

effect of plyometric training on improving the speed power for volleyball players U19 years

استخدام التدريب البليومتري على تحسين قوة السرعة لدى لاعبي الكرة الطائرة أقل من 19 سنة

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Abstract:

This research investigated the effect of a plyometric training program on enhancing speed-power in volleyball. An experimental design was applied using two groups: an experimental group and a control group. Three volleyball-specific speed-power tests were administered as instruments for data collection. The study sample consisted of sixteen players who followed an eight-week plyometric program comprising sixteen training sessions, each lasting between 30 and 40 minutes.

Data were analyzed using the SPSS-25 statistical software. A parametric analysis employing the t-test revealed that plyometric training significantly improves the velocity power of both the lower and upper limbs.

Keywords: plyometric training, speed-power, explosive strength, spiking skill, under-19 volleyball players.

ملخص:

تناولت هذه الدراسة أثر برنامج تدريبي بليومتري على تطوير القوة الانفجارية (قوة السرعة) لدى لاعبي الكرة الطائرة، تم تطبيق تصميم تجريبي اعتمد على مجموعتين: واحدة تجريبية وأخرى ضابطة، استخدمت في الدراسة ثلاثة اختبارات خاصة بقوة السرعة والموجهة لرياضة الكرة الطائرة كأدوات لجمع البيانات، تكونت عينة البحث من ستة عشر لاعبا خضعوا لبرنامج تدريبي بليومتري مدته ثمانية أسابيع بمجموع ست عشرة وحدة تدريبية تراوحت مدة كل وحدة بين 30 - 40 دقيقة، تم تحليل البيانات باستخدام البرنامج الإحصائي SPSS-25، وأظهرت نتائج اختبار "ت" على

وجود فروق ذات دلالة إحصائية مما يدل على أن التدريب البليومتري يسهم بشكل ملحوظ في تحسين قوة السرعة لكل من الأطراف السفلية والعلوية.
الكلمات المفتاحية: التدريب البليومتري، قوة السرعة، القوة الانفجارية، مهارة الضرب الساحق، لاعبو الكرة الطائرة
أقل من 19 سنة.

1. Introduction and Research Problem:

Sports training is founded on scientific and practical principles that aim to develop multiple dimensions of athletic preparation—physical, technical, mental, psychological, emotional, and social. It therefore represents a key factor influencing individual and collective performance across societies. Among modern training approaches, plyometric exercises occupy an essential position. According to Ahmad Basstouisi (1999, p.112), plyometric methods have become widely adopted as core techniques for enhancing speed—strength, one of the fundamental physical components required in numerous sports disciplines. Consequently, plyometric work is regarded as a cornerstone for improving athletic performance.

Speed—strength is a particularly dominant physical quality in volleyball, as both defensive and offensive actions demand rapid and forceful execution. Effective performance in these situations depends on an athlete's ability to transition quickly between defense and attack, which in turn requires well-developed speed—strength capabilities.

This study stems from an interest in assessing the influence of plyometric training on the enhancement of speed—strength among volleyball players under 19 years of age. It seeks to compare the effectiveness of a plyometric training program with that of a conventional training model and to clarify the importance of this physical variable for this developmental stage. The results are expected to

provide practical guidance for volleyball coaches regarding the systematic application of plyometric training.

In contemporary sports science, specialization is fundamental. Training programs are increasingly oriented toward the physical qualities specific to each sport. In volleyball, the emphasis on speed–strength corresponds to the physical demands of the game’s modern, fast-paced style. The stronger this attribute, the more effectively players can perform during matches. Field observations of competitive games revealed notable deficiencies in players’ physical readiness, particularly in aspects related to explosive power and vertical jump performance—both linked to speed–strength. These observations suggest that many coaches continue to rely on training models that overlook plyometric methods or fail to integrate them in a structured manner.

Accordingly, the present study seeks to answer the following research question:

2. General Research Question: What is the effect of plyometric training on the development of speed–strength among volleyball players under 19 years old?

2.1 Sub-questions: Based on the main research question, the following sub-questions were formulated:

Are there statistically significant differences in speed–strength improvement between the pre-test and post-test within each group (experimental and control)?

Are there statistically significant differences in speed–strength between the post-test results of the experimental and control groups?

3. General Hypothesis: Implementing plyometric training has a positive impact on enhancing the speed–strength attribute among volleyball players under 19 years of age.

Sub-Hypotheses:

There are statistically significant differences between the pre-test and post-test results within both groups (experimental and control) in favor of the post-test regarding speed—strength.

There are statistically significant differences between the post-test results of the experimental and control groups in speed—strength, favoring the experimental group.

4. Definition of Terms:

4.1. Plyometric Training

Linguistic Origin: The term plyometric originates from Greek, derived from *plyothein*, meaning “to increase” or “to expand.” It combines two roots: *plyo* (increase) and *metric* (measure) (Gills & Dominique Cometti, 2012, p. 27).

Definition: Plyometric training refers to a specialized system of exercises designed to enhance muscular elasticity through eccentric and reflexive contractions (Alford, 1989, p. 21). This training method relies primarily on the utilization of muscle elasticity to develop high levels of kinetic energy by combining maximal strength with maximal speed (Basstouisi Ahmad, 2014, p. 193).

4.2.. Speed—Strength

According to Lisan Al-Arab, strength is defined as “the individual capacity of a rope’s tension or the intrinsic energy within a tendon” (Ibn Manzoor, 1993, vol. 15, p. 207).

From a technical perspective, Matveiev (1983, p. 130) defines speed—strength as the ability to produce maximum muscular force in the shortest possible time during a specific movement. The term explosive strength is often used interchangeably with this concept.

Operationally, speed—strength is understood as the rapid expression of muscular power, reflecting the combined action of both speed and strength components following repetitive movement performance.

