

The Impact of Utilizing Plyometric Exercises on Enhancing Explosive Power and the Spiking and Blocking Skills Among Volleyball Players (16-18 Years)

Hadj SEFIR¹, Oussama BENYAHIA², Redha BENAÏSSA³, Mohamed El Hacène El Maamoun CHERIET⁴, Ali HADDI⁵, Aziz KHELLAFI⁶, Maamar Badreddine BENSAADA⁷, Henni DEHLI⁸

¹ University of Algiers, Algeria. Email: sefir.hadj@univ-alger3.dz

² University of Boumerdes, Algeria. Email: o.benyahia@univ-boumerdes.dz

³ University of Boumerdes, Algeria. Email: r.benaïssa@univ-boumerdes.dz

⁴ University of Boumerdes, Algeria. Email: cheriethassan2017@gmail.com

⁵ University of Boumerdes, Algeria. Email: a.haddi@univ-boumerdes.dz

⁶ Hassiba Benbouali University of Chlef, Algeria. Email: a.khellafi@univ-chlef.dz

⁷ Hassiba Benbouali University of Chlef, Algeria. Email: m.bensaada@univ-chlef.dz

⁸ Hassiba Benbouali University of Chlef, Algeria. Email: d.henni@univ-chlef.dz

Received: 01/01/2026 ; Accepted: 27/04/2026 ; Published: 22/05/2026

Abstract

This scientific report investigates the experimental efficacy of utilizing plyometric exercises to enhance the explosive power of the upper and lower extremities, and the subsequent reflexive impact on the development of spiking and blocking skills in volleyball players. The study was conducted on a sample of 24 athletes (aged 16-18 years), who were randomly and equally divided into a control group (n=12) and an experimental group (n=12).¹ The experimental group underwent a structured training program based on plyometric principles for a specified duration of two training units per week, while the control group continued with their traditional training paradigms.¹ Physical variables were measured utilizing standardized tests (Standing Broad Jump, Sargent Vertical Jump, and a 5 kg Medicine Ball Throw), alongside specialized accuracy tests for spiking and blocking maneuvers.¹

Statistical processing and field analyses revealed

a statistically significant superiority in favor of the experimental group across all post-test physical and skill variables. The experimental group registered progression rates of 24.02% in the vertical jump, 43.78% in spiking accuracy, and an exceptional 64.84% in blocking accuracy.¹ These findings validate that the activation of the muscular stretch-shortening cycle (SSC) through plyometric training fundamentally bridges the gap between maximal strength and speed. This positively transfers to explosive capabilities and technical precision in volleyball, dictating the necessity of integrating these drills into the preparatory programs for this age group.

Keywords: Volleyball, Plyometric Training, Explosive Power, Spiking Skill, Blocking Skill, Stretch-Shortening Cycle, Middle Adolescence.

Theoretical Framework and Scientific Grounding

Contemporary sports science is witnessing a rapid evolution fundamentally driven by the application of advanced physiological and biomechanical theories to enhance athletic performance. Volleyball is widely recognized as a dynamic team sport that demands exceptional levels of physical fitness and neuromuscular readiness due to its reliance on rapid, short-burst movements in intermittent intervals; the game is not governed by a time limit but by reaching a set score, demanding sustained peak performance.¹ One of the most critical physical requisites in this discipline is "explosive power"—defined as the capacity of the neuromuscular system to exert maximal force against external resistance in the shortest possible time. This attribute forms the biomechanical and physiological foundation for executing decisive technical skills such as the spike and the block.¹

Historically, the concept of plyometric training has been heavily associated with the Soviet sports school. The term first appeared in Russian literature in 1966, coined from roots meaning "measurable increases," and was initially utilized in track and field under the supervision of renowned coach Yuri Verkhoshansky.¹ The method garnered global attention during the 1972 Munich Olympics when sprinter Valeriy Borzov secured gold medals in the 100m and 200m events relying predominantly on this training modality.¹ As sports science advanced, researchers such as Moura and Alford defined plyometrics as a training system designed to develop the elastic strength of muscles through activities encompassing a cycle of stretching and contracting. This allows the muscle to harness reflected mechanical energy, yielding greater force and velocity than standard dynamic movements.¹

