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Effects on Performance, Perception, and Awareness of Plyometric Training in Youth Volleyball: A Novel Methodological Approach to Training

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Abstract: Plyometric training is known to improve jump height in volleyball, but few studies address athletes' perception and awareness of its benefits. This gap limits its full potential for enhancing performance. This study examines young non-elite volleyball athletes' awareness of plyometric training effects. A sample of 24 athletes (mean age 18.3 ± 3.8 years) was divided into an experimental group (EXP) and a control group (CON), each with 12 participants. The EXP group underwent plyometric training, while the CON group performed basic technical exercises. Performance and perceptions were assessed using the Spike Jump Test and surveys at pre-, mid-, and post-training phases. The EXP group showed significant vertical jump improvement, from a pre-training mean of 30.14 cm to 32.22 cm post-training, confirmed by the Friedman test (p = 0.00). In contrast, the CON group showed no significant changes (p = 0.47). Perception scores in the EXP group improved significantly, from 3.33 to 4.16, indicating enhanced awareness of plyometric training benefits, whereas the CON group showed no significant changes (p = 0.35). These findings highlight the dual benefits of plyometric training in improving both jump performance and awareness of its effectiveness, emphasizing the value of integrating perception into training for volleyball athletes.

Keywords: vertical jump; volleyball; spike jump test; plyometric training

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1. Introduction

Volleyball is a team sport marked by short bursts of explosive activity, such as serves, receptions, passes, spikes, sprints, and jumps [1,2]. Primarily an offensive game [3], it demands both technical precision and physical power to achieve high performance [4]. Vertical jumping and explosive movements are particularly significant during matches, paralleling their importance in other sports such as soccer and basketball [5]. Accordingly, it is essential for volleyball athletes to develop not only advanced technical skills but also the requisite strength to execute these dynamic movements with efficiency [6]. Vertical jumping is a fundamental element of gameplay technique, particularly in spiking and blocking [7]. There are two primary approaches to enhancing jumping ability: refining motor patterns through repetition and movement optimization and stimulating the stretch-shortening cycle of muscles via plyometric training [8]. Repeating motor patterns improves intra- and inter-muscular coordination, resulting in greater strength [9]. Furthermore, beyond the motor aspects, learning movements aimed at enhancing power also foster the development of cognitive structures, thereby reinforcing these neuromuscular patterns [10]. Enhancing motor patterns not only improves physical performance but also enables athletes to achieve greater efficiency in movement execution.

Plyometric training is the most widely used method for improving vertical jump ability. This form of training, which targets explosive strength and muscular power, has demonstrated positive effects on various athletic skills, including strength [11], agility [12,13], and sprint speed [14]. It is particularly suitable for sports requiring explosiveness, such as volleyball, where vertical jump height serves as the primary performance indicator [15]. Among plyometric exercises, the Vertical Drop Jump is one of the most employed to enhance neuromuscular readiness and the explosive power of the lower limbs [16]. In the realm of injury prevention, it is essential to recognize that landing, particularly after explosive movements like a volleyball spike, is often associated with a high risk of injury. Recent studies have highlighted the significant role that proper landing mechanics play in reducing injury risk [17,18]. Improper landing techniques can lead to various musculoskeletal injuries, particularly in the lower extremities, which are common in volleyball players due to the repetitive and high-impact nature of their jumps [19]. For instance, landing mechanics following a volleyball spike were shown to significantly influence the likelihood of injury [20]. Such findings underscore the importance of not only improving performance but also ensuring the safety of athletes by emphasizing safe landing techniques during plyometric training. By addressing both the performance enhancement and injury prevention aspects, volleyball training protocols can be more effective in fostering both physical development and long-term athletic sustainability [21].

