU produced significantly greater values (24.58±1.86 cm) compared with both TWU (22.51±0.92 cm) and IWU (21.41±0.79 cm), while TWU elicited significant advantages than IWU (p<0.001 for all comparisons).

GCT collected during DJ showed significant differences among warm-up conditions . NWU elicited significantly shorter GCT values (259.85±9.67 ms) compared with both TWU (287.35±16.02 ms) and IWU (307.78±19.53), while TWU produced significantly shorter GCT than IWU (p<0.001 for all comparisons).

Figure 1-2-3 summarize the main outcomes in jump performance and power output across the three warm-up protocols (NWU, TWU and IWU).

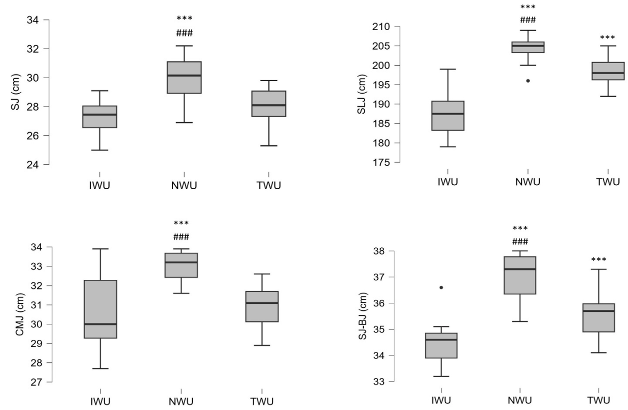

Fig. 1. Jump performance (SJ, SLJ, CMJ, SJ-BJ) after three warm-up protocols. Note. SJ: squat jump; SLJ: standing long jump; CMJ: countermovement jump; SJ-BJ: squat jump – block jump; IWU: isometric warm-up; NWU: neuromuscular warm-up; TWU: traditional warm-up; ***p<0.001 vs. IWU; ### p<0.001 vs. TWU

Table 2. Results of Friedman test for jumping performance

Variable	$\chi^2_{Friedman}$	df	p	$W_{Kendall}$	95% CI
SJ (cm)	28.00	2	<0.001	1.00	[1.00; 1.00]
SLJ (cm)	28.00	2	<0.001	1.00	[1.00; 1.00]
CMJ (cm)	15.64	2	<0.001	0.56	[0.25; 0.63]
SJ – BJ (cm)	28.00	2	<0.001	1.00	[1.00; 1.00]
RCMJ – MJH (cm)	28.00	2	<0.001	1.00	[1.00; 1.00]
RCMJ – PP (W)	22.42	2	<0.001	0.80	[0.50; 1.00]
RCMJ – MP (W)	10.42	2	0.005	0.37	[0.29; 0.60]
DJ (cm)	25.78	2	<0.001	0.92	[1.00; 1.00]
GCT (ms)	28.00	2	<0.001	1.00	[1.00; 1.00]

Note. SJ: squat jump; SLJ: standing long jump; CMJ: countermovement jump; SJ-BJ: squat jump – block jump; RCMJ: repeated countermovement jump; MJH: average jump height; PP: peak power; MP: average power; DJ: drop jump; GCT: ground contact time; χ2: Friedman chi-square statistic; df: degrees of freedom; CI 95%: confidence interval.

