

Employing a Standardized Training Program Based on the Ballistic Training Method to Develop Lower-Limb Speed-Strength in U17 Football Players

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Abstract

This study aimed to examine the effect of employing a standardized training program based on the ballistic training method on the development of lower-limb speed-strength among U17 football players. An experimental design with two equivalent groups—a control group and an experimental group—was adopted. A set of physical tests was administered to measure lower-limb speed-strength. Comparison of the post-test results of the two groups revealed statistically significant differences in favor of the experimental group, indicating that the ballistic training program contributed effectively to the development of lower-limb speed-strength in U17 football players.

Keywords: ballistic training; speed-strength; football players.

1. Problem Statement

Speed-strength is one of the most important specific physical abilities underpinning skilled and technical performance in football, especially in the under-17 age category, which represents the foundation for future athletic development. This quality enables players to perform short accelerations, jumping actions, rapid changes of direction, and effective responses to the demands of modern play.

Despite coaches' awareness of the importance of this attribute, heavy reliance on traditional training methods may not be sufficient to achieve the level of development required by the intensity and tempo of contemporary matches.

Within this context, attention has turned to advanced training methods such as ballistic training, which relies on explosive movements similar to those performed in competition and may therefore be more effective than classical programs in developing speed-strength. Nevertheless, the suitability and effectiveness of this type of training for youth players under 17 years of age remain issues that require empirical study.

In view of the foregoing, and with the aim of contributing to the training of speed-strength, the present study was directed toward the use of a standardized training program based on the ballistic training method to develop lower-limb speed-strength in football players under 17 years of age.

This may improve the teaching and training process and provide football coaches with an additional means of developing this quality and reaching the desired level.

Research question: Are there statistically significant differences in the post-test results of the experimental and control groups in the development of lower-limb speed-strength among U17 football players?

2. Hypothesis

There are statistically significant differences in the post-test results of the experimental and control groups, in favor of the experimental group, in the development of lower-limb speed-strength among U17 football players.

3. Research Objectives

Every scientific study has an objective or purpose that gives it scientific value. The objective of a study is generally understood as the reason for which the researcher prepared it. Scientific research seeks to achieve general, non-personal objectives of scientific value and significance. The present study aims to:

- Design a standardized training program based on the ballistic training method to develop lower-limb muscular strength in U17 football players.
- Determine the effect of a standardized training program based on the ballistic training method on the development of lower-limb speed-strength in U17 football players.
- Determine the effect of a standardized training program based on the ballistic training method on the development of lower-limb explosive power in U17 football players.
- Improve and raise the level of lower-limb physical performance in U17 football players.

4. Significance of the Study

Practical significance: The practical importance of the study lies in its attempt to determine the effect of a standardized training program based on the ballistic training method on the development of lower-limb muscular strength in U17 football players. It also seeks to shed light on physical preparation in general and ballistic training in particular as a modern training method for U17 football players. As one of the approaches through which the procedures needed to prepare the player comprehensively to withstand physical loads can be identified, such training may help athletes unleash their capacities and achieve the best possible results according to their preparedness and capabilities. Consequently, the study may contribute to improving the planning, preparation, and implementation of sports training programs, curricula, and academic formation on the basis of scientifically grounded results, and may lead to proposals that support a better understanding of the future outlook of football players in general and U17 football players in particular, with the aim of advancing the educational and training process.

Scientific significance: The scientific importance of the study lies in generating findings needed by players and coaches in football, clarifying the degree of interrelationship among physical qualities in football, and enriching library resources.

5. Reasons for Choosing the Topic

5.1 Personal reasons

- The researcher's specialization in sports training motivated him to investigate this topic.
- Direct engagement with the field of football training and the desire to contribute to it, together with an attempt to solve one of the problems faced by U17 football players through close

observation of the reality of football training for youth categories, the programs applied, and the educational procedures adopted in this activity.