Although the scientific literature clearly highlights the effectiveness of plyometric training in enhancing vertical jump performance, limited attention has been given to athletes' perceptions of the benefits associated with such training. Awareness of the advantages of a training protocol plays a pivotal role in an athlete's emotional engagement, positively influencing motivation and the improvement process. It is therefore essential for athletes not only to observe improvements in their performance but also to understand how and why these improvements occur [22]. However, most studies focus exclusively on the quantitative aspects of performance, neglecting the qualitative dimension related to athletes' perception and awareness.

The present pilot study aims to investigate the effectiveness of plyometric training in enhancing vertical jump performance by integrating quantitative data on athletic performance with the qualitative aspects of athletes' perception and awareness of the benefits achieved. The objective is to provide an innovative methodological approach that unites these two aspects, helping to fill the gap in the literature that separates objective performance outcomes from athletes' subjective experiences. In doing so, the study seeks to optimize training methods, enhancing not only physical performance but also athletes' motivation and awareness.

2. Materials and Methods

2.1. Type of Study

This pilot study is a controlled, longitudinal experiment designed to evaluate the effects of plyometric training on vertical jump performance. The intervention lasted six weeks and followed a structured weekly schedule of five training sessions and one competition day. Performance was assessed using the Spike Jump Test at three time points: pre-training, mid-training, and post-training.

2.2. Study Participants

The sample consisted of 24 female athletes, aged between 17 and 19 years, with a mean age of 18.3 ± 3.8 years, all registered at A.S.D. CUS Salerno and actively participating in sports activities. The athletes had a mean weight of 68.2 ± 6.8 kg, a mean height of 174.5 ± 6.2 cm, and a mean BMI of 20.7 ± 1.5. The sample included athletes with diverse athletic backgrounds, selected from the competitive youth sector, which competes in the Under-20 category championship, and from the university team. A convenience sampling method was used, and informed consent was obtained from all athletes, with parental consent provided for minors. All participants were briefed on the study's objectives and procedures, including the methods, duration, and resources involved. The inclusion criteria required participants to be female athletes aged between 17 and 19 years, actively involved in regular competitive volleyball training and competition. Eligible athletes were enrolled in either the Under-20 category or the university team at A.S.D. CUS Salerno. The exclusion criteria included athletes with injuries or medical conditions that would impair their ability to participate in physical activity, those not regularly engaged in training or competition, and athletes who had participated in plyometric training within the last six months. Additionally, individuals who did not provide informed consent, or whose parents did not provide consent for minors, were excluded from the study.

2.3. Procedure

The sample was divided into 2 groups: experimental (EXP) and control (CON), each consisting of 12 participants. The athletes were tested at three different times, pre-training, mid-training, and post-training, using the Spike Jump Test. After the initial tests, both groups underwent training protocols for six weeks, characterized by weekly microcycles consisting of five training sessions and one competition day. Each weekly microcycle alternated between technical/tactical exercises and conditioning protocols based on plyometrics for the experimental group, and on fundamental skills for the control group. Table 1 presents a detailed description of the general training protocol applied to both groups.

Table 1. General weekly microcycle scheme.

Training Session Description
Monday: Training session lasting 2 h, divided into 1 h 30 min of conditioning and 30 min of technical analysis (without jumps)
Tuesday: Training session lasting 2 h, consisting of 40 min of specific motor skills work with overload (high number of jumps) and 1 h 20 min of technical analysis (reduced jumps and load)
Wednesday: Training session lasting 2 h, dedicated entirely to global technical and tactical aspects
Thursday: Differentiated training session lasting 1 h 30 min, focusing on specific aspects of the discipline and certain roles, which may vary weekly
Friday: Training session lasting 2 h, focusing on tactical development for most of the session in preparation for the competition
Saturday: Competition day

The training protocol for the control group, as outlined in Table 2, was structured around fundamental exercises with a load progression approach. This methodology focused on gradually increasing the intensity, frequency, and volume of the exercises to ensure progressive overload, while maintaining emphasis on proper technique and coordination. Initially, the intensity of each exercise was set at a moderate level, with a frequency of