The Physiological Mechanism of Plyometric Work

Structurally and physiologically, plyometric training relies on what is known as the Stretch-Shortening Cycle (SSC), a complex neuromuscular mechanism composed of three interconnected phases. The first is the eccentric phase (the stretch), where the muscle is subjected to forced elongation under the influence of an external load—often body weight compounded by gravity during landing.¹ In this phase, kinetic energy is stored as elastic energy within the series elastic components (SEC) of the muscles and tendons. The degree of stretch is directly proportional to the intensity of the external stimulus.¹ The second phase is the amortization or transitional phase, an exceedingly brief, imperceptible temporal window separating the eccentric stretch from the subsequent concentric contraction.¹ Biomechanical theories emphasize that minimizing the duration of this phase is critical for effective utilization of stored energy; prolonged amortization leads to the dissipation of elastic energy as heat within the tissues. The third is the concentric phase, wherein the muscle forcefully contracts, capitalizing on voluntary contractile force augmented by the released elastic energy and the myotatic reflex, culminating in a rapid, explosive movement that surpasses regular, isolated concentric power.¹ Plyometric exercises encompass a broad spectrum of movements scaling in intensity from simple horizontal and vertical hops, to bounding over hurdles, up to profound depth jumps from boxes and benches, and incorporating elastic bands and medicine balls.¹ The success of these exercises is predicated on rigorous training principles: progressive overload, provision of adequate rest and recovery between sets (up to 5 minutes to ensure central nervous system recovery), and proper landing mechanics. Emphasizing a full-foot landing serves to attenuate shock absorption across the ankle,

knee, and hip joints, thereby protecting the athlete from injury and guaranteeing efficient kinetic transfer.¹

Technical and Physical Requisites in Volleyball

Volleyball is characterized by an intricate correlation between physical fitness and technical proficiency. The spike, serving as the primary offensive weapon, relies entirely on the strength of the leg, back, and abdominal muscles to convert the horizontal velocity acquired from the approach run into maximal vertical velocity during takeoff.¹ This execution necessitates precise neuromuscular coordination to elevate the striking arm and strike the ball at the highest possible apex with a violent, whip-like motion.¹ Spiking maneuvers vary—encompassing straight, flat, wrist-drop, lateral (hook), and deceptive spikes—each imposing specific biomechanical demands that rely on explosive power to ensure accurate trajectory placement within the opponent's court while evading the block.¹

Conversely, the blocking skill emerges as a dual defensive and offensive element aimed at intercepting spiked balls and preventing them from crossing the net.¹ This skill, whether executed individually or collectively, mandates an immediate reaction and an instantaneous vertical leap from a static position or following a brief lateral shuffle, coupled with arm extension and wrist stabilization to withstand the spike's force.¹ Blocks are categorized into offensive and defensive, as well as open and closed blocks. The explosive power of the lower extremities plays a pivotal role in enabling the player to elevate sufficiently and timely to seal striking angles against opposing attackers.¹

Age-Specific and Biological Characteristics (16-18 Years)

The target sample in this study falls within the middle adolescence stage (16-18 years), a period

characterized by radical transformations across physiological, morphological, and psychological dimensions.¹ Morphologically, players approach their definitive height and experience notable weight increases driven by the hypertrophy of the muscle's physiological cross-section, heavily influenced by intense hormonal activity (e.g., testosterone spikes).¹ Physiologically, stomach volume and capacity expand, while cardiorespiratory endurance improves, evidenced by a lowered resting heart rate and enhanced oxygen consumption efficiency.¹

Regarding motor capabilities, this phase represents a golden window for developing maximal strength and speed-strength. Neuromuscular coordination reaches elevated levels, endowing movements with exceptional dynamism, stability, and flexibility, thereby allowing the athlete to attain high tiers of technical mastery.¹ Psychologically and socially, adolescents at this age seek self-actualization and aim to solidify their social standing among peers, gravitating towards intellectual independence and innovation.¹ Therefore, appropriate athletic guidance through structured regimens—such as plyometric training—serves as an effective medium to channel adolescent energies, enhance focus, and bolster decision-making capacities under competitive pressure.¹

Experimental Design and Field Procedures

To actualize the intended scientific objectives, the experimental method was adopted, being the most suitable approach for manipulating variables under rigorously controlled conditions to discern causal relationships between plyometric training and the development of physical and technical capabilities.

