

The Effect of Plyometric Training on Developing Explosive Power Specific to Jump Shooting in Handball – An Experimental Study

Oussama BENYAHIA¹, Hadj SEFIR², Mohamed El Hacène El Maamoun CHERIET³, Redha BENAÏSSA⁴, Ali HADDI⁵, Fayçal BELDJOUHEUR⁶, Aziz KHELLAFI⁷, Maamar Badreddine BENSAADA⁸

Abstract

This comprehensive study aims to investigate the profound impact of plyometric training on developing muscular capabilities—specifically explosive power—and its direct correlation with enhancing the biomechanical and skill execution of the high jump shot among youth handball players (aged 17–19 years). Given the precise nature of the research problem, a rigorous experimental methodology was adopted. The sample comprised 20 elite youth players from the Boukadir and Oued Sly teams, distributed purposefully and equally into a control group and an experimental group, while goalkeepers were deliberately excluded due to their divergent biomechanical requirements.¹ The experimental group underwent a highly periodized, 7-week plyometric program consisting of 14 training units. The statistical analyses yielded statistically significant superiority for the experimental group across all physical assessments (Sargent vertical jump, 3kg medicine ball push, 30-second incline pushups, and the 3-step jump) as well as skill-based execution (jump shooting from outside the 9-meter zone). These findings unequivocally establish the efficacy of mechanically deploying the Stretch-Shortening Cycle (SSC) to recruit high-threshold motor units. This neural optimization translates directly into elevated kinematic explosive power, enabling athletes to bypass and conquer defensive blocks with maximal efficiency.¹

Keywords: *Plyometric Training, Explosive Power, High Jump Shot, Handball, Youth Category, Stretch-Shortening Cycle (SSC).*

Received: 11/01/2026 ; Accepted: 27/04/2026 ; Published: 23/05/2027

Introduction and Research Problem

Ascending to global elite echelons in sporting events, particularly securing consistent victories in team sports, is no longer an easily attainable endeavor relying solely on general physical conditioning. Modern coaching paradigms in handball have aggressively shifted towards the specialized cultivation of specific physical traits that meticulously serve tactical and technical mastery.¹ Contemporary handball is characterized by blindingly fast transitions, severe physical confrontations, and densely packed defensive lines, which compel offensive players to engineer unconventional and superior biomechanical solutions to penetrate them. Within this aggressive framework, the high jump shot emerges as one of the most critical offensive weapons, permitting the athlete to exploit the aerial zone above the defensive wall.¹

The optimal mechanical execution of this complex skill relies fundamentally on "explosive power," which is the physiological capacity to exert maximal dynamic muscular force in the absolute shortest time possible.¹ Through extensive field observation and performance analysis, a pivotal problem crystallized: a noticeable deficiency in explosive power among youth players during offensive phases, which significantly degrades the efficacy of their jump shots. Consequently, the research problem is defined by the following

¹ University of Boumerdes, Algeria. Email: o.benyahia@univ-boumerdes.dz.

² University of Algiers, Algeria. Email: sefir.hadj@univ-alger3.dz

³ University of Boumerdes, Algeria. Email: cheriethassan2017@gmail.com

⁴ University of Boumerdes, Algeria. Email: r.benaïssa@univ-boumerdes.dz

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

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

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

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

central inquiry: To what extent does plyometric training impact the development of explosive power specific to the jump shooting skill within the research sample? Furthermore, does this training modality enhance vertical explosive power to a greater degree than horizontal explosive power?¹

Theoretical Foundation and the Biomechanics of Plyometric Training

Historical Roots and Conceptual Evolution

The origins of plyometric training trace back to the Eastern European bloc (the former Soviet Union) during the mid-1960s, where it was colloquially known under simplified monikers such as "jump training" or "shock training".¹ The conceptualization of the term in its current academic format is credited to the American track and field coach Fred Wilt in 1975. Wilt derived the terminology from Latin roots, where "plio" signifies increase or expansion, and "metric" denotes measurement, collectively expressing a methodology aimed at achieving the maximum measurable increase in athletic performance.¹ By the 1980s, this training paradigm transcended the exclusive domain of track and field athletes, becoming deeply integrated into team sports such as handball and soccer, owing to its unparalleled effectiveness in bridging force and velocity to produce peak power.¹

Plyometric Physiology and the Stretch-Shortening Cycle (SSC)