4.3. Volleyball Players Under 19:

This category represents a pivotal stage in volleyball training and athlete development, serving as a transition between the junior and senior levels. It corresponds to mid-adolescence (Larousse Dictionary, 1997, p. 864).

During this stage, physical growth tends to stabilize compared with earlier developmental phases, while physiological and physical transformations—such as increases in height and weight—continue. Adolescents at this age become more aware of their physical appearance, health, and bodily capabilities, which positively influences their self-confidence (Hamed Abd El-Salam Zahran, 1995, p. 253).

Study objectives:

- To determine the effect of a plyometric training program on improving speed—strength among volleyball players.

To identify possible solutions to challenges faced by volleyball coaches during the training process.

- To highlight the importance of developing speed—strength in this specific age category.

5. Previous Studies:

5.1. Study by Tine Sattler et al. (2012). Vertical Jumping Tests in Volleyball: Reliability, Validity, and Playing-Position Specifics. *Journal of Strength and Conditioning Research*, 26(6), 1532–1538.

Methodology:

An experimental design was employed, as it was appropriate for the study's objectives.

Tests Applied:

Countermovement Jump (CMJ) from a standing position

Squat Jump (SJ) from a 90° knee angle

Standing Broad Jump

Attack Jump

Anthropometric measurements (height and weight)

Sample:

The study included 95 elite volleyball players aged between 18 and 30 years. Their heights ranged from 177 to 207 cm (mean = 189 cm), and weights ranged from 57.2 to 128.6 kg (mean = 85.1 kg). All participants were active competitors in the Slovenian National Championship.

Statistical Analysis:

Analysis of Variance (ANOVA) was used to determine differences across variables.

Results:

All jump tests demonstrated high reliability, particularly the Attack Jump (A), Broad Jump (B), Countermovement Jump (CMJ), and Squat Jump (SJ). The authors recommended that training programs should focus on improving jumping performance under various conditions while considering players' morphological characteristics.

5.2. Study by Tomislav Kirsticevic et al. (2016). Effects of Short High-Impact Plyometric Training on Jumping Performance in Female Volleyball Players.

Acta Kinesiologica, 10(Suppl 1), 25–29. Faculty of Kinesiology, University of Zagreb, Croatia.

Objective:

To examine the effects of a five-week plyometric training program on the jumping performance of female volleyball players.

Methodology:

An experimental approach was utilized to suit the nature of the research question.

Sample:

The study involved 54 female volleyball players under 15 years old from youth volleyball teams in Serbia, including several players selected for the national youth squad.

Tests Conducted:

Vertical jumps (Block Jump, Spike Jump, CMJ, SJ)

Physical assessments (height, weight, body mass)

Statistical Tools:

Kolmogorov–Smirnov Test

Levene's Test

t-Test

Key Findings:

Significant improvements were recorded in the CMJ and SJ tests among the experimental group, whereas the control group showed no progress. The short-term plyometric program effectively enhanced selected jump variables, though no notable differences appeared in Spike Jump and Block Jump performance for either group.

5.3. Study by Daniel Sporri et al. (2018). The Effect of Water-Based Plyometric Training on Vertical Stiffness and Athletic Performance. PLOS ONE, São Paulo State University – UNESP, Brazil. DOI: <https://doi.org/10.1371/journal.pone.0208439>.

Methodology:

The research employed an experimental design consistent with the nature of the problem investigated.

Sample:

Participants were divided into two groups: an experimental group that completed an eight-week water-based plyometric training program (APG), and a control group (CG) that did not participate in plyometric activities.

Statistical Analysis:

Shapiro–Wilk Test for normality

Levene’s Test for variance homogeneity

t-Test

ANOVA

(Statistical software: Stats of t version, USA, 2014).

Main Results:

Water-based plyometric exercises were shown to improve athletic performance while simultaneously minimizing the risk of soft-tissue injuries. The authors concluded that aquatic plyometric training provides an effective and safe alternative for enhancing explosive ability and reducing injury potential in athletes.

5.4 Study by Dr. S. Varalakshmy et al. (2020). Collision of Ballistic and Plyometric Training on Selected Explosive Power and Vertical Capacity of Male Volleyball Players. HTL Journal, 26(6), 593–601.

Objective:

The purpose of the study was to examine the comparative effects of ballistic and plyometric training on explosive power and vertical jumping ability among male volleyball players.

Methodology:

An experimental design was adopted due to its suitability for testing cause–effect relationships relevant to the study objectives.

Sample:

The participants were 45 male volleyball players aged 18–23 years, randomly assigned into three equal groups (15 athletes per group): one performed ballistic training, another plyometric training, and the third served as a control group. The intervention lasted eight weeks.

Statistical Analysis:

Analysis of Variance (ANOVA) was applied to identify differences among the three groups.

Findings:

Both experimental groups recorded statistically significant improvements in explosive power and vertical jumping capacity compared with the control group. These results confirm the effectiveness of ballistic and plyometric training methods in enhancing specific motor abilities essential for volleyball performance.

Utilization of Previous Studies

The reviewed literature formed the scientific and methodological foundation for the present research. These prior studies provided both theoretical insight and empirical evidence that guided the design and implementation of the current investigation. They also helped determine the most appropriate procedures, measurement tools, and training variables to be adopted.

The selected works represent a focused sample of contemporary research addressing the role of plyometric training in improving physical and sport-specific abilities. Collectively, they demonstrate that earlier studies complement one another and serve as progressive stages in expanding scientific understanding.

In this study, we sought to identify the converging points among these works to establish a coherent framework for further inquiry. The present research aims to contribute new perspectives and fill the existing knowledge gap concerning the

effect of plyometric training on enhancing speed–strength performance among volleyball players under 19 years old.

