

Impact of plyometric training on skill component in young volleyball players

 Aida Shehu^{1*},  Altin Gorenca²,  Dean Qefalia³

¹Department of Sports Collective, Faculty of Movement Sciences, Sports University of Tirana, Albania; ashehu@ust.edu.al (A.S.).

²Department of Physical Education and Sports, Faculty of Social Sciences, Tourism and Sports, Barleti University, Albania; altin.gorenca@hotmail.com (A.G.).

³Sports Activities Specialist, Tirana Medical University, Albania; deanqefalia@gmail.com (D.Q.).

Abstract: This study aimed to examine the effectiveness of a 12-week plyometric training program in improving agility in young male volleyball players. Methods: 42 volleyball players (mean age = 15 ± 1.3 years) from Tirana, Albania, with five years of experience and training four times a week for 90 minutes, participated in the study. Participants were randomly assigned to an experimental group (EG, $n = 21$) and a control group (CG, $n = 21$). EG completed a 12-week plyometric program with seven exercises, three times a week for 20 minutes after regular ball training. Groups were assessed before and after the intervention on anthropometric measures (body height, body weight, BMI) and agility tests (T-Test and Conical Agility Training). Descriptive statistics and ANOVA ($p < .05$) were used to analyze the data. Results: Significant improvements were observed in EG. T-Test performance increased from 14.11 s to 15.42 s, and Conical Agility Training improved from 13.43 s to 11.25 s, CG showed minimal changes. Conclusions: A 12-week plyometric program effectively and rapidly increases agility in young male volleyball players. These findings highlight the importance of incorporating structured plyometric exercises into regular training sessions to improve multidirectional and lateral agility.

Keywords: *Agility skill, Plyometric, Training, Volleyball, Young.*

1. Introduction

Volleyball is widely acknowledged as a highly dynamic, intermittent, and complex team sport, characterized by rapid transitions between offensive and defensive phases, as well as by the continuous interaction of technical, physical, and cognitive components [1]. The multifactorial nature of performance in volleyball requires athletes to execute a broad range of motor actions, such as jumping, landing, sprinting, and multidirectional movements, within highly constrained temporal and spatial conditions. Consequently, optimal performance is not determined solely by technical proficiency in fundamental skills, including passing, attacking, and ball reception, but is also strongly influenced by the development of specific physical and motor capacities, such as agility, speed, coordination, strength, and balance [2].

Within this framework, agility has been consistently identified as a critical determinant of performance in volleyball. Traditionally, agility has been defined as the ability to rapidly change body position or direction in response to a given stimulus [3]. However, this classical definition has been increasingly challenged for its reductionist nature, as it primarily emphasizes the physical dimension of movement while neglecting the underlying perceptual and cognitive processes. Contemporary perspectives conceptualize agility as a multidimensional construct, integrating both change-of-direction speed (CODS) and perceptual–decision-making abilities. In this regard, motor qualities such as

explosive strength, dynamic balance, flexibility, and inter- and intramuscular coordination are considered essential contributors to agility performance [4].

Furthermore, Sheppard and Young [5] proposed a more comprehensive model of agility, highlighting the importance of cognitive components, including stimulus perception, anticipation, and decision-making processes. This expanded conceptualization is particularly relevant in the context of volleyball, where players are frequently required to respond to unpredictable and rapidly evolving game situations. Actions such as attacking, blocking, and defensive coverage necessitate not only rapid execution of movement but also the ability to process visual information, anticipate opponents' intentions, and select appropriate motor responses under time pressure. Supporting this perspective, Horička et al. [6] emphasized that perceptual factors, such as anticipation and situational awareness, play a fundamental role in the execution of agile movements in sport-specific contexts.

Although agility is often associated with speed, these constructs represent distinct yet interrelated performance components. Speed is generally defined as the capacity to perform rapid linear movements, whereas agility encompasses additional elements, including rapid deceleration, reacceleration, and efficient changes of direction [7]. Subsequent research has further refined this distinction, identifying speed as a necessary but insufficient component of agility. According to Plisk [8], agility performance is also dependent on neuromuscular control, postural stability, and the ability to adapt to continuously changing environmental stimuli. Similarly, Měkota [9] described agility as a complex motor ability arising from the interaction of multiple physical, coordinative, and neural factors.