This training modality operates on a highly precise neurophysiological mechanism known as the "Stretch-Shortening Cycle" (SSC). Sports scientists diverge slightly in segmenting its phases; Donald Chu divides it into three distinct biomechanical phases, whereas Yuri Verkhoshansky consolidates it into two.¹ According to the tripartite model, the action commences with the Eccentric Phase, involving the rapid elongation of the agonist muscle under resistance or gravitational load. This forced lengthening stores kinetic energy as potential elastic energy within the musculotendinous unit and simultaneously triggers the muscle spindles.¹ This is followed by the Amortization Phase, representing the micro-second transitional delay between eccentric yielding and concentric overcoming. The brilliance of any plyometric protocol lies in minimizing this ground-contact time to prevent the stored elastic energy from dissipating as heat.¹ The cycle concludes with the Concentric Phase, where the stored energy is violently released, augmented by the myotatic (stretch) reflex, thereby producing an explosive force output that significantly eclipses the capacity of the muscle under standard concentric conditions.¹

Foundations and Modalities of Plyometric Work

Plyometric training is anchored by a triad of inseparable foundational principles: Physical foundations (representing structural elements like absolute strength, velocity, and elasticity), Mechanical foundations (relying on biomechanical laws of levers and acceleration), and Psychological foundations (demanding immense willpower and perseverance to adapt to the delayed onset muscle soreness associated with eccentric loading).¹ The training encompasses diverse modalities, including in-place vertical jumps, bounding, hurdle hops, and depth jumps. Determining the optimal drop height (typically between 30 and 70 cm) and strictly minimizing amortization time are the primary determinants of a program's success, crucial for avoiding the severe connective tissue injuries that represent the primary drawback of haphazardly applied plyometrics.¹

Explosive Power and the Jump Shooting Skill in Handball

Muscular strength is the biological bedrock upon which all athletic achievements are built. Scientifically, it is categorized into maximal strength (static and dynamic), strength endurance, and explosive power.¹ According to researcher Larson, explosive power is defined as the ability to unleash maximal force in the shortest possible time for a single repetition, relying heavily on the recruitment speed of fast-twitch (Type II) muscle fibers.¹

In handball, the supremacy of this power manifests acutely in the "high jump shot," a skill specifically designed to counter the immense evolution in defensive tactics and the rapid closure of defensive gaps. The

kinematic execution of this skill traverses precise phases, initiating with the approach steps to acquire horizontal momentum. This is followed by the take-off phase (impact, amortization, and thrust), which violently translates horizontal momentum into vertical acceleration. The flight phase ensues, characterized by the contralateral rotation of the torso and the retraction of the throwing arm, culminating in a powerful whip-like release and a safe, shock-absorbent landing.¹

Methodology and Experimental Design

The study was architected employing a pre-test/post-test experimental design, globally recognized as the most scientifically rigorous approach for controlling variables and testing causal hypotheses.¹

Population and Sample

The research population was purposefully selected from the youth category (17-19 years) of the Ain Tadles and Oued Sly handball teams, totaling 24 players. Four goalkeepers were excluded due to the fundamentally different biomechanical nature of their positional play. The final sample stabilized at 20 field players, randomly divided into an experimental group (10 players) and a control group (10 players).¹

Measurement Tools and Scientific Validation

To guarantee data integrity, the sample underwent a comprehensive battery of physical and skill-based tests. Physical assessments included the Sargent vertical jump test to evaluate lower-extremity explosive power, the 3kg medicine ball push test to measure arm and shoulder power, the 30-second incline pushup test, and the 3-step horizontal jump test.¹ On the skill spectrum, the high jump shot test from both the right-back and left-back positions outside the 9-meter zone was administered to calculate the volume of precise, high-velocity shots executed within a 30-second window.¹

To verify the scientific robustness of these tests, a pilot study was conducted on an auxiliary sample of 8 players. Reliability coefficients (using Pearson's correlation) and validity coefficients (using intrinsic validity calculations) demonstrated highly accurate scientific parameters, as illustrated in the tables below:

Tests	Sample Size	Degrees of Freedom	Significance Level	Tabular Pearson Correlation	Reliability Coefficient
Sargent Vertical Jump	08	07	0.05	0.76	0.93
3kg Med Ball Push	08	07	0.05	0.76	0.95
Incline Pushups (30s)	08	07	0.05	0.76	0.96
3-Step Jump	08	07	0.05	0.76	0.98
Jump Shot outside 9m (Right)	08	07	0.05	0.76	0.91
Jump Shot outside 9m (Left)	08	07	0.05	0.76	0.89

Table illustrating the reliability coefficients of physical and skill tests ¹.