2–3 sessions per week. As the training progressed, the intensity was incrementally increased by incorporating more demanding movements or additional resistance. Additionally, the volume of repetitions and sets was progressively elevated, ensuring a gradual adaptation to the exercises. The frequency of sessions remained consistent throughout the study to allow for adequate recovery and prevent overtraining. This structured progression was designed to enhance strength, endurance, and coordination without placing undue strain on the participants. The exercises included foundational movements and drills aimed at improving overall physical conditioning, with a particular focus on building strength, stability, and muscular endurance. In contrast, the training for the experimental group, also detailed in Table 2, followed a progression rooted in the plyometric component. This program began with low-impact plyometric exercises, such as jump-and-land drills emphasizing soft landings and controlled movements, and advanced to high-impact plyometric activities as the athletes adapted [23]. High-impact drills included explosive jumps, bounding exercises, and depth jumps designed to maximize power output and neuromuscular efficiency [24]. This structured progression ensured a gradual increase in intensity and complexity, minimizing injury risk while enhancing explosive strength and vertical jump performance.

Table 2. Training protocols for EXP and CON groups.

Group	Training Focus	Progression Details	Exercises
CON	Fundamental exercises with load progression	The training focused on basic strength and conditioning exercises, progressively increasing load over time to enhance strength, stability, and endurance. The exercises emphasized technique and control.	• Strength Training: Squats, deadlifts, lunges, bench press, shoulder press (using free weights, barbells, and machines). • Core Stability: Planks, leg raises, Russian twists. • Agility Drills: Ladder drills, cone weaving, short sprints.
EXP	Plyometric training with a progression from low-impact to high-impact exercises	The training began with low-impact plyometric exercises to develop explosive power with minimal joint stress. As adaptation occurred, exercises progressed to high-impact plyometric movements, increasing intensity for greater power output and jump height.	• Low-Impact Plyometrics: Box step-offs, low-intensity vertical jumps, squat jumps, lunge jumps. • Moderate-Impact Plyometrics: Depth jumps from low boxes (15–20 cm), jump rope, skipping. • High-Impact Plyometrics: Depth jumps from higher boxes (30–50 cm), bounding, tuck jumps, broad jumps, sprinting with explosive starts, plyometric push-ups.

2.4. Procedures

The Spike Jump Test was administered at three points (pre, mid, and post) over six weeks, using the Vertek, a commonly used tool in volleyball to measure jump height [25]. A standardized starting line was marked for all participants, from which each athlete performed a specific approach for their jump, preceded by a run-up. The distance of the assisted run was standardized to 10 m, based on the typical approach run distances, to ensure consistency across all participants. Athletes began the run-up with the non-dominant leg, and they were asked to jump as high as possible, focusing on achieving maximum extension of the dominant leg above their head. The jump was performed with both legs, utilizing a two-legged take-off. During this phase, the coach or tester did not focus on jump technique, but rather on the athlete's maximal force expression and jump height.

Before performing the test, all athletes underwent a standardized warm-up lasting 20 min. The warm-up was identical for both groups and for all measurements, minimizing variables related to differences in warm-up protocols. After completing the general and specific warm-up for the jump, athletes performed the jump tests with the Vertek. Each athlete performed three jumps during the test session, with sufficient recovery time allowed between attempts based on their perceived physical condition to minimize fatigue. Jump height was recorded for each attempt, and the average of the three recorded jump heights was calculated to obtain the final result. The three measurements (pre, mid, and post) were performed in succession, with a standardized starting distance for all participants. Each athlete performed three jumps, with individualized recovery time based on their perceived physical condition. After the jumps, the jump heights achieved by each athlete were recorded, and the average of the jump heights was calculated.

2.5. Survey

To assess possible differences in perception between the EXP and CON groups regarding the effects of plyometric training on athletic performance improvement, a perception survey was developed and administered. The survey, with multiple-choice questions on a 1-to-5 Likert scale, was distributed via Google Forms. The survey was administered at three different points: at the beginning (pre-training), midway through the program (mid-training), and at the end (post-training). The questions in the survey are shown in Table 3.