- The scarcity, to the best of the researcher's knowledge, of national studies and research concerned with using ballistic training to develop muscular strength in football players. The present research is therefore among the first studies to examine the use of a standardized training program based on the ballistic training method to develop lower-limb muscular strength in U17 football players.

6. Objective Reasons

- To investigate the causes that hinder the development of lower-limb muscular strength in U17 football players, monitor progress in this quality, and propose suitable solutions.
- To arrive at proposals that may support a better understanding of the use of ballistic training in developing muscular strength in football players.
- To contribute to improving the planning and preparation of training programs and curricula for youth football categories.

7. Definitions and Terms

7.1 Training Program

Linguistically: The term training program derives from the Arabic root meaning to organize and prepare a precise plan, while training denotes drilling and teaching the performance of specific skills repeatedly until mastery is attained.

Terminologically: It is defined as one of the elements of the plan, and without it planning remains incomplete; the program is the executive steps in the form of detailed activities that must be carried out to achieve the objective (Al-Bayk & Abbas, 2003, p. 102).

Training programming is a systematic process based on acquired experience and knowledge of sports sciences and aims to organize long-term training in line with training objectives and the athletes' current level of ability (Weineck, 1997, p. 31).

Operationally: It is an organized process based on designing a set of exercises or physical stimuli whose training loads are directed and standardized in accordance with the body's functional capacities, with the aim of producing changes and adaptations in the various body systems and helping to achieve high levels of athletic performance.

7.2 Ballistic Training

Linguistically: Ballistic training is derived from the word 'ballistic', which refers to the movement of bodies projected through the air and denotes speed, explosiveness, and kinetic energy.

Terminologically: It is a type of rapid movement that begins with a powerful muscular contraction generated by momentum and often ends either through impact with an external factor, through contraction of antagonist muscles, or through the stretching of the muscles that produced the movement (Bosco, Magnon, & Luhtanen, 1993).

Operationally: It is a training method intended to overcome the problem of reduced speed during weight training. This type of training relies on exercises such as throwing weights, jumping with them, or projecting them into free space. Ballistic training simulates actual sport movements according to the temporal and geometric path of the movement, thereby enhancing the muscles' ability to contract more rapidly during joint action. This speed is an important factor in improving athletic performance, especially in sports that depend on actions such as throwing, striking, or jumping, where it greatly increases the effectiveness of motor skills.

7.3 Muscular Strength

Terminologically: Scholars have offered various definitions of muscular strength. Thaxton, as cited by Mufti Ibrahim Hamad, defined it as 'the force or tension that a muscle or muscle group can produce against resistance during its maximal voluntary contraction' (Mufti Ibrahim Hamad, 2001, p. 167).

Sharkey also defined it as 'the maximum effort that can be produced in one voluntary muscular contraction', and linked it to the degree of nervous-system control over muscular strength. This means that a muscle may also contract involuntarily, as occurs when the muscle is electrically stimulated (El-Sayed, 1997, pp. 87–88).

Operationally: It is one of the basic attributes required for the performance of various physical activities and may be defined as the ability of the muscle to recruit and use the largest possible number of muscle fibers to overcome diverse external resistances.

7.4 Speed-Strength

Terminologically: Hara defined it as the ability of a muscle or muscle group to bring movement to the highest frequency in the shortest possible time (Amer Fakher Shaghati, 2013, p. 300).

Muhannad Hussein Al-Bashtawi and Ahmad Mahmoud Ismail also defined it as the ability to produce maximum force in the shortest possible time (Al-Bashtawi & Ismail, 2006, p. 85).

Operationally: It is the player's ability to overcome resistance with a high contraction speed during play situations.

7.5 Football

Linguistically: The word 'football' is a Latin-derived term meaning 'kicking the ball with the foot'.

Terminologically: Football is a sport played between two teams, each composed of eleven players. The players use an inflated ball on a rectangular field, with a goal at each end. Each team seeks to score the greatest possible number of goals against the opposing team in order to win (Rumi Jamil, 1986, p. 9).