Tests	Sample Size	Degrees of Freedom	Significance Level	Tabular Pearson Correlation	Validity Coefficient
Sargent Vertical Jump	08	07	0.05	0.76	0.96
3kg Med Ball Push	08	07	0.05	0.76	0.97
Incline Pushups (30s)	08	07	0.05	0.76	0.97
3-Step Jump	08	07	0.05	0.76	0.98
Jump Shot outside (Right)	08	07	0.05	0.76	0.95
Jump Shot outside (Left)	08	07	0.05	0.76	0.94

Table illustrating the validity coefficients of physical and skill tests ¹

It is evident from the preceding tables that all calculated correlation values exceeded the tabular threshold (0.76), unequivocally confirming that the tests possessed highly objective reliability and validity grades, rendering them suitable for the primary experimental protocol.¹

The Proposed Plyometric Training Program

The training program was meticulously engineered to span 7 consecutive weeks (comprising 14 training units, at two units per week), with each unit lasting 35 minutes. Load undulating depended on an intensity ranging from 50% to 80% of the athlete's one-repetition maximum, with volumes restricted to 3 to 5 repetitions distributed across 2 to 3 sets.¹ Critically, the program accommodated neurological recovery by enforcing rest intervals of 3 to 4 minutes. This ensured that the fast-twitch muscle fibers did not succumb to central nervous system fatigue, which would critically inhibit the SSC mechanics.¹

The training units encompassed a complex biomechanical progression. Initial phases prioritized upper-extremity explosive power (e.g., explosive medicine ball chest passes against a wall with immediate rebound catching), before transitioning to lower-extremity activation (bounding over hurdle sequences and vertical explosion from deep squats). In the advanced stages (the final weeks), raw explosiveness was seamlessly integrated with specialized skill execution. Athletes were compelled to perform depth jumps from boxes, followed immediately by receiving a pass mid-air and executing a jump shot over active defensive blocks.¹

Results Presentation, Analysis, and Discussion

The following tables provide a quantitative translation of the physiological and mechanical adaptations induced by the field intervention, followed by an in-depth analysis of their scientific implications.

Sample Homogeneity in Pre-Test Measurements

Statistical treatments were applied to ascertain the baseline equivalence between the experimental and control groups, thereby neutralizing any pre-existing bias.

Tests	Experimental (Mean ± SD)	Control (Mean ± SD)	Calculated "t"	Tabular "t"	Sig. Level	Difference Significance
Vertical Jump	0.48 ± 0.05	0.46 ± 0.04	0.98	2.10	0.05	Not Sig.
Med Ball Push	8.2 ± 1.41	7.54 ± 1.14	1.10	2.10	0.05	Not Sig.

Incline Pushups	28.6 ± 4.76	25.8 ± 4.20	1.83	2.10	0.05	Not Sig.
3-Step Jump	2.80 ± 0.14	2.10 ± 0.10	1.25	2.10	0.05	Not Sig.
Jump Shot (Right)	13.1 ± 2.02	10.8 ± 1.80	1.46	2.10	0.05	Not Sig.
Jump Shot (Left)	12.9 ± 1.95	10.60 ± 1.70	1.38	2.10	0.05	Not Sig.

Table indicating the homogeneity of the control and experimental groups in pre-test measurements ($df = 18$)¹

The values indicate that all calculated "t" statistics ranged between (0.98 - 1.83), falling well below the tabular value of 2.10. This clearly confirms absolute parity between the members of both groups prior to the application of the independent variable.¹

Development of Lower and Upper Extremity Explosive Power

Here, we review the acquired variance between the pre- and post-tests for both groups across the explosive power assessments.

Test	Group	Pre-Test (Mean ± SD)	Post-Test (Mean ± SD)	Calculated "t"	Tabular "t"	Progression %	Statistical Significance
Sargent Jump	Experimental	0.48 ± 0.05	0.81 ± 0.08	4.86	2.26	68.75%	Significant
	Control	0.46 ± 0.04	0.65 ± 0.06	3.11	2.26	41.30%	Significant
3kg Med Ball	Experimental	8.20 ± 1.41	10.03 ± 1.52	4.45	2.26	25.60%	Significant
	Control	7.54 ± 1.14	8.95 ± 1.19	2.94	2.26	18.70%	Significant
Incline Pushups (30s)	Experimental	28.6 ± 4.76	32.9 ± 4.86	5.09	2.26	15.03%	Significant
	Control	25.8 ± 4.20	27.9 ± 4.27	2.92	2.26	13.29%	Significant
3-Step Jump	Experimental	2.80 ± 0.14	3.65 ± 0.19	3.81	2.26	30.35%	Significant
	Control	2.10 ± 0.10	2.46 ± 0.16	2.65	2.26	25.71%	Significant

Note: $df = 9$, significance level = 0.05.¹

Development of Jump Shooting Skill Performance

The data delineates the extent to which physiological physical development translated into skill efficiency for backcourt players.