In team sports such as volleyball, agility extends beyond purely physical execution to include perceptual-cognitive and tactical dimensions. Athletes must demonstrate the ability to anticipate opponents' actions, interpret dynamic game patterns, and respond effectively in real time [10, 11]. This highlights the importance of integrating perceptual and decision-making training into agility development programs, rather than focusing exclusively on pre-planned change-of-direction drills. Indeed, emerging evidence suggests that sport-specific agility training, which incorporates reactive and open-skill elements, may yield greater transfer to competitive performance.

The development of agility is underpinned by a structured and systematic training process that targets multiple physiological and neuromuscular components. Key factors include improvements in muscular power, rate of force development (RFD), intramuscular and intermuscular coordination, dynamic balance, and movement efficiency. Additionally, effective assessment of agility should reflect the specific demands of the sport, incorporating tasks that involve rapid acceleration, deceleration, and multidirectional changes of movement, ideally under reactive conditions.

In applied practice, coaches employ a variety of training modalities to enhance agility performance. These include technical drills focused on movement mechanics, rapid changes of direction, sprint training, and exercises targeting jumping and landing techniques. Among these methods, plyometric training has received considerable attention due to its effectiveness in improving neuromuscular function and explosive performance. Plyometric exercises, such as countermovement jumps, drop jumps, and bounding drills, are designed to enhance the stretch-shortening cycle (SSC), thereby improving the efficiency of force production and utilization during dynamic movements.

The efficacy of plyometric training in enhancing agility-related performance can be attributed to its positive effects on neuromuscular coordination, muscle-tendon stiffness, and rate of force development. These adaptations are particularly relevant for volleyball players, who frequently perform explosive and multidirectional movements during gameplay. Moreover, plyometric training has been shown to improve both pre-planned and reactive agility, especially when combined with sport-specific drills that simulate game conditions [12].

Despite the growing body of literature on agility and plyometric training, there remains a need for further research examining their combined effects in youth volleyball populations. In particular, limited evidence exists regarding the optimal design, duration, and specificity of training interventions aimed at improving agility performance in young athletes. Addressing this gap is practically important for

coaches and practitioners seeking to implement evidence-based training strategies in developmental contexts.

In light of the aforementioned considerations, the present study aims to examine the effects of a 12-week plyometric training program on the agility performance of young male volleyball players. By employing a structured, progressive, and sport-specific intervention, this research seeks to contribute to the existing body of knowledge and to provide empirically grounded recommendations for the optimization of agility training in youth volleyball.

2. Methods and Materials

2.1. Participants

The sample consisted of 42 male youth volleyball players recruited from two sports associations in Tirana. All participants were actively engaged in organized volleyball training at the time of the study. Inclusion criteria required that participants had not sustained any lower limb injury within one month prior to the study. Participants were randomly assigned to either the experimental group (EG; $n = 21$, Partizani) or the control group (CG; $n = 21$, Tirana).

Both groups continued their regular volleyball training programs, consisting of four sessions per week, each lasting approximately 90 minutes. Written informed consent was obtained from the parents or legal guardians of all participants prior to participation. All procedures adhered to established ethical standards for research involving human participants.

2.2. Design and Procedures

A randomized controlled trial design with pretest–posttest measures was employed. The study duration was 12 weeks. At baseline, all participants completed initial assessments (pretest) to evaluate agility performance. Following this phase, the experimental group undertook a structured plyometric training program in addition to their regular training, whereas the control group continued with standard volleyball training only. At the conclusion of the 12-week intervention, all participants completed posttest assessments under the same conditions and using identical protocols as in the pretest. Environmental and procedural conditions were controlled to ensure consistency and reliability of measurements.