The practical chapter:

6. Study methodology: In accordance with the research problem, which focuses on identifying the differences in the development of strength qualities among volleyball players through plyometric exercises, the researcher adopted the experimental method. This approach aligns with the study’s practical nature, as it involves applying and evaluating a specific training program. A series of tests designed to assess speed-strength were administered to measure the effectiveness of the program.

7 .Research sample and its characteristics

7.1 Study population (statistical population) comprised all volleyball teams in the province of Sétif competing in the under-19 category, totaling fourteen (14) teams representing various municipalities within the province.

7.2 Primary study sample: A total of sixteen (16) players from the Jil As-Saad volleyball club in Ouled Addouane were selected. All participants were under 19 years old. They were randomly divided into two equal groups—an experimental group and a control group—while ensuring equivalence in essential characteristics such as physical condition and skill level.

8. Exploratory Study

8.1 Phase One: Identify the organizational and practical challenges that may arise during the experiment’s implementation.

Verify the efficiency and suitability of the measurement tools and devices used.

Train the assisting research team.

Estimate the exact time required to conduct the tests.

8.2 Phase Two: During this phase, the study tests were conducted twice, separated by a four-day interval, to determine the reliability and validity coefficients of the instruments applied in the research.

8.3 Phase Three: A pilot training session using plyometric exercises was carried out with the research sample. The purpose was to evaluate the appropriateness of the training content for the participants, as well as to practice and refine the timing and execution procedures of the training unit in all its aspects.

9. Experimental Variables

Independent Variable: Plyometric training program.

Dependent Variable: Speed-strength performance.

Control Variables (Intervening Variables): These variables ensured the equivalence between the experimental and control groups in factors that could affect performance, such as skill level, height, weight, and years of experience (Mohamed Hassan Allawi & Osama Kamel Rateb, 1999, p. 223).

10. Scope and Boundaries of the Field Study

10.1. Human Scope (Research Sample): The field research focused on athletes from the Jil As-Saad volleyball club, located in the municipality of Ouled Addouane. The participants were male players under 19 years of age, actively engaged in volleyball during the 2024–2025 training season.

10.2. Time Scope: The exploratory phase and testing schedule were organized as follows:

Preliminary (exploratory) tests: conducted between October 5 and 7, 2024.

Post-tests: conducted from October 12 to 14, 2024.

The main experimental period extended for ten weeks, from October 20, 2024, to December 20, 2024, distributed as follows:

Week 1: Baseline tests and anthropometric measurements.

Weeks 2–9: Implementation of the plyometric training program.

Week 10: Final testing and data collection.

10.3. Spatial Scope: All testing sessions and training procedures were conducted at the multi-sports hall of the Jil As-Saad club in Ouled Addouane, within the Ain El Kebira district of Sétif Province. This facility provided a standardized and controlled environment suitable for executing the training program and collecting data.

11. Tools and Instruments for Data Collection:

The following instruments, materials, and references were utilized to gather, organize, and analyze data throughout the study:

Literature and References: Academic sources, both in Arabic and English, alongside reliable electronic databases and online resources.

Measurement Devices: Technological tools such as digital cameras and computers for documentation and data processing.

Training Equipment: Sports materials essential for implementing the plyometric program, including cones, markers, hoops, medicine balls, hurdles, and ropes, in addition to other equipment facilitating the training process.

Questionnaires:

A survey for experts to validate the selection of physical tests employed in the study.

A survey for experts to evaluate and approve the proposed training units forming the experimental program.

11.1. Measurements and Tests Applied in the Research:

Anthropometric Measurements Following a review of relevant scientific literature, the researcher selected specific body measurements that best reflect the athletes' physical profiles. The variables assessed included:

Height (in centimeters).

Body weight (in kilograms).

Speed-Strength Tests To evaluate explosive and reactive strength, the following tests were administered:

Three-Jump Test

Hexagonal Agility Test

10-Second Push-Up Test

12. Scientific Basis of the Tests

12.1. Test Reliability represents the degree of consistency and accuracy with which a test measures the phenomenon it is designed to evaluate. According to Layla Sayed Farhat (2007, p.143), reliability reflects the precision of a measurement tool in assessing the intended characteristic. Similarly, Nabil Abdelhadi (1999, p.66) emphasizes that a reliable test is one that produces identical results when repeated on the same participants under identical conditions.

To verify the reliability of the tests used in this research, the test–retest technique was employed. A random subsample of eight players from the main study group was selected. The tests were administered twice, with a four-day interval between applications, while maintaining the same testing conditions to ensure measurement consistency.

The Pearson correlation coefficient (r) was then calculated to determine the degree of reliability for each test.

- Physical Tests:

Table 03: Shows the reliability coefficient values of the physical tests.

Tests		Preliminary Exploratory Experimental Sample								
		test		retest		Test r		Standar error of test r	Test r	Self validity
		mean	Standard deviation	mean	Standard deviation	test	retest			
Speed Strength Tests	Three jumps test	5,46	0,118	5,46	0,095	0,28	1,33	0,752	0,86	0,92
	Hexagonal test	18,25	0,70	18,50	0,53	0,40	0,00		0,58	0,76
	10-Second Push-Up Test	18,25	0,70	18,50	0,53	0,40	0,00		0,75	0,86

From Table 3, it is evident that all Pearson correlation coefficients (reliability) range between (0.58–0.86) with a validity coefficient ranging from (0.76–0.92). All these results indicate that the tests used have strong reliability and validity coefficients.

12.2. Test Validity: Although the tests employed in this study have previously demonstrated validity coefficients supported by numerous prior investigations, the researcher ensured their appropriateness by examining **two distinct types of validity**:

Content Validity This form of validity is based on evaluating how well a test represents the intended domain of performance or skill. To establish this, the researcher submitted the selected tests to a panel of **nine experts and academics** specializing in **sports training and volleyball**. Each expert was asked to provide a detailed evaluation of the test items. After reviewing the feedback, **seven experts confirmed the suitability and relevance** of the tests, with modifications incorporated according to their constructive remarks and observations.