Skill Test	Group	Pre-Test (Mean ± SD)	Post-Test (Mean ± SD)	Calculated "t"	Tabular "t"	Progression %	Statistical Significance
Jump Shot > 9m (Right)	Experimental	13.1 ± 2.02	15.8 ± 2.14	2.90	2.26	20.61%	Significant
	Control	10.8 ± 1.80	12.7 ± 1.88	1.88	2.26	17.59%	Not Significant
Jump Shot > 9m (Left)	Experimental	12.9 ± 1.95	14.8 ± 1.98	2.84	2.26	14.72%	Significant
	Control	10.6 ± 1.70	11.9 ± 1.74	2.99	2.26	12.26%	Significant

Post-Test Inter-Group Comparison

Independent samples t-test results on post-test metrics demonstrated an overwhelming dominance by the experimental group across all variables.¹ Calculated "t" values ranged from a minimum of (2.98) for the 3-step jump test to an astonishing (4.82) for the incline pushup test, and (3.87) for the right-back jump shot. All these values surpassed the tabular threshold of (2.10), definitively forcing the rejection of the null hypothesis and conclusively proving the efficacy of the training intervention.¹

Discussion and Second/Third-Order Insights

Neural Adaptation and Vector-Specific Force Production

An advanced analysis of the percentage progress detailed in the preceding tables exposes a biomechanical insight of pivotal significance in sports science. The experimental group registered a colossal enhancement in vertical explosive power (Sargent test) calculated at 68.75%, whereas horizontal explosive power (3-step jump) evolved by only 30.35%.¹ This numerical disparity does not denote a training flaw; rather, it is an absolute vindication of the "Principle of Specificity." The utilized plyometric drills, such as depth jumps from boxes and rapid vertical bounding, intentionally emphasized the generation of a Vertical Force Vector. This vector mirrors, with microscopic precision, the mechanical demands of the "high jump shot," where the attacker strives to maximize vertical displacement to clear the defensive wall, rather than penetrating horizontal distance.¹ It is therefore deduced that plyometric training did not merely increase the physiological cross-sectional area of muscle fibers; it profoundly reprogrammed the central nervous system to fire and discharge force explosively at the most critical, sport-specific angles required.¹ This comprehensively validates the second research hypothesis.

Mechanical Energy Transfer via the Kinetic Chain

A physiologically compelling conclusion highlighted by the data is the remarkable development of upper-extremity explosive power (improving by 25.60% in the medicine ball push and 15.03% in incline pushups for the experimental cohort).¹ Many practitioners mistakenly restrict plyometric protocols to the lower extremities; however, embedding a series of plyometric chest and shoulder exercises within this program fostered a complex "Motor Synchronization." The impact extends to indicate an elevated efficiency in energy transfer across the "Kinetic Chain." An athlete's capability to summon ground reaction forces via the ankle and knee joints, transmit this energy stably across an isometric core, and culminate in an astonishing acceleration of the whip-like throwing arm, is the direct scientific rationale behind the dramatic surge in shot accuracy and velocity (improving by 20.61% for right backs and 14.72% for left backs).¹ Any delay or sluggishness during the Amortization phase would inevitably leak this energy, dissipating it as heat. However, the reduction in ground-contact time achieved via plyometrics exponentially multiplied the efficiency of this mechanical transfer.

Tactical Repercussions of Increased Hang Time

The surge in successful jump shots executed outside the 9-meter zone transcends a purely physical milestone; it constitutes an indispensable tactical and cognitive mutation at competitive levels. The acquired vertical ascension inherently guarantees the athlete an extended relative duration suspended in the air, recognized as "Hang Time." This supplementary fraction of a second of voluntary suspension gifts the player—especially playmakers and backcourt shooters—expanded visual processing bandwidth. It allows them to surveil the goalkeeper's positioning and exploit the disruption of balance within the defensive wall.¹ Consequently, the physiological adaptation resulting from explosive training practically upgraded the quality of "Motor Decision Making" under intense pressure, thereby elevating the comprehensive offensive lethality of the team.¹

Physiological Utilization of the Adolescent Cohort (17-19 Years)