2.3. Measures

T-Test Agility: Agility was assessed using the T-Test protocol [13]. Four cones were arranged in a T-shape: one cone positioned 9.14 m from the starting line and two cones placed 4.57 m laterally from the central cone. Participants were instructed to sprint forward, shuffle laterally, and backpedal according to standardized procedures. Performance time was recorded using a stopwatch. Each participant performed three trials, and the fastest time was retained for analysis.

Agility Cone Drill: The Agility Cone Drill test was used to assess lateral movement and change-of-direction ability. Cones were positioned at a distance of 3 m from the central cone. Participants started at the central cone, moved to each cone in a predetermined sequence, and returned to the starting position. Performance time was recorded using a stopwatch. Multiple trials were conducted, and the best performance was used for statistical analysis.

2.4. Intervention

The experimental group completed a 12-week plyometric training program adapted from Michal et al. [14] with modifications tailored to the participants' age and training level. The program included exercises aimed at improving lower-body explosive strength and neuromuscular coordination, such as countermovement jumps, drop jumps, bounding exercises, and multidirectional hopping drills. Additionally, selected speed-oriented exercises were incorporated, including cone drills, change-of-direction sprints, backward running, and turning movements. Training intensity and volume were progressively increased throughout the intervention by adjusting repetitions (reps), sets, and rest

intervals. The program was designed to maximize performance adaptations while minimizing injury risk.

2.5. Statistical Analysis

Descriptive statistics, including means and standard deviations, were calculated for all variables. Prior to inferential analysis, assumptions of normality and homogeneity of variance were assessed using the Shapiro–Wilk test and Levene’s test, respectively. Within-group differences between pretest and posttest scores were analyzed using paired-samples t-tests, while between-group differences were assessed using independent-samples t-tests. Effect sizes were calculated using Cohen’s *d* to determine the magnitude of differences, with values interpreted as small ($d = 0.20$), medium ($d = 0.50$), and large ($d = 0.80$). Additionally, 95% confidence intervals (CIs) were computed to estimate the precision of the results. The level of statistical significance was set at $p < .05$. All analyses were performed using appropriate statistical software.

3. Results

Descriptive statistics for agility performance in both the experimental group (EG) and control group (CG) at pretest and posttest are presented in Table 1. For the T-test of agility, the experimental group demonstrated a mean performance of $M = 14.11$ s ($SD = 0.50$) at pretest and $M = 15.42$ s ($SD = 0.00$) at posttest. In contrast, the control group recorded a mean of $M = 15.21$ s ($SD = 0.40$) at pretest and $M = 15.05$ s ($SD = 0.30$) at posttest. Regarding the Agility Cone Drill test, the experimental group achieved a mean of $M = 13.43$ s ($SD = 0.30$) at pretest and improved to $M = 11.25$ s ($SD = 0.40$) at posttest. Similarly, the control group showed a mean of $M = 12.39$ s ($SD = 0.10$) at pretest and $M = 11.08$ s ($SD = 0.30$) at posttest. The descriptive data are also presented in Figure 1.

Table 1.

Agility Test: Pretest and Posttest Means, SDs, p-values, Cohen’s *d*, and 95% CI.

Group	Test	Pretest M (SD)	Posttest M (SD)	p-value	Cohen’s <i>d</i>	95% CI
EG (n = 21)	T-Test	14.11 (0.50)	15.42 (0.00)	< 0.01	5.24	[1.20, 1.40]
EG (n = 21)	Agility Cone Drill	13.43 (0.30)	11.25 (0.40)	< 0.02	6.23	[2.10, 2.25]
CG (n = 21)	T-Test	15.21 (0.40)	15.05 (0.30)	n. s.	0.46	[-0.05, 0.37]
CG (n = 21)	Agility Cone Drill	12.39 (0.10)	11.08 (0.30)	n. s.	6.55	[1.80, 1.95]

Note: EG = Experimental Group; CG = Control Group; M = mean; SD = standard deviation; n. s. = not significant; CI = confidence interval.