Construct Validity: To assess the construct validity of the applied tests, the **square root of the reliability coefficient** was computed, as presented in **Table 3**, thereby confirming the internal consistency and coherence of the measurement tools.

12.3. Objectivity of the Tests: According to **Fatima Awad Saber (2003, p.164)**, a test is considered objective when it produces consistent results irrespective of the evaluator. To ensure objectivity in this study, all test procedures were clearly defined, with **straightforward instructions** and **explicit evaluation criteria** provided. Moreover, the researcher ensured uniformity by using the **same instruments, timing, and execution procedures** throughout the testing sessions, which reduced the likelihood of subjective interpretation and enhanced the precision of recorded results.

13. Description of Measurement and Testing Protocols:

13.1. Physical Measurements:

Height Measurement (Standing Position, in Centimeters)

Height refers to the **vertical distance** between the lowest point of the feet and the highest point of the head. During measurement, the participant should stand **upright and barefoot**, arms relaxed at the sides, ensuring proper alignment of

the body.

The measurement is taken using a **sliding stadiometer (toise)** calibrated in centimeters, which consists of a **vertical rod** fixed on a **wooden base** measuring **250 cm** in height. The zero mark aligns precisely with the base level. A **movable horizontal headpiece** slides along the pole to contact the top of the participant's head. The individual stands with their **back against the vertical rod**, maintaining **three points of contact**:

The upper back (between the shoulder blades),

The most prominent part of the pelvis,

And the back of the calves.

The subject extends gently upward while keeping the **gaze forward and head level**. The final height is recorded at the **point where the headpiece meets the vertex of the skull**.

Table 03: Presents the classification of human types according to height
(Gning, 2006, p.27).

Tall cm	Classifications
Less than 155	Exceptionally Very Short
155.5 – 161	Very Short
161.5 – 167.5	Short
168 – 174	Average
174.5 – 181	Tall
181.5 – 187	Very Tall
More than 187	Exceptionally Very Tall

Body Weight Measurement (in Kilograms): Body weight is among the simplest **anthropometric indicators** to obtain; however, measurement errors can occur if proper tools or standardized procedures are not followed. The

participant is positioned upright on a **calibrated medical scale**, ensuring that the digital display is clearly visible. The researcher records the reading directly from the screen, with precision up to **50 grams**, to guarantee accuracy and consistency in all measurements.

13.2 Physical Tests:

Speed-Strength Assessments

Three Consecutive Hops for Maximum Distance (Single-Leg Test):

In this test, the athlete begins **behind the starting line**, balancing on one foot (right or left). Upon signal, they execute **three consecutive hops** on the same leg, aiming to achieve the **greatest possible horizontal distance**. The test area is marked with two parallel lines on the floor, which the participant must remain within throughout the sequence. The participant must ensure that **no body part other than the hopping leg** contacts the ground during the attempt (as described by Abdul Jabbar Qais Naji and Ahmed Basstouisi, 1987, p. 346).

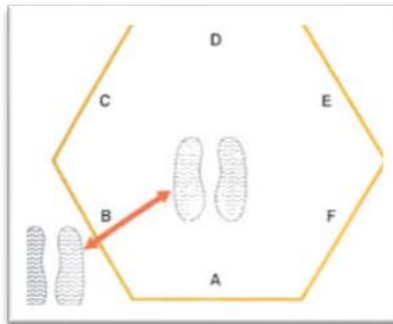
The distance achieved is determined by measuring from the **starting line** to the **rear edge of the heel** on the final landing. Each participant performs **three trials per leg**, and the **best result** among the attempts is recorded for analysis.

Figure 02: Illustrates the execution method of the three jumps test for the greatest possible distance, performed separately with each leg.



Hexagonal Test: The player performs circular zigzag jumps around the lines of a hexagon (each side measuring 61 cm) three times. The time taken to complete the jumps is measured, both for jumping to the right and to the left. The purpose of this test is to measure coordination during the ascent (Aurelien, 2012, p. 146).

Figure 03: Illustrates the hexagonal obstacle test.



Front Hand Support Test for 10 Seconds:

Purpose of the Test: To measure the explosive strength of the arm muscles.

Performance Specifications: From a prone, inclined position, the subject must fully bend and extend their arms for 10 seconds without stopping while maintaining body alignment throughout the test. The elbows must be fully bent and extended to their maximum range. Any violation of these conditions will result in the trial being disqualified.

Scoring: The number of correct attempts performed by the subject is recorded (Mohamed Sobhi Hassanien, 2000, p. 226-227).

Figure 04: Shows the method for performing the Front Hand Support Test for 10 seconds.



14. The Main Study:

14.1. Research Samples:

Experimental Group: The experimental group in our study underwent a training program based primarily on plyometric exercises to improve explosive strength, speed strength, and the performance of the spike skill in volleyball. The program consisted of 16 training units, with each unit lasting between 30 to 40 minutes, as shown in Table 06.

Control Group: The control group followed a traditional program designed by the team's coach, which included a specific proportion of plyometric exercises.

14.2. Normality of Data Distribution in the Research Tests:

Homogeneity and Equivalence of the Research Groups:

Homogeneity: We calculated the homogeneity between the members of the research groups concerning the anthropometric variables (height, weight, age), as shown in the following table:

Table 05: Shows the homogeneity of the experimental and control groups in terms of weight,height, and age variables.