Table 3. Perception survey.

Pre-training (responses on a scale from 1 to 5):	• How useful do you think a plyometric training program is for improving your physical performance? • How motivated are you to follow a training protocol to improve your explosive strength? • How prepared do you feel physically to start a plyometric training program?
Mid-training (during the study):	• How much do you feel the training program you are following is improving your explosive strength? • How much do you perceive an improvement in your ability to perform plyometric exercises compared to the beginning? • How challenging but effective do you find the training program for achieving your goals?
Post-training:	• How much do you perceive the plyometric protocol (or the training you followed) has improved your overall performance compared to before the study? • How much do you feel your explosive strength has improved as a result of the training program? • How satisfied are you with the results obtained from the training program?

2.6. Statistical Analysis

Given the non-normal distribution of the data, a non-parametric statistical approach was used to ensure the appropriateness of the analyses. Specifically, the Friedman test, a non-parametric version of the repeated measures ANOVA, was used to assess differences in scores within each group across the three time points (pre, mid, and post). To further explore specific differences between the time phases, post hoc analyses were conducted using the

Wilcoxon test for pairwise comparisons. This approach allowed for the identification of significant differences between the pre–mid, pre–post, and mid–post scores for each group. The statistical significance level was set at $p < 0.05$ for all analyses. Data processing and analysis were conducted using the SPSS (Statistical Package for the Social Sciences; version 22; IBM, Armonk, NY, USA) software.

3. Results

Table 4 presents the vertical jump scores (in centimeters) collected at different time points (pre, mid, and post) for both the experimental and control groups. The means and standard deviations are calculated for each time point, illustrating the performance trends in the two groups. The control group (CON), which followed a program focused on fundamental exercises with progressive loads, showed a modest increase in vertical jump height of 0.32 cm, rising from 28.06 cm at the pre-test to 28.38 cm at the post-test (+1.1%). In contrast, the experimental group (EXP), which followed a plyometric-only training protocol, demonstrated a more substantial improvement of 2.08 cm, increasing from 30.14 cm at the pre-test to 32.22 cm at the post-test (+6.9%).

Table 4. Vertical jump data for EXP and CON groups.

Athletes	EXP Pre	EXP Mid	EXP Post	CON Pre	CON Mid	CON Post
1	31.4	33.9	36.4	28.41	28.57	28.5
2	27.8	28.6	29.4	27.32	27.29	27.86
3	25.6	28.1	30.6	27.78	28.13	28.65
4	30.9	31.05	31.2	29.47	29.35	29.52
5	36.2	39.3	32.4	27.28	27.46	27.77
6	23.5	23.9	24.3	27.77	27.86	27.77
7	26.4	27.55	28.7	29.13	29.31	29.58
8	25.6	25.75	25.9	28.9	28.34	28.77
9	29.9	32.55	35.2	27.97	28.97	27.53
10	35.1	36.55	38	28.16	28.47	28.54
11	33	35.2	37.4	27.8	27.56	27.54
12	36.3	36.75	37.2	26.74	27.11	28.53
Mean	30.14	31.60	32.22	28.06	28.20	28.38
SD	4.41	4.87	4.65	0.80	0.76	0.70

The EXP showed a significant increase in vertical jump height over time, with an increase evident as early as the middle of the training program and further growth at the end of the program. The CON, on the other hand, showed no substantial change over time, with relatively stable values at all stages. This suggested that the intervention adopted in the EXP group had a positive effect on vertical jump performance compared with the control group. A detailed description is depicted in Figure 1.