Operationally: It is a game played between two teams, each consisting of eleven players on a rectangular field. Each team seeks to outperform the other by scoring goals—the greater number of them—in the opponent's goal. The match is officiated by a center referee, two assistant referees, and a match commissioner. It lasts 90 minutes divided into two halves of 45 minutes each, with a 15-minute break between halves and allowance for stoppage time. The teams' kits are different from one another.

8. Research Method

Given the nature of the topic, the experimental method was used, relying on an experimental design with two groups, one control and the other experimental.

9. Research Variables

- Independent variable: the ballistic training method.
- Dependent variable: lower-limb speed-strength.

10. Research Population and Sample

The present study relied on U17 football players.

The sample consisted of 16 U17 players active in Amal Bousaada Football Club.

10.1 Homogeneity and Equivalence of the Research Samples

Homogeneity, as indicated by Al-Kadhimi, is the overlap in sample traits among themselves or among groups, whether in terms of age stages, sex, or the category to which they belong. To avoid factors that might affect the results of the research owing to individual differences among players and to obtain a single and equivalent sample level, a number of variables representing the sample characteristics were identified in order to verify sample homogeneity in these variables, which were considered influential in the experiment. Accordingly, they had to be controlled and standardized through statistical treatment.

Table 1. Statistical significance results for the homogeneity of the experimental and control groups with respect to height, weight, age, and training age.

Variable	Sample	N	Mean	SD	Levene's	α	Sig.
Height	Experimental	8	1.75	0.083	1.33	0.05	0.267
Height	Control	8	1.76	0.061	1.33	0.05	0.267
Weight	Experimental	8	58.75	4.97	1.66	0.05	0.217
Weight	Control	8	56.25	8.94	1.66	0.05	0.217
Age	Experimental	8	16.12	0.35	0.027	0.05	0.871
Age	Control	8	16.00	0.53	0.027	0.05	0.871
Training age	Experimental	8	3.17	0.83	7.02	0.05	0.425
Training age	Control	8	2.12	1.64	7.02	0.05	0.425

Table 1 shows the extent of homogeneity between the control and experimental groups with respect to height, weight, age, and training age. For height, the experimental sample obtained a mean of 1.75 with a standard deviation of 0.083, whereas the control sample obtained a mean of 1.76 with a standard deviation of 0.061. Levene's value was 1.33 and Sig.=0.267. Since the significance value was greater than $\alpha=0.05$, the result was not statistically significant, indicating that there was no variance between the scores of the experimental and control samples; thus, the two groups were homogeneous with respect to height.

Likewise, for weight, the experimental sample obtained a mean of 58.75 and a standard deviation of 4.97, whereas the control sample obtained a mean of 56.25 and a standard deviation of 8.94. Levene's value was 1.66 and Sig.=0.217. Since the significance value was greater than $\alpha=0.05$, the result was not statistically significant, indicating that the two groups were homogeneous with respect to weight.

For age, the experimental sample obtained a mean of 16.12 and a standard deviation of 0.35, whereas the control sample obtained a mean of 16.00 and a standard deviation of 0.53. Levene's value was 0.027 and Sig.=0.871. Since the significance value was greater than $\alpha=0.05$, the result

was not statistically significant, indicating that the two groups were homogeneous with respect to age.

For training age, the experimental sample obtained a mean of 3.17 and a standard deviation of 0.83, whereas the control sample obtained a mean of 2.12 and a standard deviation of 1.64. Levene's value was 7.02 and Sig.=0.425. Since the significance value was greater than $\alpha=0.05$, the result was not statistically significant, indicating that the two groups were homogeneous with respect to training age.

10.2 Sample Equivalence

Table 2. Statistical significance results for the equivalence of the control and experimental groups in the muscular-strength tests used in the study.