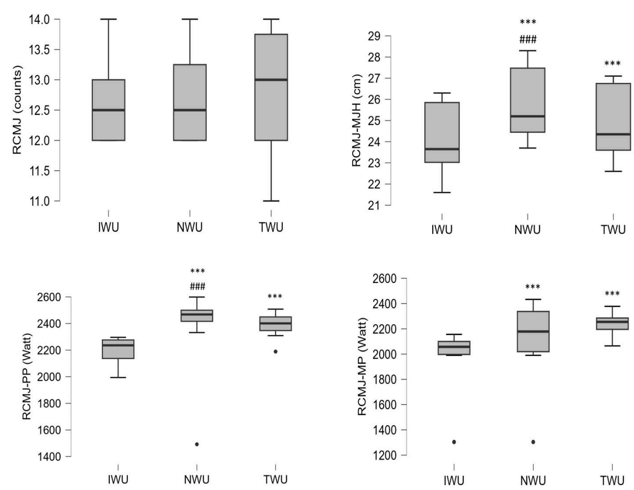

Fig. 2. RCMJ performance after three warm-up protocols. Note. RCMJ: repeated countermovement jump; MJH: average jump height; PP: peak power; MP: average power ***p<0.001 vs. IWU; ### p<0.001 vs. TWU

Discussion

The aim of the present study was to assess the effects of different warm-up protocols on jumping performance and muscle power in Under-17 volleyball players.

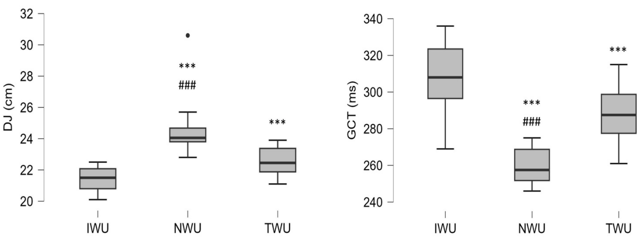

Fig. 3. Drop jump outocomes (height and GCT) after the three warm-up protocols.DJ: drop jump; GCT: ground contact time; ***p<0.001 vs. IWU; ### p<0.001 vs. TWU

The hypothesis that incorporating plyometric exercises into the warm-up routine could induce significant changes in jumping performance, muscle power and neuromuscular responsiveness was supported by the results.

Jumping performance, particularly in the SJ, CMJ, SLF and SJ–BJ tests, demonstrated that U17 players can benefit from a warm-up protocol involving rapid plyometric muscle contractions. Indeed, the neuromuscular warm-up (NWU) elicited significantly higher values across all four jumping assessments compared with both traditional (TWU) and isometric (IWU) warm-up protocols. These findings suggest that the plyometric exercises effectively improve the ability of young volleyball players to elevate their centre of mass. The vertical jump values observed in the present study are consistent with those reported in the literature for Under-16 volleyball players (Bertozzi et al., 2025; Nikolaidis et al., 2012).

Similarly, horizontal jump performance was comparable to, and in some cases exceeded, values reported for volleyball players of similar or slightly older age groups (Deng et al., 2025; Zhu & Cui, 2024; Trajkovic et al., 2024).

These findings may be partially explained by the characteristics of the study sample. Specifically, participants competed at sub-elite level and frequently performed plyometric exercises due to limited access to gyms equipped for resistance training. This contextual factor may have improved their technical execution in plyometric tasks, which require a high levels of neuromuscular control and motor coordination.

However, no significant differences were found in the RCMJ test among the three warm-up protocols. This result may be attributed to the brief duration of the test (15 s), which may have been insufficiently to elicit meaningful differences in jump count. To date, few studies have applied this specific assessment in Under-17 volleyball players, whereas longer repeated jump tests (e.g., 30 s) have primarily been applied in professional athletes (Soslu et al., 2022).

Despite the absence of differences were observed in jump frequency, the NWU elicited greater benefits for MJH, PP and MP outcomes compared with the other warm-up protocols.

These findings reflect the specific physical demands of volleyball, which involve repeated jumps actions while counteracting fatigue and maintaining neuromuscular efficiency throughout the match (Soslu et al., 2022; Hernandez-Martinez et al., 2023).

The inclusion of plyometric exercises in the NWU likely improved the elastic properties of the musculotendinous structures, thereby promoting enhanced mechanical performance during repetead jumping tasks (Papagiannis et al., 2024; Ramirez-Campillo et al., 2022).

According to some authors, repetitive high-intensity jumps may also facilitate more efficient motor unit recruitment and firing patterns, which are essential for generating high levels of force and power (Behrens et al., 2016).