The Friedman test results, reveal a statistically significant difference in the experimental group's scores over time (F = 10.24; $p = 0.00$). Post hoc analysis using the Wilcoxon test indicates a non-significant difference between the initial and mid scores (F = 6.0; $p = 0.60$). However, a statistically significant difference is observed between the pre- and post-scores (F = 2.5; $p = 0.01$), as well as between the mid- and post-scores (F = 3.5; $p = 0.01$). In contrast, the Friedman test for the control group shows no significant results ($p = 0.47$). Post hoc analysis indicates no significant changes in scores between the pre- and post-values (F = 17.0; $p = 0.09$), pre- and mid-values (F = 18.0; $p = 0.11$), or mid- and post-values (F = 26.0; $p = 0.33$). This reflects stable performance levels within the control group. Tables 5 and 6 summarizes the Friedman test results and the post hoc analyses conducted to identify differences in scores across the three time points for both groups.

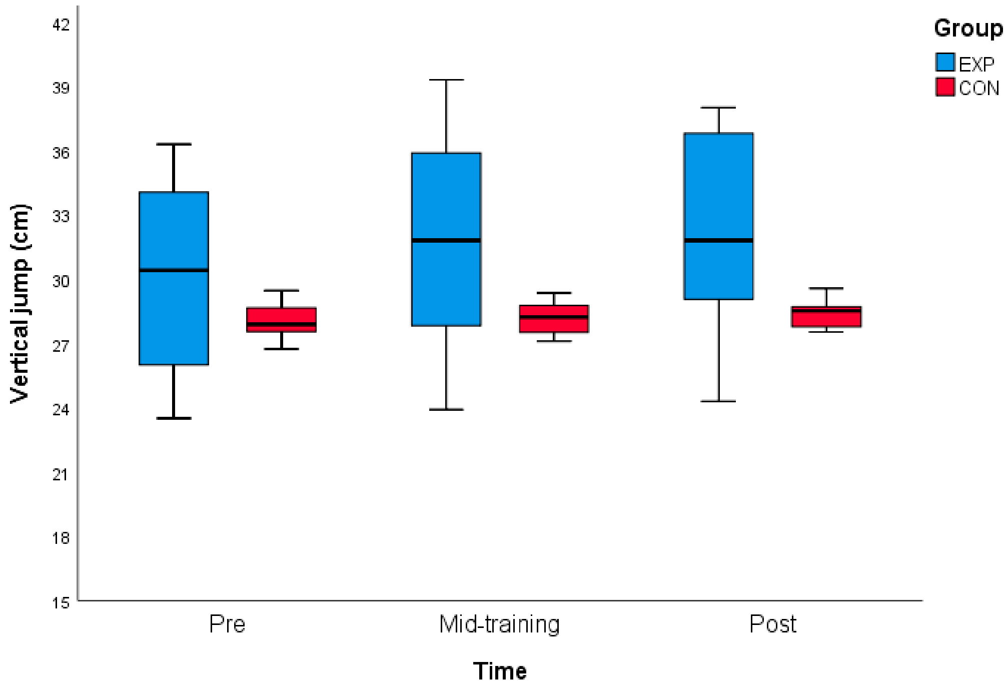

Figure 1. Vertical jump results comparison between EXP and CON during time.

Table 5. Friedman test results and post hoc analysis for vertical jump test.

Variable	χ^2_F	*p*-Value	Comparison	*p*-Value
EXP	10.24	0.00	Pre vs. Mid	0.60
			Pre vs. Post	0.01
			Mid vs. Post	0.01
CON	2.67	0.47	Pre vs. Mid	0.11
			Pre vs. Post	0.09
			Mid vs. Post	0.33

Table 6. Mean perception scores for EXP and CON groups across three time points.

Athletes	EXP Pre	EXP Mid	EXP Post	CON Pre	CON Mid	CON Post
1	2	4	4	3	2	3
2	4	4	4	3	3	5
3	3	3	4	3	3	3
4	3	3	4	3	4	3
5	3	4	4	3	4	3
6	4	3	4	3	3	3
7	4	2	4	4	3	3
8	3	3	4	3	4	3
9	2	4	5	3	3	3
10	4	4	3	3	3	3
11	4	4	5	4	3	3
12	4	4	5	2	3	3
Mean	3.33	3.50	4.16	3.08	3.16	3.16
SD	0.77	0.67	0.57	0.51	0.57	0.57