Sample Characteristics and Spatiotemporal Domains

The original population comprised volleyball

players. A purposive sample of 24 male athletes was selected from Chbaiki Abdelkader High School in Ksar Chellala, Tiaret Province, ensuring they met the age criteria (16-18 years) and possessed foundational game experience.¹ The participants were randomly allocated into two equivalent groups: an experimental group of 12 players who underwent the proposed plyometric program, and a control group of 12 players who trained according to conventional methodologies.¹ Furthermore, an exploratory pilot study involving 5 players was conducted to standardize the tools and tests; these individuals were excluded from the main experiment to guarantee the integrity of the results.¹

Physical and Skill Measurements and Tests

To ensure objective measurement, a battery of standardized tests was selected to assess the targeted variables. These tests underwent arbitration and statistical verification for validity and reliability prior to the main experiment. Results demonstrated that the tests possessed high reliability coefficients (ranging from 0.85 to 0.97) and excellent self-validity scores (ranging from 0.89 to 0.98) using Pearson's correlation coefficient.¹ The tests included:

1. **Standing Broad Jump Test:** Designed to evaluate the horizontal explosive power of the legs. The subject stands behind the starting line, flexes the knees, swings the arms, and leaps forward as far as possible. The distance is measured from the starting line to the closest heel mark.¹
2. **Sargent Vertical Jump Test:** Aimed at assessing the vertical explosive power of the legs. The player stands beside a graduated board, marks the highest reach from a flat-footed stance with chalk, then flexes the trunk and knees to leap vertically and place a second mark. The distance between the marks is recorded.¹
3. **5 kg Medicine Ball Throw (Seated):** Designed to measure the explosive power of the upper

extremities while isolating the trunk and legs. The player sits on a chair and forcefully pushes the medicine ball overhead for maximal distance; the measurement is taken from the shoulder line to the point of impact.¹

4. **Spiking Accuracy Test:** Conducted on a regulation volleyball court. The coach sets the ball from zone (3), and the attacking player initiates from zone (4) to execute a spike, aiming at specific scored zones on the opponent's court. The player is granted 5 attempts, with a maximum possible score of 25 points.¹
5. **Blocking Accuracy Test:** Evaluates the player's capacity to leap and block balls directed by the coach, attempting to deflect and route the rebounding ball into precise zones within the opponent's court. The player is given 5 attempts, evaluated out of 25 points.¹

Structure of the Plyometric Training Program

The plyometric training program was designed drawing upon specialized scientific literature in training physiology (e.g., Komi, Verkhoshansky, and Abu Al-Ela Abdel Fattah). It was administered to the experimental group during weekly training units, specifically two sessions per week (Saturday and Tuesday).¹ The training unit incorporated a general and specific warm-up to prevent joint and tendon injuries, followed by the main section featuring plyometric exercises at intensities ranging from 90% to 100% of the player's maximal capacity.¹ The exercises included multiple bounding to develop acceleration, depth jumps from varying box heights (30-70 cm) to enhance reflexive rebound, single and double-leg hops, and medicine ball thrusts targeting the arms and core.¹ Progressive overload was maintained by incrementing the repetitions (from 6 to 14 reps per set), while ensuring ample rest intervals of 4 to 5 minutes between sets. This facilitated the recovery of the alactic anaerobic energy system

and the central nervous system, mitigating fatigue that could compromise motor execution speed.¹ The exercises were characterized by a diversification of postures (dynamic and static) and alterations in joint angles and leverages to mimic the authentic competitive scenarios inherent to volleyball.

Statistical Analysis and Presentation of Results

To evaluate the efficacy of the training program, a series of statistical treatments were performed on the data collected from the pre- and post-measurements of both groups, utilizing the arithmetic mean, standard deviation, and Student's t-test for paired and independent

Analysis of Leg and Arm Explosive Power Results

samples.

Initially, group homogeneity was confirmed prior to the program's implementation. A comparison of the pre-test measurements between the control and experimental groups revealed no statistically significant differences across any physical or skill tests. The calculated (t) values were 0.04 for the broad jump, 1.23 for the Sargent jump, 0.16 for the medicine ball throw, 1.27 for spiking accuracy, and 0.58 for blocking accuracy. All these values were substantially lower than the critical tabular (t) value (2.07) at 22 degrees of freedom and a 0.05 significance level, thus confirming an equivalent starting baseline.¹

Table (1): Significance of Differences Between Pre- and Post-Measurements for Both Groups in Physical Tests.