A similar trend in jumping performance was observed following the TWU compared with IWU.

This result may be explained by the inclusion of additional sport-specific plyometric drills during the final phase of the TWU, which likely may have induced greater neuromuscular activation than prolonged isometric contractions.

Comparable effects have been reported in the literature for sprinting, jumping and throwing performance (Seitz et al., 2016).

Overall, the present findings emphasize the importance of carefully planning all phases of the training session. This observation is particularly relevant in sports characterized by ballistic movements, as these are associated with a high risk of non-contact injury (Aquino et al., 2022; Altavilla et al., 2023; Watanabe et al., 2016).

Therefore, it is particularly essential to understand the effects of specific warm-up exercises in youth sports in order to appropriately adapt all phases of the training sessions.

Indeed, literature consistently highlights findings derived from adult populations should not be directly extrapolated to young athletes (Ramirez-Campillo et al., 2023).

During maturation, biological processes such as rapid increases in stature, potential temporary alteration in motor coordination, large increases in fat-free mass and changes to muscle–tendon architecture may influence responsiveness to plyometric exercise (Ramirez-Campillo et al., 2022, 2023).

Conversely, the findings of the present study suggest that isometric exercises applied during warm-up did not provide meaningful benefits for jumping performance in young volleyball players.

Accordingly, greater emphasis should be placed on warm-up protocols incorporating high-speed plyometric movements (e.g., NWU) or partially including them (e.g. TWU), in order to enhance vertical and horizontal jump performance. In contrast, warm-up protocols based primarily on isometric exercises appear to be less effective for improving these performance outcomes.

Similar benefits of plyometric-based warm-up strategies have also been observed in other sports, in which vertical jump performance is nota a primary performance determinant.

In line with this observation, a recent study has revealed that including hops, skipping and sport-specific jumps during warm-up improved CMJ performance for up to 9 minutes post-warm-up (Papagiannis et al., 2024).

Therefore, we suggest incorporating plyometric exercises within the warm-up due to enhanced stretch-reflexes activation, elastic energy reutilization, motor unit recruitment and the rate of force development (Ramirez-Campillo et al., 2022; Wu et al., 2025; Tillaar et al., 2020).

Additionally, combining initial metabolic activation with plyometric exercises, as implemented in the NWU, may be crucial for triggering PAPE. Previous studies have reported that increases in muscle temperature and excitability of high-threshold motor units may persist for up to 20 minutes following warm-up (Villalon-Gasch et al., 2022).

In contrast, the limited effects obtained following the IWU suggest that the role of isometric exercises during warm-up should be carefully reconsidered in volleyball context.

In this regard, while the present findings differ from those reported in soccer players (Jarosz et al., 2025), they align with the results observed in handball players regarding jumping performance (Krzysztofik et al., 2022).

It is worth noting that the present study did not include maximal isometric contractions against external resistance (Helbin et al., 2025); instead, exercises were performed using only body weight and maintained for a prolonged time interval (30 s).

Accordingly, the absence of external resistance and the nature of the isometric stimulus may not have been sufficient to elicit meaningful neuromuscular activation, potentially explaining the limited effectiveness of the IWU.

In conclusion, the type of warm-up appears to be particularly relevant in sports requiring explosive and high-speed actions, since it can directly affect both training quality (e.g., neuromuscular-oriented sessions) and competition performance (Papagiannis et al., 2024).

Therefore, the results of this study demonstrate that PAPE may be observable in Under-17 female volleyball players when appropriate warm-up exercises are selected.

The study could provide insights into warm-up strategies in youth clubs that have limited opportunities to resistance training equipment.

Although this study provides valuable practical applications, it is necessary to note some limitations and be very prudent in interpreting the results for several different reasons.

First, the sample observed had correct jump technique because this type of exercise was frequently used by the staff: this factor may have increased the efficiency of the integrative warm-up strategies.

Second, data collection occurred in a mid-season break, during which training frequency was reduced. Finally, the small sample size limits the generalisability of the findings, which should be considered preliminary.