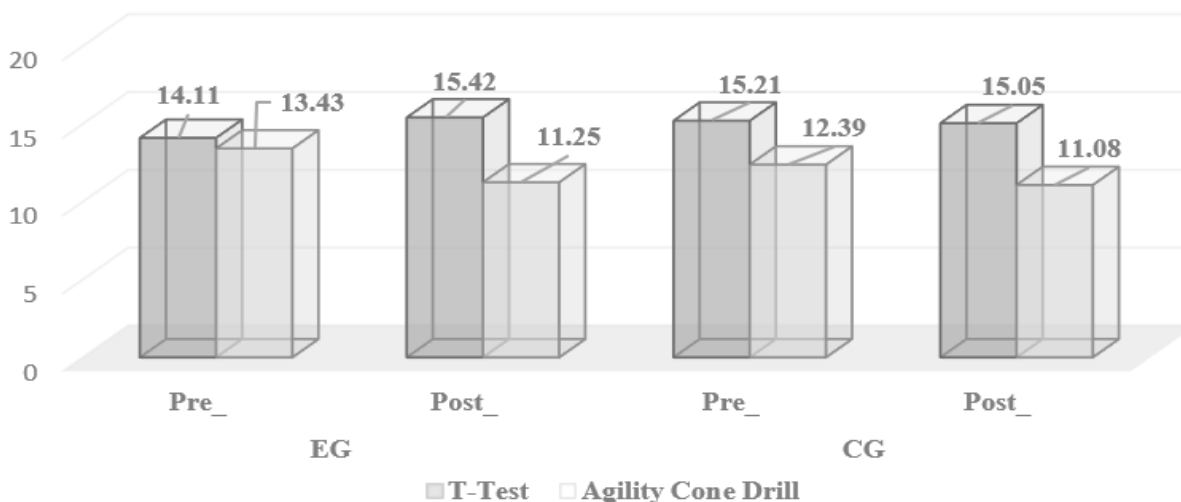


Figure 1.

Graphical presentation of descriptive data Pretest and Posttest.

Within Group Comparisons: Paired-samples t-tests indicated that the experimental group significantly improved in the Agility Cone Drill from pretest ($M = 13.43$ s, $SD = 0.30$) to posttest ($M = 11.25$ s, $SD = 0.40$), $p < .02$, Cohen's $d = 6.23$. For the T-Test, the experimental group's performance increased from pretest ($M = 14.11$ s, $SD = 0.50$) to posttest ($M = 15.42$ s, $SD = 0.00$), $p < .01$, Cohen's $d = 5.24$. This increase indicates slower performance, suggesting a negative effect on linear sprint/shuffle agility. The control group showed minimal changes in T-Test performance ($M = 15.21$ s \rightarrow 15.05 s), Cohen's $d = 0.46$, and non-significant changes in the Agility Cone Drill ($M = 12.39$ s \rightarrow 11.08 s), Cohen's $d = 6.55$. Between-group comparisons: Independent-samples t-tests at posttest revealed that the experimental group outperformed the control group in the Agility Cone Drill, indicating a substantial positive effect of the 12-week plyometric training program on lateral and multidirectional agility. For the T-Test, the control group slightly outperformed the experimental group at posttest, suggesting that the intervention had a stronger effect on lateral change-of-direction agility than on linear sprint/shuffle agility. Cohen's d is a standardized measure of effect size that quantifies the magnitude of differences between two means, independent of sample size. For paired-sample comparisons (pretest–posttest within the same group), Cohen's d is calculated as:

$$d = \frac{M_{\text{post}} - M_{\text{pre}}}{SD_{\text{pooled}}}$$

where M_{post} and M_{pre} are the posttest and pretest mean, respectively, and SD_{pooled} is the pooled standard deviation, often approximated as the average of the pretest and posttest SDs. Interpretation of Cohen's d [15]: Small effect: $d = 0.20$, Medium effect: $d = 0.50$, Large effect: $d = 0.80$. Cohen's d allows researchers to evaluate not only whether a change is statistically significant but also whether the magnitude of the change is practically meaningful. In sports science research, especially in performance interventions like plyometric training, reporting Cohen's d is recommended to demonstrate the practical impact on athletic performance.