Physical Variable	Group	Pre-Test Mean	Standard Deviation	Post-Test Mean	Standard Deviation	Calculated t-value	Improvement Rate	Significance (0.05)
Broad Jump (m)	Control	2.16	0.15	2.16	0.17	1.06	0.42%	Non-significant
	Experimental	2.15	0.17	2.32	0.14	2.92	6.99%	Significant
Sargent Jump (cm)	Control	47.41	6.14	47.83	5.70	1.10	0.88%	Non-significant
	Experimental	44.41	5.79	55.08	7.16	11.97	24.02%	Significant
Med Ball Throw (m)	Control	3.85	0.46	3.85	0.46	1.34	0.21%	Non-significant
	Experimental	3.81	0.63	4.29	0.51	8.37	12.56%	Significant

The statistical data in Table (1) lucidly indicate a lack of significant development among the control group participants in any physical variable; their progress rates were marginal, peaking at a mere 0.88%, with all (t) values reflecting non-significance.¹ Conversely, the experimental group achieved a massive, highly statistically significant leap across all post-test

physical measurements. In the vertical jump (Sargent test), the arithmetic mean soared from 44.41 cm to 55.08 cm, denoting a remarkable improvement rate of 24.02%, and yielding a (t) value of 11.97—far exceeding the tabular threshold.¹ Medicine ball throw performance also improved by 12.56%, and the broad jump by 6.99%.¹

This radical enhancement in the experimental group is attributed to the nature of plyometric exercises, which focus on developing neuromuscular mechanisms and stimulating fast-twitch muscle fibers. The repetitive jumping and landing cycles programmed the nervous system to increase motor unit synchronization and reduce ground braking time during the

eccentric phase. This elevated the efficiency of the stretch-shortening cycle, permitting the release of immense explosive energy during the concentric phase.¹ Furthermore, upper-body medicine ball drills directly improved the velocity of intramuscular coordination within the arm and pectoral muscles.

Analysis of Skill Performance Level Results (Spiking and Blocking)

Table (2): Significance of Differences Between Pre- and Post-Measurements for Both Groups in Skill Tests.

Skill Variable (Out of 25)	Group	Pre-Test Mean	Standard Deviation	Post-Test Mean	Standard Deviation	Calculated t-value	Improvement Rate	Significance (0.05)
Spiking Accuracy	Control	10.25	1.54	10.41	1.61	0.26	1.56%	Non-significant
	Experimental	9.50	1.88	13.66	1.96	4.89	43.78%	Significant
Blocking Accuracy	Control	10.16	2.16	10.58	2.35	0.76	4.13%	Non-significant
	Experimental	9.50	3.28	15.66	2.46	5.67	64.84%	Significant

The outcomes presented in Table (2) display an unprecedented qualitative leap in the skill performance of the experimental group, contrasted by a virtual plateau in the control group. The mean for spiking accuracy in the experimental group rose from 9.50 to 13.66 points, achieving an exceptional progression rate of 43.78% with a significant (t) value of 4.89.¹ However, the blocking skill witnessed the most dramatic evolution, as its mean surged from 9.50 to 15.66 points, reflecting a colossal improvement rate of 64.84% and a (t) value of 5.67.¹

explosive power of the lower extremities empowered the players to achieve higher vertical leaps and reduced the time required to reach maximal elevation. This kinematic advantage afforded attackers and defenders a relatively prolonged "hang-time" in the air, providing them with the temporal window and optimal visual angle to assess opponent positioning and direct the ball with superb precision into vacant strategic zones.¹ Moreover, the heightened explosive power of the arms enabled attackers to execute forceful and abrupt whip-like strikes, complicating the defenders' ability to anticipate the ball's trajectory.

In-Depth Analytical Discussion

These findings corroborate the hypothesis of the positive transfer of training, illustrating that the impact of plyometric exercises was not confined to a purely physical scope, but rather translated fundamentally into skill outputs. The augmented

A meticulous reading of the statistical variances uncovers precise physiological and biomechanical mechanisms governing the

relationship between plyometric training and volleyball performance. Physiologically, the surge observed in the vertical jump and medicine ball throw tests is rooted in the activation of muscle spindles. These receptors respond to rapid stretching by generating a reflex action that multiplies the force of the subsequent contraction to shield the muscle from tearing.¹ With the programmed repetition of plyometric loads, a gradual desensitization of the Golgi Tendon Organs occurs; these organs typically perform a protective inhibitory function when subjected to high forces. Their inhibition allows the muscles to contract with maximal force and increasing velocity without defensive braking.¹ These neural adaptations align perfectly with the biological profile of adolescents (16-18 years), an age where hormonal responses and the hypertrophy of fast-twitch fibers (Type IIx) are at their peak.¹