Statistical Treatment	Experimental Group				Control Group				Degrees of Freedom (n - 2)	sig	Significance Level
	Mean	Standard Deviation	Median	Skewness	Mean	Standard Deviation	Median	Skewness			
Weight	67,23	6,74	65,40	0,14	67,76	7,24	69,57	-0,69	14	0,87	Not Significant
tall	1,75	0,08	1,77	-0,75	1,76	0,04	1,76	-0,93		0,82	Not Significant
Age	214,37	7,02	212	0,59	215,12	7,19	212,5	-0,13		0,08	Not Significant

It can be seen from **Table 05** that the values of the skewness coefficient range between (-1 and +1), indicating a normal distribution. By comparing the arithmetic mean, standard deviation, and median for both the experimental and control groups in terms of weight, height, and age variables, we find that they are very close, which indicates the homogeneity of the two samples. Additionally, from the same table, it is clear that all **sig** values (0.87, 0.82, 0.08) are greater than the error margin (0.05), which indicates that there are no statistically significant differences between the experimental and control groups, confirming the homogeneity of the two samples in terms of **weight, height, and age** variables.

Equivalence: In order to attribute differences to the experimental factor, the two groups (experimental and control) must be equivalent in all conditions and variables except for the experimental variable, which affects the experimental group but not the control group (Manal Aboud Abdel Majid Al-Anbaki, 1995, p. 35). In this context, we ensured the equivalence of the research groups by using the **T-test** for independent and equal samples.

Table 06: Shows the equivalence of the two groups in the physical tests.

Statistical Treatment	Experimental Group		Control Group		Calculate d (T) Value	Margi n of Error	Degrees of Freedom	sig	Significance Level
variation	Mean	Standard Deviation	Mean	Standard Deviation					
Three jump test	5,412	0,099	5,38	0,17	0,89	0,05	14	0,401	Not Significant
Hexagon Test	19,31	0,37	19,45	0,23	-0,72			0,493	Not Significant
10-Second Push-Up Test	17,62	0,91	17,75	1,03	-0,24			0,819	Not Significant

It can be seen from **Table 06** that all **sig** values are between (0.158 – 0.819), which are greater than the significance level (0.05), indicating the absence of statistical significance for all research tests. This shows that there are no statistically significant differences between the experimental and control groups, meaning that they are equivalent in the research tests.

15. Statistical Methods Used:

- Arithmetic mean
- Standard deviation
- Pearson correlation coefficient
- Reliability and validity coefficients
- Shapiro-Wilk normality test
- T-test for differences between means
- Data analysis using the SPSS statistical software package (SPSS-25).

16. Results and Discussion:

16.1. Presentation and Analysis of the Study Results: Presentation of the pre- and post-test results and the calculated T values for the experimental and control groups in the speed-strength tests:

Results of the Three jump test:**Table 07: Shows the comparison of the pre- and post-test results for the Three jump test for both the experimental and control groups.**

Three jump test				
Statistical Treatment	Experimental Group		Control Group	
	Pre-tests	Post-tests	Pre-tests	Post-tests
Mean	5,412	05,60	5,381	5,481
Standard Deviation	0,099	00,08	0,175	0,205
Percentage of Increase	%3,47		%1,85	
Calculated (T) Value	-6,70		-4,73	
Sig	0,000		0,02	
Significance Level	Significant		Significant	

Figure 05: Graphical representation of the mean scores for the pre- and post-test results of the Three Hurdle Test for the longest possible distance with each leg individually.

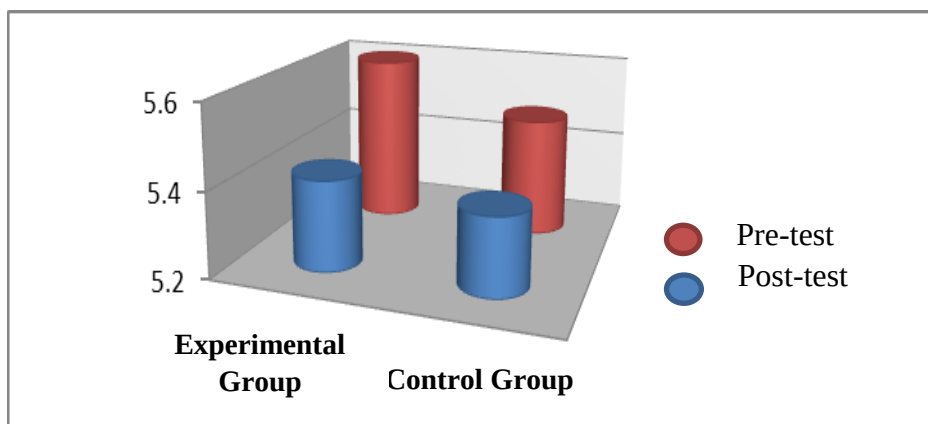


Table 07 shows the pre- and post-test results for the 3 hops for maximum distance test (each leg separately) for both the experimental and control groups. The mean value for the pre-test of the experimental group was (5.412), and for the post-test, it was (5.60), showing an increase of 3.47%. The statistical results of the **T-test** revealed statistically significant differences between the two means in favor of the post-test, as the **sig** value shown in the table was less than the error level (0.05), which was (0.000).

As for the control group, the mean value for the pre-test was (5.381), and for the post-test, it was (5.481), showing an increase of 1.85%. The statistical results of the **T-test** also indicated statistically significant differences between the two means in favor of the post-test, as the **sig** value was less than the error level (0.05), which was (0.02).

Results of the Hexagonal Test:

Table 08: Shows the comparison of the pre- and post-test results for the Hexagonal Test (test hexagonal) for both the experimental and control groups.

Hexagonal Test				
Statistical Treatment	Experimental Group		Control Group	
	Pre-tests	Post-tests	Pre-tests	Post-tests
Mean	19,318	18,831	19,456	19,356
Standard Deviation	0,372	0,397	0,232	0,197
Percentage of Increase	%2,58		%0,52	
Calculated (T) Value	6,513		3,191	
Sig	0,000		0,15	
Significance Level	Significant		No Significant	

Figure 06: Graphical representation of the mean scores for the pre- and post-test results of the Hexagon Test.