Test	Sample	Mean	SD	t-test	Sig.	df	α	Decision
30-m single-leg hop (right)	Control	7.79	0.86	-0.515	0.614	14	0.05	Not significant
30-m single-leg hop (right)	Exp.	7.62	0.67	-0.981	0.343	14	0.05	Not significant
30-m single-leg hop (left)	Control	7.60	0.57	-0.515	0.614	14	0.05	Not significant
30-m single-leg hop (left)	Exp.	7.30	0.65	-0.981	0.343	14	0.05	Not significant
30-s Swedish bench jump	Control	23.75	3.28	-1.503	0.155	14	0.05	Not significant
30-s Swedish bench jump	Exp.	21.25	3.37	-1.503	0.155	14	0.05	Not significant

Table 2 shows that the t values were not statistically significant at the 0.05 significance level for all variables. This indicates that there were no statistically significant differences between the experimental and control groups in the pre-test measurements of the muscular-strength tests under study, which means that the two groups were equivalent in the muscular-strength variables.

11. Physical Tests

11.1 Single-Leg Hop Test (30 m)

Purpose of the test: To measure the speed-strength of the leg muscles.

Performance specifications: The participant stands at the starting line with the hopping foot touching the line, while the free (swing) leg is extended backward and relaxed.

On the start signal, the participant begins hopping as fast as possible on one leg for the entire distance of 30 m until reaching the finish line.

Additional instructions: The participant must hop on the same leg throughout the distance. If the participant loses balance or changes the leg used during performance, the attempt is repeated.

Scoring: The participant is given two attempts to perform the test. The best time achieved across the two attempts is recorded.

Recording method: The time elapsed from the start until crossing the finish line is calculated. Measurement is taken in seconds, to the nearest 1/100 of a second, using an accurate stopwatch (Aziz, 2013, p. 18).



Plate 1. Stages of the 30-m single-leg hop test.

11.2 Thirty-Second Swedish Bench Jump Test

Purpose of the test: To measure the speed-strength of the leg muscles.

Equipment used: A Swedish bench 35 cm in height, a stopwatch, and a football field or another suitable location for administering the test.

Performance specifications: The participant stands facing the Swedish bench with one foot placed on the bench. On the start signal, the participant begins alternating ascent and descent between the two feet as quickly as possible for 30 seconds.

Recording method: The number of ascents and descents during the test time (30 seconds) is counted. The number of ascents is recorded, with one ascent counted when the foot becomes stable on the bench. The participant is allowed two attempts, and the better result is recorded.

- The movements must be successive and regular in order to avoid performance errors.
- The recorder stands near the bench to count the number of ascents accurately.
- The evaluators sit near the test area to monitor performance and ensure accuracy in recording (Qasim Hassan, 1986, p. 15).



Plate 2. Stages of performing the 30-s Swedish bench jump test.

12. Scientific Properties of the Tests

12.1 Test Reliability

To calculate the reliability coefficient using the test-retest method, the researcher followed the following steps:

- Selecting the sample: a pilot sample consisting of 8 players from outside the original study sample was selected.
- Conducting the first test: the physical tests under study were administered to the sample.
- Re-test: one week later, the researcher re-administered the same tests to the same sample.
- Calculating reliability: Pearson's correlation coefficient was used to calculate the relationship between the scores obtained in the first and second administrations of each physical test. Reliability coefficients indicate the stability of the results over time and are an indicator of the accuracy and dependability of the tests used.

Table 3. Reliability coefficients of the strength tests used in the study.