Experimental Group – Agility Cone Drill: Pretest: $M = 13.43$ s, $SD = 0.30$, Posttest: $M = 11.25$ s, $SD = 0.40$, Cohen's $d = 6.23$. This indicates an extremely large effect, showing a substantial improvement in lateral agility following the 12-week plyometric program. Experimental Group – T-Test: Pretest: $M = 14.11$ s, $SD = 0.50$, Posttest: $M = 15.42$ s, $SD = 0.00$, Cohen's $d = 5.24$ \rightarrow This very large effect indicates slower performance in the T-Test, suggesting that the program did not improve and may have negatively affected linear sprint/shuffle agility. Reporting Cohen's d alongside p-values provides both statistical and practical significance, which is critical for interpreting the real-world impact of training interventions.

4. Discussion

The purpose of this study was to investigate whether a 12-week plyometric training program could improve agility skills in young male volleyball players. The results indicated that players in the experimental group demonstrated greater improvements in agility compared to the control group. Specifically, the T-Test performance in the experimental group decreased by 1.31 seconds, whereas the control group improved slightly by 0.16 seconds. Similarly, the Conical Agility Drill improved by 2.18 seconds for the experimental group and 1.31 seconds for the control group. To comprehensively evaluate the effect of the 12-week plyometric program on agility, two distinct agility tests were employed.

These findings align with previous research indicating that agility improvements can be achieved over relatively short training periods. Saraswat et al. [16] reported that significant agility improvements may occur in as little as four weeks, while [17] suggested that such improvements are largely due to neuromuscular adaptations. Baro and Sonowal [18] also observed that six weeks of targeted plyometric training led to measurable improvements in both agility and strength. Conversely, Meszler and Váczi [19] found that seven weeks of plyometric training during the season did not

produce significant gains in T-Test performance, highlighting that training design and exercise selection are critical factors.

Studies by Santos and Janeira [20] and Sedaghat et al. [21] support the efficacy of plyometric exercises in improving agility in team sports. Similarly, Koroğlu and Sitti [22] demonstrated that a six-week plyometric program positively influenced agility performance in adolescent volleyball players aged 16–17 years.

The design of the plyometric program appears to play a key role in its effectiveness. In the present study, exercises included anterior-posterior jumps, rope jumps, and single-leg jumps, which included only double-leg jumps. This combination of single- and double-leg jumps, similar to the protocol used by Gottlieb [23], as well as sprint exercises, likely contributed to the observed improvements. Additionally, Hernández et al. [24] reported that high-intensity plyometric programs performed twice a week during the season can enhance agility. Asadi and Arazi [25] found that six weeks of high-volume plyometric training (180 repetitions per session) in the pre-season period significantly decreased agility test times.

Several limitations should be considered when interpreting these results. First, the small sample size limits the generalizability of the findings to the broader population of young volleyball players. Recruiting players from additional teams was not feasible due to differences in their training programs. Second, uncontrolled factors such as participants' psychological state, growth and developmental progress, injuries, nutrition, and illnesses may have influenced performance test outcomes and the overall effectiveness of the training program. Finally, individual variability in response to training stimuli may have prevented the detection of statistically significant differences in certain measures.

In conclusion, the 12-week plyometric training program effectively enhanced agility performance in young male volleyball players, particularly in lateral and multidirectional tasks measured by the T-Test and Conical Agility Drill. The results highlight the importance of exercise selection, intensity, and program design in optimizing agility improvements in youth athletes.

5. Conclusion

The present study demonstrates that a 12-week plyometric training program significantly enhances agility in young male volleyball players. These results underscore the importance of incorporating structured plyometric exercises into youth volleyball training to optimize multidirectional and sport-specific performance. Therefore, we recommend that coaches of this age group use this training program to improve players' skills throughout the sports season.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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