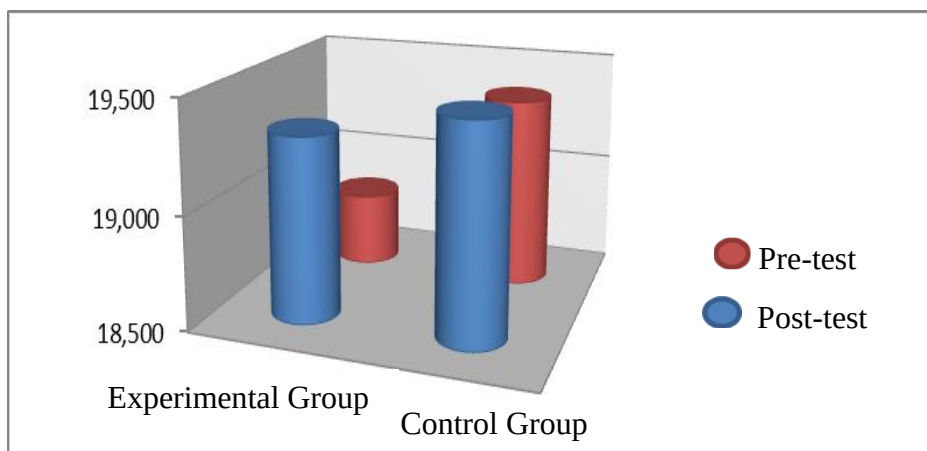


Table 08 shows the pre- and post-test results for the Hexagonal Test (test hexagonal) for both the experimental and control groups. The mean value for the pre-test of the experimental group was (19.318), and for the post-test, it was (18.831), showing an increase of 2.58%. The statistical results of the **T-test** revealed statistically significant differences between the two means in favor of the post-test, as the **sig** value is greater than the error level (0.05), which was (0.000).

As for the control group, the mean value for the pre-test was (19.456), and for the post-test, it was (19.356), showing an increase of 3.19%. The statistical results of the **T-test** indicated no statistically significant differences between the two means, as the **sig** value shown in the table is less than the error level (0.05), which was (0.15).

16-1-3 Results of the 10-Second Push-Up Test:

Table 09: Shows the comparison of the pre- and post-test results for the 10-Second Push-Up Test for both the experimental and control groups.

10-Second Push-Up Test				
Statistical Treatment	Experimental Group		Control Group	
	Pre-tests	Post-tests	Pre-tests	Post-tests
Mean	17,625	18,375	17,750	18,250
Standard Deviation	0,916	0,744	1,035	0,707
Percentage of Increase	%4,25		%2,81	
Calculated (T) Value	-4,583		-1,871	
Sig	0,003		0,104	
Significance Level	Significant		No Significant	

Figure 07: Graphical representation of the mean scores for the pre- and post-test results of the 10-second push-up test.

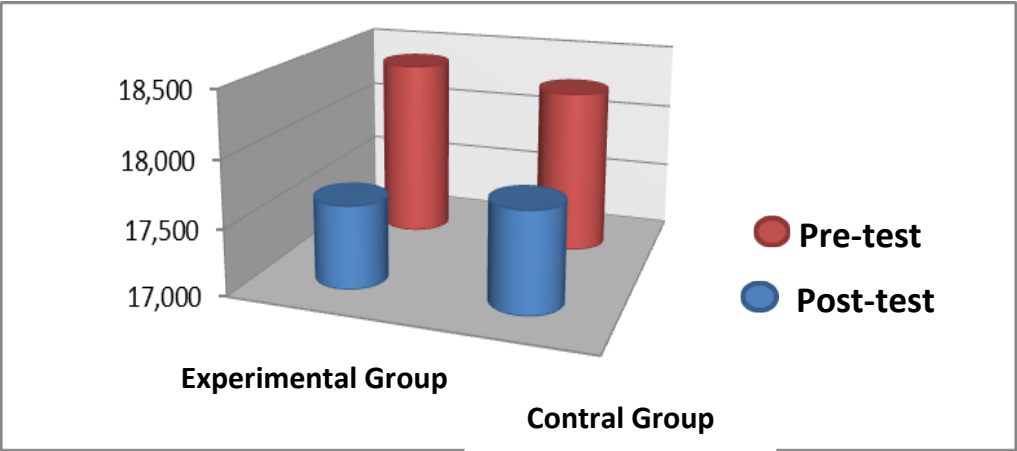


Table 09 shows the pre- and post-test results for the handstand test (10 seconds) for both the experimental and control groups. The mean value for the pre-test of the experimental group was (17.625), and for the post-test, it was (18.375), showing an increase of 4.25%. The statistical results of the **T-test** indicated statistically significant differences between the two means in favor of the post-test, as the **sig** value is less than the error level (0.05), which was (0.003).

As for the control group, the mean value for the pre-test was (17.750), and for the post-test, it was (18.250), showing an increase of 2.81%. The statistical results of the **T-test** indicated no statistically significant differences between the two means, as the **sig** value shown in the table is greater than the error level (0.05), which was (0.104).

16-2 Presentation of Post-Test Results and Calculated "T" Value for the Experimental and Control Groups in Speed Strength Tests:

16-2-1- 3 Hops for Maximum Distance Each Leg Individually Test:

Table 10: Shows the comparison of the post-test results for the 3 hops for maximum distance each leg individually test for both the experimental and control groups.

Three jump test		
Statistical Treatment	Experimental Group	Control Group
	Pre-tests	Post-tests
Mean	5,60	5,48
Standard Deviation	0,088	0,205
Calculated (T) Value	1,503	
Sig	0,165	
Significance Level	No Significant	

Figure 08: Graphical representation of the mean post-test results of the Three Hurdle Test for the longest possible distance with each leg individually.