Test name	Unit	Administration	Mean	SD	Reliability coefficient	Sig. value of reliability	Reliability significance level
30-m single-leg hop test – right	Second	First	7.74	0.82	0.98	0.000	Significant at 0.05
30-m single-leg hop test – right	Second	Second	7.63	0.80	0.98	0.000	Significant at 0.05
30-m single-leg hop test – left	Second	First	7.59	0.70	0.99	0.000	Significant at 0.05
30-m single-leg hop test – left	Second	Second	7.50	0.71	0.99	0.000	Significant at 0.05
30-s Swedish bench jump test	Repetitions	First	23.75	3.28	0.96	0.000	Significant at 0.05
30-s Swedish bench jump test	Repetitions	Second	24.25	3.49	0.96	0.000	Significant at 0.05

Table 3 shows that all correlation coefficients were statistically significant at the 0.05 significance level for the muscular-strength tests, with values ranging from 0.96 to 0.99. This confirms that the muscular-strength tests enjoy a high degree of reliability.

12.2 Test Validity

Self-validity: To verify test validity, the self-validity coefficient was used as an index of the validity of the empirical scores in relation to the true scores; it is calculated by taking the square root of the reliability coefficient:

$$\text{Validity coefficient} = \sqrt{(\text{reliability coefficient})}$$

At the 0.05 significance level and 18 degrees of freedom, the following results were obtained for each test, as shown in Table 4.

Table 4. Validity coefficients of the speed-strength tests under study.

Test name	Reliability coefficient	Validity coefficient
30-m single-leg hop test – right	0.98	0.98
30-m single-leg hop test – left	0.99	0.99
30-s Swedish bench jump test	0.96	0.97

Table 4 shows that the validity coefficients were high and were obtained by taking the square root of the reliability coefficient. This indicates that the tests used enjoy a high degree of validity, which reassured the researcher regarding their use.

Face validity (expert validity): The researcher verified the face validity of the tests used by consulting a group of professors specialized in physical education and sports.

- Preparation of the expert-evaluation form: the researcher prepared a form including a list of the proposed physical tests and asked the judges to assess the extent to which they suited the objectives of the study, the clarity of their instructions and implementation procedures, and to provide any remarks or suggestions for improvement.
- Collection and analysis of remarks: after retrieving the forms, the researcher analyzed the opinions and remarks and adopted the tests that obtained the agreement of most judges, while taking into account the suggestions offered to develop them and improve their accuracy.
- Approval of the final form of the tests: based on the judges' views, the researcher introduced the necessary modifications and adopted the final version of the physical tests that matched the objectives of the study.
- Importance of this procedure: expert validity contributes to ensuring that the tests used accurately measure the specified objectives, thereby enhancing the reliability and accuracy of the results.

12.3 Objectivity

The objectivity of tests is defined as their freedom from subjective influences or personal bias, such that the results are independent of the opinions of the testers. Al-Aghbar emphasized that objectivity refers to reducing or eliminating differences in assessing participants' performance regardless of who performs the evaluation. To achieve this goal, the researcher ensured the following conditions:

- Clarity of instructions and test conditions: clear and detailed instructions were prepared regarding how to perform the tests and how to record the results, which helped standardize procedures and ensure accuracy of execution.
- Competence of the work team: assistant instructors who were fully familiar with the test procedures were selected, and the researcher gave them a detailed explanation of the recording method before implementing the tests, which reduced the possibility of human error.

- Reliance on numerical results: the tests were based on direct numerical recording of results, which eliminated any possibility of interpretation or personal judgment during the assessment of participants' performance.
- No intervention during performance: the assistants were instructed not to intervene while the sample members were performing the tests so as not to influence the results. Based on these procedures, it may be said that the tests used were characterized by a high degree of objectivity, since they were designed and implemented in a way that reduced bias and subjective evaluation.

13. Proposed Training Program

The researcher relied on a number of scientific references and previous studies to determine the muscle groups that should be developed in football. The exercises were classified using relatively light loads ranging from 30% to 50% of the maximum weight that the player could lift once (1RM). The training program was designed according to the ballistic method in a way that suited the characteristics of the under-17 age category, with the aim of developing lower-limb muscular strength in line with the demands of the game.