The age bracket of the study sample (17-19 years) represents mid-to-late adolescence, a phase where the endocrine system is flooding the body with peak anabolic hormones (such as testosterone and human Growth Hormone), which heavily support muscular hypertrophy and tissue remodeling.¹ Implementing programs reliant on severe eccentric contractions during this phase creates micro-tears in the muscle fibers. These translate to delayed onset muscle soreness, yet simultaneously—facilitated by the methodical 3-4 minute recovery intervals between sets—they exponentially boost the density and protein synthesis of fast-twitch (Type II) muscle fibers.¹ However, the slight variance observed in the post-test standard deviations hints at individual genetic discrepancies in muscle fiber distribution. This underscores an absolute mandate for coaches to strictly individualize volume loading to avert overuse injuries in connective tissues and ligaments.¹

General Conclusion and Recommendations

The empirical data and statistical parameters extracted from this experimental research demonstrate an irrefutable, structural supremacy of plyometric training in shaping and directing the biomechanical and physiological profiles of handball players.¹ The inclusion of explosive exercises reliant on stimulating the Stretch-Shortening Cycle does not merely inflate absolute muscular strength; it neurologically re-engineers the neuromuscular system to generate this force within the narrowest possible time window. This neural adaptation materialized brilliantly in the players' ability to transmute kinematic momentum into tangible skill efficiency, translating into extraordinary elevations over defensive blocks and dynamic, precision-guided shots that defenses struggle to contain.¹

Based on the findings of this study, we offer the following profound recommendations:

- **Institutionalization of Plyometric Training:** This training modality must transition from being a supplementary accessory to an indispensable, periodized cornerstone within the annual macrocycles of modern handball academies.¹
- **Biological Monitoring of Effort:** It is imperative to enforce recovery and prophylactic measures between units (e.g., alternating a plyometric day with a rest or low-intensity day) to avert neural fatigue and mitigate the risk of tendon ruptures in youth athletes.¹
- **Specialized Motor Compatibility:** Plyometric drills must be seamlessly fused with fundamental handball skills. A bounding or jumping sequence should ideally culminate in an actual shot with a ball, ensuring a "positive transfer" of the training effect from a purely conditioning environment directly into the tactical, competitive arena.¹

References

- Abu Ala Abd al-Fattah, Ibrahim Shaalan: *Physiology of Training in Football*, Dar Al-Fikr Al-Arabi, Cairo, 1994.
- Amr Allah Al-Basati: *Functional Physical Preparation in Football: Planning and Measurement*, Dar Al-Jami'a Al-Jadida for Publishing, Alexandria, 2002.
- Bastawisi Ahmed: *Foundations and Theories of Sports Training*, Dar Al-Fikr Al-Arabi, Cairo, 1999.
- Essam Abd El-Khaleq: *Sports Training: Theories and Applications*, Dar Al-Kitab Al-Jamia, Alexandria, 1972.
- Jamal Sabri Faraj: *Power, Capacity, and Modern Sports Training*, Dar Dijla, Amman, 2011.
- Hussein Abd Al-Amir Hamza Sharba: *Shooting (Scoring) in Handball*, College of Physical Education, 2012.
- Khairiya Ibrahim Al-Sukkari: *Plyometric Training for the Athlete's Locomotor System, Part Four*, 2010.
- Kamal Al-Din Abd Al-Rahman Darwish: *Measurement, Evaluation, and Match Analysis in Handball: Theories and Applications*, Center for Books Publishing, 2002.
- Kamal Abd Al-Hamid Ismail: *The Quartet of Modern Handball*, Center for Books Publishing, 1st ed., 2001.
- Mohamed Sobhi Hassanin: *Evaluation and Measurements in Physical Education*, Dar Al-Fikr Al-Arabi, Cairo, 1979.
- Mufti Ibrahim Hammad: *Modern Sports Training: Planning, Application, and Leadership*, Dar Al-Fikr Al-Arabi, Cairo, 2001.

Mounir Gerges Ibrahim: Handball for All, 4th ed., Dar Al-Fikr Al-Arabi, 1994.

Ali Nasef Qasim Hassan Hussein: Strength Training, Baghdad, 1978.

Abd Al-Razzaq Rahmani: The Effect of a Proposed Program Using Selected Plyometric Exercises on Improving Digital Performance, 2002.

Subhi Ahmed Qablan: Handball: Skills, Coaching, Drills, Injuries, Arab Society Library for Publishing, 1st ed., 2011.

Yasser Dabour: Modern Handball, Mansha'at Al-Ma'arif, Alexandria, 1996.

Zaki Mohamed Mohamed Hassan: Towards Better Muscular Power: Plyometric Training, Egyptian Library, Alexandria, 2004.