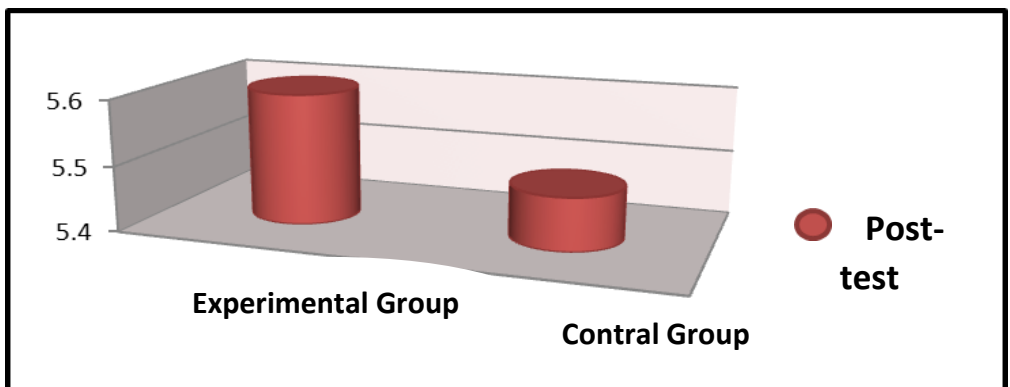


Table 10 shows the comparison of the post-test results for the 3 hops for maximum distance each leg individually test between the experimental and control groups. The statistical results of the **T-test** showed no statistically significant differences between the two groups, with the **sig** value being (0.165), which is greater than the error level (0.05).

16-2-2 Hexagonal Test:

Table 11 shows the comparison of the post-test results for the hexagonal test (test hexagonal) for both the experimental and control groups.

Hexagonal Test		
Statistical Treatment	Experimental Group	Control Group
	Pre-tests	Post-tests
Mean	18,831	19,365
Standard Deviation	0,397	0,197
Calculated (T) Value	-3,348	
Sig	0,005	
Significance Level	Significant	

Figure 09: Graphical representation of the mean post-test results of the Hexagon Test.

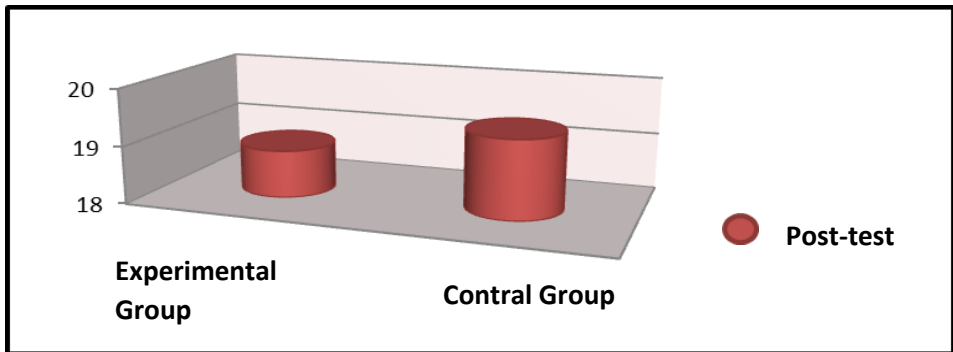


Table 11 shows the comparison of the post-test results for the hexagonal test (test hexagonal) between the experimental and control groups. The statistical results of the **T-test** showed significant differences between the two groups, with the **sig** value being (0.005), which is smaller than the error level (0.05). However, if we examine the mean values, we see that the mean of the experimental group is higher.

16-2-3- 10-Second Push-Up Test:

Table 12 shows the comparison of the post-test results for the handstand test for 10 seconds (Pompes 10s) between the experimental and control groups.

10-Second Push-Up Test		
Statistical Treatment	Experimental Group	Control Group
	Pre-tests	Post-tests
Mean	18,37	18,25
Standard Deviation	0,744	0,707
Calculated (T) Value	0,344	
Sig	0,736	
Significance Level	No Significant	

Figure 10: Graphical representation of the mean post-test results of the 10-second push-up test (10s Pompes).

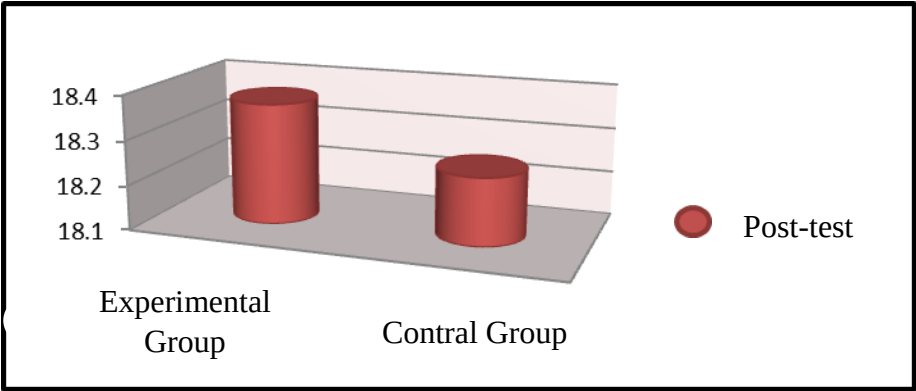


Table 12 presents a comparison of the post-test results for the 10-second hand support test (Pompes 10s) between the experimental and control groups. The statistical results of the "T-test" show that there were no significant differences

between the two groups, with a sig value of 0.736, which is higher than the error rate of 0.05.

17. Discussion of Speed Strength Test Results

Hypothesis 1:

There are statistically significant differences between the pre-test and post-test in favor of the post-test results regarding speed strength.