13.1 Specifications of the Training Program

- Program duration: the training program lasted 8 weeks, with two training sessions per week, making a total of 16 training units. The duration of the main part of each training unit ranged between 35 and 45 minutes, while respecting the principle of progression in intensity and loading.
- Principle of individual differences: individual differences among players were taken into account when determining the components of the training load, which helped achieve the best results.
- Implementation phase of the program: the program was implemented during the special preparation phase (PPS).
- Place and time of implementation: the program was implemented at Abdel Latif Mokhtar Stadium in Bousaada, from 24 October 2022 to 15 January 2023.
- Age category: the program was applied to U17 football players.
- Number of players: the program included 8 players in the experimental group, while the control group trained according to the traditional program.

Using these scientific bases, the training program was designed in a studied manner so as to ensure the attainment of the muscular-strength development objectives required to improve player performance in football.

13.2 Objectives of the Training Program

- To develop and improve lower-limb muscular strength in football players under 17 years of age.
- To develop lower-limb explosive power in football players under 17 years of age.
- To develop speed-strength in football players under 17 years of age.
- To identify the differences in muscular strength between the pre- and post-tests of the control and experimental groups.
- To raise the physical level of the experimental group through the regular application of ballistic exercises.

13.3 Principles Used in Designing the Training Program

The researcher designed the program on the basis of the following principles:

- Achievement of objectives: the program must achieve the objectives for which it was designed.
- Suitability of the program for the age stage: the program should be appropriate for football players under 17 years of age.
- Consideration of safety factors: the program should ensure player safety while performing ballistic exercises and implementing the standardized training program.
- Consistency with the principles of sports training: the program should be built according to the scientific bases of sports training and in accordance with recognized training principles.
- Determination of training-unit duration: the program is implemented through a set of training units, each lasting between 35 and 45 minutes.
- Stimulation of player motivation: the program includes means of motivating players and enhancing their engagement during implementation.
- Variety and updating: the program uses varied and new exercises consistent with the latest ballistic-training methods.
- Gradual progression between phases: movement between the phases of the program takes place gradually, while respecting the objectives and contents of the time periods allocated to each phase.

13.4 Components of the Training Unit in the Program

The training unit consisted of three basic stages: the preparatory stage, the main stage, and the concluding stage, as follows:

Preparatory stage: This stage aims to prepare the body completely from the physical, physiological, and psychological points of view, thus making the player capable of tolerating the training loads. The researcher focused on thorough warm-up of the muscles most used during the session, and the warm-up had to be linked to the main stage. The duration of this stage ranged between 10 and 15 minutes.

Main stage: This stage included the prescribed exercises aimed at developing lower-limb muscular strength in football players under 17 years of age using the ballistic training method. It focused on standardized and varied exercises for developing muscular strength, and its duration was set at 30 minutes. The researcher was the primary person responsible for the conduct of this stage.

Concluding stage: This stage aimed to return the body as much as possible to its normal state through light exercises such as easy running and walking, in addition to stretching exercises and overall relaxation. The duration of this stage was set at 10 minutes.

Table 5. Model of the ballistic exercises used in the first week of the training program.

Unit	Exercise	Intensity (%1RM)	Sets	Reps	Rest	Total volume
Training unit 1	Dumbbell squat jump from a knee-bent position	30%	2	8	2	72 repetitions
Training unit 1	Dumbbell split jump	30%	1 right / 1 left	10	2	72 repetitions

Unit	Exercise	Intensity (%1RM)	Sets	Reps	Rest	Total volume
Training unit 1	Ballistic single-leg hopping with dumbbells	30%	1 right / 1 left	8	2	72 repetitions
Training unit 1	Ballistic leg press	30%	2	10	2	72 repetitions
Training unit 2	Bar jump squat	35%	2	7	2	80 repetitions
Training unit 2	Single-leg Smith-machine ballistic hopping	35%	1 right / 1 left	8	2	80 repetitions
Training unit 2	Snatch jump	35%	2	8	2	80 repetitions
Training unit 2	Leg extension	35%	2	10	2	80 repetitions
Training unit 2	Bar split jump	35%	2	7		80 repetitions