The Friedman test results in Table 7, indicate a statistically significant difference in perception scores for the experimental group (EXP) over time ($\chi^2_F = 10.24$; $p = 0.006$). Post hoc analysis reveals no statistically significant difference between pre- and mid-scores (χ^2_F = 5.5; p = 0.607), but significant differences are observed between pre–post (χ^2_F = 3.0; p = 0.016) and mid–post (χ^2_F = 4.0; p = 0.012). For the control group (CON), the Friedman test shows no significant differences in perception scores across the three time points (p = 0.352). Post hoc comparisons for pre–mid (χ^2_F = 28.0; p = 0.424), pre–post (χ^2_F = 22.0; p = 0.301), and mid–post (χ^2_F = 33.0; p = 0.575) are also not significant, indicating stable perceptions over time for the control group.

Table 7. Friedman test results and post hoc analysis for athlete perceptions.

Variable	χ^2_F	*p*-Value	Comparison	*p*-Value
EXP	10.24	0.00	Pre vs. Mid	0.60
			Pre vs. Post	0.01
			Mid vs. Post	0.01
CON	2.09	0.35	Pre vs. Mid	0.42
			Pre vs. Post	0.30
			Mid vs. Post	0.57

4. Discussion

The results obtained from the Spike Jump Test indicate that both training methodologies led to improvements in the vertical jump performance of volleyball players. The difference in jump height gains between the two groups is approximately 1.76 cm, with the EXP group achieving a greater relative improvement of 6.9% (from 30.14 cm at the pre-test to 32.22 cm at the post-test) compared to the CON group, which showed a modest improvement of 1.1% (from 28.06 cm at the pre-test to 28.38 cm at the post-test). These findings are consistent with the existing literature, which highlights the effectiveness of plyometric training in enhancing explosive power. Previous studies have reported similar trends, emphasizing the superiority of plyometric protocols over traditional strength-based approaches for jump performance enhancement. Research conducted by D'Elia et al. [26] on under-16 volleyball players reported significant enhancements in vertical jump ability after one month of plyometric training. Jakšić et al. [27] observed similar improvements in handball players, while Čaprić et al. [28] demonstrated that a six-week plyometric training program significantly enhanced neuromuscular performance in soccer players. Collectively, these studies and the current findings suggest that plyometric training is an effective method for improving vertical jump ability across various sports.

The responses to the perception survey further reinforce the differences observed between the two groups. Athletes in the EXP group reported greater awareness of the benefits of the plyometric protocol. Specifically, they indicated an improvement in vertical jump performance and expressed a higher perception of achievement compared to previous training methodologies. The perception scores in the EXP group increased from a mean of 3.33 on the pre-test to 4.16 at the post-test, reflecting a positive shift in their self-assessment and motivation. In contrast, the CON group showed relatively stable perceptions over time, with minimal changes in their self-reported awareness or perceived performance gains. Their perception scores remained constant at 3.08 across all time points (pre, mid, and post), suggesting no significant change in their belief about the effectiveness of their training.

Comparing the results of the perception survey, the EXP group demonstrated a significant increase in their perception scores, with a mean increase from 3.33 at pre-test to 4.16 at post-test (a change of approximately 0.83 points), which aligns with the substantial performance gains observed in the vertical jump test. This reflects the athletes' growing awareness of their progress and their increased confidence in the training's effectiveness. In contrast, the CON group showed no significant change in perception scores, with a stable mean score of 3.08 across all time points. This discrepancy could suggest that the EXP group not only benefited from physical improvements but also felt more motivated and engaged in the training process, possibly due to the novelty and intensity of the plyometric exercises. It is essential to acknowledge that the specificity of the plyometric protocol, which focused on targeted high-impact exercises, may have shaped the athletes' expectations and potentially induced a placebo effect. This psychological influence could have amplified the perceived effectiveness of the training, thereby affecting the study's outcomes. To mitigate such biases in future research, adopting strategies such as a double-blind design, where athletes remain unaware of the specific training regimen they are undertaking, could be beneficial. Additionally, ensuring that all groups receive comparable levels of attention and engagement during training sessions may further help to control psychological influences and enhance the validity of the findings.