After analyzing the data using the **T-test** to identify differences between the mean scores, the findings presented in Tables (7) through (12) revealed statistically significant improvements at the **0.05** level between pre- and post-test results for the **experimental group** in all assessments (Triple Jump, Hexagonal Test, and 10-second Push-up Test).

This enhancement can be attributed to the **plyometric training program** implemented by the researcher, which was carefully designed based on scientific principles that controlled for **training intensity, load, and density**, while maintaining the essential principles of training progression. Consequently, this structured approach led to notable improvements in performance.

In contrast, the **control group** exhibited a significant improvement only in the **Triple Jump test**. This progress may be linked to the coach's emphasis on **horizontal jumping exercises** within their regular training routine, which directly influenced this specific test. However, no significant changes were observed in the **Hexagonal Test** or the **10-second Push-up Test**, likely due to the limited focus on **lower-limb coordination** and **upper-body speed-strength** in the control group's training sessions.

Overall, while both groups showed progress in the Triple Jump, the **experimental group's improvement percentage** was substantially higher,

underscoring the effectiveness of the plyometric training program in enhancing speed strength performance.

Hypothesis 2:

There are statistically significant differences between the post-test results of the experimental and control groups in terms of speed strength.

In examining this hypothesis, the analysis revealed that significant differences appeared in the **Hexagonal Test**, whereas no statistically significant differences were observed in the **10-Second Push-Up Test**.

It is well established in sports science that **plyometric training** contributes to notable enhancements in strength and speed attributes—particularly in **speed-strength**. Several studies have reinforced this finding. For instance, **Nizar Al-Waisi et al.** reported a positive effect of plyometric exercises on selected motor abilities and performance levels in the **Triple Jump** event. Likewise, **Bokrattam Belkacem (2008)** demonstrated that plyometric training had a beneficial influence on speed-strength test outcomes. Similarly, **Zaid Ahmed Khalid (2015)**, in research published in the *Zakho University Journal*, concluded that plyometric exercises improved performance and the percentage of progress in the **Triple Jump** among experimental subjects. Additionally, **Hussein and Raed (2009)** emphasized the significant role of plyometric exercises in developing motor and skill-related abilities during **Triple Jump** training. **Hamada Haji (2016)** also confirmed that plyometric programs produced substantial post-test improvements in speed-strength, especially in the Triple Jump.

Furthermore, **Mohamed Abdel-Moneim El-Shafie (1994)** found that a plyometric training program targeting leg muscle strength led to marked improvement in the experimental group compared to pre-test results, and he recommended extending the training duration for greater effect. Similarly, **Darwish Mohamed (2014)** observed that plyometric programs significantly

enhanced speed-strength characteristics. This can be linked to the **principle of training specificity**, as noted by **C. Doucet (2005)**, who stated that exercises should closely replicate the movements performed in actual competition. Supporting this, **Ferkoshansky** highlighted the effectiveness of deep jump exercises in improving speed-strength performance.

However, these findings contrast with those of **Bounap Shaker**, whose research on the **Hexagonal Test** indicated that a plyometric training program did not lead to measurable improvement in Hexagonal Jump performance. Likewise, **Guillaume Leblanc (2012)** found no significant post-training changes in balance performance on explosive tests such as the Hexagonal Test among athletes who trained exclusively with plyometric methods.

The results of the present study are consistent with the views of **Russian researchers**, who regard plyometric training as the most efficient means of enhancing **neuromuscular stimulation**. According to **Smith (2001)**, plyometric exercise represents one of the most effective approaches for developing **dynamic strength**, particularly **speed-strength**. Additionally, **Bosco, Komi, and Cometti (1997)** demonstrated that the **stretch–shortening cycle** (the reflex-based mechanism activated during plyometric work) plays a critical role in improving both **explosive** and **maximal strength** (Weineck, 1997).

18. Conclusion

This research examined the effect of **plyometric training** on developing **speed-strength qualities** among **under-19 volleyball players** from the *Rising Generation* team in *Ouled Addouane*. The study began by clearly defining the research problem, conducting a literature review, and then implementing the practical phase that applied experimental methods to test the proposed hypotheses.

An **experimental design** was adopted, consisting of two groups:

- An **experimental group**, which followed a structured plyometric training program.
- A **control group**, which continued with its traditional training regimen.

The plyometric program lasted **eight weeks**, with **two sessions per week**, integrated within the players' regular in-season training schedule. Upon completion of the program, various **physical and performance tests**—including those assessing **speed-strength** and **smash execution**—were analyzed.

The main findings were as follows:

1. Systematic application of plyometric exercises for eight weeks (two sessions weekly) produced a clear improvement in **speed-strength** among volleyball players under 19 years of age.
2. The **experimental group** showed statistically significant progress between pre- and post-tests across all speed-strength measures, particularly in the **Triple Jump** test.
3. The **control group**, however, exhibited no significant differences between pre- and post-tests in the **Hexagonal** and **10-Second Push-Up** tests.
4. When comparing post-test outcomes for both groups, no significant variations were detected except in the **Hexagonal Test**, where the experimental group outperformed the control group.

Based on these outcomes and in light of previous literature, it can be concluded that **plyometric training** plays a vital role in enhancing **speed-strength performance** among young volleyball players. The results of this study aim to support the development of **physical conditioning programs**, with a focus on improving **explosive strength and movement efficiency** for athletes in the under-19 category.

Moreover, these findings can serve as a valuable reference for **coaches and sports professionals** in designing scientifically grounded training programs tailored to different age groups. They also highlight the need for continued **research and technological integration** in sports science to strengthen the empirical foundation of modern training methodologies, as the current field still lacks sufficient, up-to-date experimental data and advanced analytical tools to validate long-term effects with high precision.

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