Further research should investigate NWU protocols with different workloads in order to provide further guidance for practitioners.

Moreover, further analysis must be conducted to understand the volumes of neuromuscular exercise that can be introduced into the warm-up without inducing fatigue in young volleyball players.

Additionally, it may also be interesting to investigate the effectiveness of NWU protocols by comparing elite and sub-elite athletes, as well as to explore how strength and conditioning coaches can integrate supplementary exercises into warm-up routines to optimise performance outcomes in youth volleyball.

Conclusions

The findings of this study indicate that the type of warm-up protocol plays a decisive role in jumping performance and muscle power in Under-17 female volleyball players. A neuromuscular warm-up incorporating high-speed plyometric exercises (NWU) was consistently more effective than traditional and isometric protocols in enhancing vertical and horizontal jump performance. In contrast, warm-up routines based primarily on isometric exercises without external resistance did not provide meaningful performance benefits. These results suggest that appropriately structured plyometric-based warm-up strategies may facilitate PAPE effects in youth volleyball players, particularly in contexts with limited access to resistance training equipment.

Ethics Approval

Ethical approval for this study was granted by the Ethics Committee of the University of Foggia (Approval No. 00149ss/2024, dated October 1, 2024).

Informed Consent

Written informed consent was obtained from all participants involved in the study.

Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

AI Transparency Statement

The authors declare that no artificial intelligence (AI)–assisted tools were used in the preparation of this manuscript.

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Conflict of Interest

The authors declare that there is no conflict of interest related to this study.

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Чи впливають стратегії розминки на показники стрибкової працездатності юних волейболісток?

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 9 с., 2 табл., 3 рис., 52 джерела.

Мета. Метою дослідження було оцінити, чи сприяє розминка з включенням пліометричних вправ більшому підвищенню стрибкової працездатності, потужності та нейром'язової реактивності порівняно з розминками, які зазвичай застосовуються у волейбольній практиці.

Матеріали і методи. У дослідженні взяли участь 24 волейболістки субелітарного рівня (вік: 16,3 ± 0,6 року; маса тіла: 58,7 ± 3,8 кг; зріст: 165,6 ± 6,8 см), які представляли регіональний клуб. Учасниці виконували три різні протоколи розминки тривалістю по 20 хвилин кожен: традиційну розминку (TR), нейром'язову розминку (NR) та ізометричну розминку (IR). З метою мінімізації впливу втоми три експериментальні сесії проводилися з інтервалом 48 годин. Після завершення кожного протоколу розминки учасниць у випадковому порядку тестували за допомогою стрибка з напівприсіду (SJ), стрибка з попереднім замахом (CMJ), стрибка в довжину з місця (SLJ), стрибка з напівприсіду – блокувального стрибка (SJ–BJ), повторного стрибка з попереднім замахом (RCMJ) та стрибка вниз (DJ).

Результати. Результати тестів стрибкової працездатності показали вищі та статистично значущі значення ($p < 0{,}001$) після застосування нейром'язової розминки. Порівняно з ізометричною розминкою, традиційна розминка забезпечувала вищі показники у тестах SLJ, SJ–BJ, RCMJ, а також менший час контакту з опорою під час виконання тесту DJ.

Висновки. Нейром'язова розминка є особливо ефективною у видах спорту, що вимагають вибухових високошвидкісних рухів, оскільки вона може безпосередньо впливати на якість тренувального процесу та стрибкову працездатність у змагальній діяльності. Отримані результати свідчать про те, що ефект постактиваційного підвищення працездатності (PAPE) може проявлятися у волейболісток до 17 років за умови застосування адекватно підібраних вправ розминки. Дослідження надає практичні орієнтири щодо вибору стратегій розминки у дитячо-юнацьких клубах з обмеженим доступом до силового тренувального обладнання.

Ключові слова: стрибок, волейбол, PAPE, нейром'язова інтегративна вправа, пліометрія.

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