Biomechanically, the variance in improvement rates between the blocking skill (64.84%) and the spiking skill (43.78%) within the experimental group can be rationalized by the degree of congruence between the plyometric exercises and the kinetic pathways of each skill. The blocking maneuver is primarily a defensive action requiring a direct, rapid vertical leap from a static stance in response to a visual stimulus (the opponent's attack). This kinetic pathway exhibits a near 100% biomechanical alignment with the depth jumps and hurdle hops utilized in the program.¹ Conversely, the spiking skill represents a highly complex kinematic chain integrating horizontal running (the approach), rapid braking (the plant), vertical propulsion, and an airborne arm strike.¹ Although plyometric training substantially elevated the efficiency of the braking and takeoff phases, attaining maximal spiking accuracy also demands supplementary tactical and spatial coordination linking the player's speed with the

set ball's velocity. Consequently, its improvement rate, while massive, was slightly lower than that of the straightforward blocking skill.¹

In light of the above, it becomes evident that excessive reliance on traditional weight training, as was historically prevalent, may induce sluggishness in motor execution. In contrast, plyometric exercises act as the "vital bridge" linking maximal strength to execution speed, transmuting raw strength into applied explosive power that caters to the dynamic competitive situations inherent in volleyball.¹

General Conclusions

Based on rigorous scientific inquiry and documented statistical analyses, this report deduces the following conclusions:

1. Standardized plyometric training possesses exceptional and statistically significant efficacy in elevating the explosive power (horizontal and vertical) of both the lower and upper extremities among volleyball players aged 16-18 years, outperforming traditional training methodologies.¹
2. A direct causal relationship and a clear positive transfer exist between the physical development induced by the plyometric regimen and the enhancement of skill performance levels; the acquired explosive capacities were practically translated into superior accuracy and biomechanics in the spiking and blocking maneuvers.¹
3. Training mechanisms predicated on dropping and rebounding (e.g., depth jumps) verified their superior efficiency in reducing reaction times and amplifying muscular acceleration through the optimal exploitation of the stretch-shortening cycle and the elastic energy stored within tendons.¹
4. The age cohort of 16-18 years constitutes an optimal biological and neurological window for absorbing high plyometric loads, provided that

progressive overload and recovery principles are respected to prevent injuries and achieve maximal neuromuscular adaptation.¹

5. Plyometric training emerges as an indispensable physical and tactical imperative for coaches, dictating its systematic integration into preparatory and competitive training paradigms, while customizing exercises to simulate the precise kinetic pathways of volleyball.¹

References

- Abdel Fattah, A., & Shaalan, I. (1994). *Physiology of Training in Football*. Cairo: Dar Al-Fikr Al-Arabi.¹
- Bastaweesy, A. (1996). *Foundations and Theories of Movement*. (1st ed.). Cairo: Dar Al-Fikr Al-Arabi.¹
- Bastaweesy, A. (1999). *Foundations and Theories of Sports Training*. Cairo: Dar Al-Fikr Al-Arabi.¹
- Cometti, G., & Cometti, D. (2007). *La pliométrie: méthodes, entraînement, exercices*. Paris: Chiron.¹
- Hassan, Z. M. (2005). *For Better Muscular Strength, Plyometric Training*. Egypt: Al-Maktaba Al-Masriya.¹
- Ibrahim, M. A. (2001). *The Scientific Encyclopedia of Volleyball - Skills - Tactics - Tests*. (1st ed.). Amman: Al-Warraq Publishing Foundation.¹
- Taha, A. M. (1999). *Volleyball: History-Education-Training-Analysis-Rules*. (1st ed.). Cairo: Dar Al-Fikr Al-Arabi.¹
- Weineck, J. (1990). *Manuel d'entraînement*. (3ème éd.). Paris: Vigot.¹
- Zahran, H. A. (1982). *Developmental Psychology - Childhood and Adolescence*. Cairo: Alam Al-Kotob.¹
- Zatsiorski, V. (1966). *Les qualités physiques du sportif*. (Traduction INSEP).¹

Works cited

1. MSTAPS14068.pdf