Despite the promising outcomes, the study is not without limitations. Notably, the study lacks a formal sample size calculation and is based on a convenience sample of 24 athletes. As such, it should be regarded as a pilot study, and the conclusions drawn should be interpreted as preliminary approximations of the subject. The relatively short six-week duration of the training protocol may have limited the extent of observable improvements, particularly among athletes with already high baseline performance levels. The differences in training protocols between the experimental and control groups complicate the attribution of improvements in the experimental group solely to the plyometric training, as the inherent differences between the protocols may have also influenced the results. Additionally, relying on the Spike Jump Test as the sole performance metric may have constrained the scope of the findings, as it does not account for variables such as jump technique or fatigue resistance, which are critical in real-game scenarios. Furthermore, the use of a 1-to-5 Likert scale in the perception survey may not have been sufficiently sensitive to detect subtle variations in athletes' perceptions of the training effects. A more detailed scale or the inclusion of additional qualitative feedback could provide a more comprehensive understanding of the athletes' experiences.

The findings of this study offer valuable insights for volleyball coaches and athletes seeking to enhance vertical jump performance. The improvements observed in the EXP group suggest that plyometric training is particularly effective in developing muscular power and enhancing the speed of explosive movements. Moreover, the increased awareness of the benefits of plyometric training among athletes in the EXP group highlights its potential to enhance motivation, fostering greater commitment and overall performance improvements. In contrast, the relatively stable perceptions of the CON group indicate that traditional training methods may not evoke the same level of engagement or perceived effectiveness. This suggests that athletes in the CON group did not experience the same sense of progress or motivation that their counterparts in the EXP group did, despite the modest physical improvements in their vertical jump scores.

Future research could address some of the limitations of this study by extending the duration of the training protocol to determine whether the observed improvements are sustainable over time. Including additional performance metrics, such as agility, endurance, and speed tests, would provide a more comprehensive assessment of the effects of plyometric training [29,30]. Investigating the biomechanical mechanisms underlying the observed improvements could also offer a deeper understanding of the factors driving performance gains [31–33]. Additionally, expanding the sample size, including elite players, would enhance the generalizability of the findings. Comparing plyometric training with hybrid training protocols that combine fundamental exercises with progressive loads would help identify the most effective approaches for improving overall athletic performance.

5. Conclusions

The results suggest that plyometric training has a positive impact on improving athletic performance, particularly in terms of vertical jump height. Although the experimental group showed greater improvements compared to the control group, this confirms the potential of this type of training to enhance explosive power. Additionally, the increased awareness of the benefits of the program in the experimental group highlights the importance of the psychological aspect in athlete motivation and engagement during training. This study indicates that plyometric training not only improves physical performance but can also contribute to increasing motivation and athletes' awareness of the long-term benefits of such a program. Future research could further explore these aspects, including the relationship among awareness, motivation, and performance.

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Institutional Review Board Statement: All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki. According to Regulation (EU) 536/2014 and Directive 2001/20/EC, research involving minimal risks to participants may be exempt from formal ethical review, as it does not involve invasive or experimental interventions. Additionally, under Legislative Decree No. 211 of 24 June 2003, research that does not pose significant risks and is aimed at improving educational practices might be exempt from Institutional Review Board (IRB) or Ethics Committee review and approval.

Informed Consent Statement: Informed consent was obtained from the parents or guardians of all child participants in the study. Each parent or guardian was assured of the anonymity of their child and was provided with complete and transparent information about the content, purpose, and procedures of the research in a clear and understandable manner. Participation was entirely voluntary, and no child was forced to take part.

Data Availability Statement: All data generated or analyzed during this study are included within the manuscript.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

EXP	experimental group
CON	control group

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