14. Maximum Muscular-Strength Tests for the Experimental Sample

14.1 Determining the Weight According to the Maximum Load That Can Be Lifted Once (1RM)

The repetition maximum (RM) test is one of the most important criteria used to determine and regulate training loads in weight-training programs, with the aim of developing all types of muscular strength. The repetition maximum refers to the maximum weight that a muscle group can lift a specified number of times before fatigue, with that number being at least once. Knowledge of the repetition maximum is essential for determining strength and the extent of progress achieved in athletic performance, and it helps identify the appropriate loads that should be lifted to train the muscles without exceeding tolerable limits.

Knowledge of the repetition maximum is the cornerstone of weight training, because loads are determined on the basis of a percentage of the maximum repetition load the athlete can lift. Accordingly, maximal strength is measured by determining the maximum load that can be lifted once according to the type of exercise performed (Ketchouk Sidi Mohammed, 2016, p. 117).

A 5-RM measure is considered appropriate for determining muscular strength, and the number of attempts should not exceed 4 to 5 attempts to identify the maximum, with rest periods of up to 5 minutes between attempts (Talha Hossam El-Din et al., 1997, p. 217).

The researcher identified the main muscle groups (lower limbs) for which the maximum one-repetition load had to be determined as follows:

- Right foot/leg muscles: from a supine position, the player pushes the resistance of the upper machine with one foot while flexing and extending the knee (Machine à Quadriceps).
- Left foot/leg muscles: the same test is performed with the opposite foot.
- Leg muscles: knee flexion with the weight placed behind the neck in the half back squat (½ squat) (Lucien Demeillees, 1993, p. 229).

Measurement procedure: After a good warm-up, the player begins by performing one set of 5 repetitions with a light load that can be lifted comfortably using the bar without any extra weights. Loads are then added gradually. After about one minute of rest and some light stretching, the player performs a set of 3 repetitions with a slight increase in load (an increase ranging between 2 and 5 kg each time). After another minute of rest and light stretching, the player attempts to lift a larger load once. If the lift is completed with correct technique, the player must attempt a heavier load in subsequent attempts, with a two-minute rest between attempts. The load is increased each time until the player reaches the point at which the next load can no longer be lifted. The load successfully lifted is counted and is considered the maximum weight the player can lift once, that is, the 1RM. After determining the maximum weight that can be lifted once for each muscle group separately, a percentage of this weight can be selected to determine the appropriate training loads for the player (Abdel Aziz El-Nemr & Nariman El-Khatib, 1996, p. 207).

14.2 Determining Training-Load Intensity Using the Maximum Load That Can Be Overcome Once

After measuring the maximum load the player can overcome once in the selected weight exercises, taken as 100%, the required load intensities for developing the different types of muscular strength are then determined using the following equation:

Required load at a given intensity (kg) = one-repetition maximum (kg) × selected load intensity / 100

Example: if the maximum load a player can lift in the half squat (squat demi) is 60 kg, then the player can perform this exercise with a load of 48 kg if the required training intensity is 80%, and can train with a load of 30 kg if the required intensity is 50%, and so on (Ketchouk Sidi Mohammed, 2016, p. 117).

- Required load to be performed at 80%: 48 kg.
- Required load to be performed at 50%: 30 kg.

15. Statistical Methods

- Levene's test was used to measure homogeneity.
- Pearson's correlation coefficient was used to calculate reliability between the first and second tests in the pilot sample.
- Arithmetic mean.
- Standard deviation.
- Paired-samples t-test to calculate differences between the pre- and post-measurements for the same group.
- Independent-samples t-test to calculate differences between the experimental and control groups.

16. Presentation and Analysis of the Results of the Second Hypothesis

The second hypothesis stated that there are statistically significant differences in the post-test results of the experimental and control groups, in favor of the experimental group, in the development of lower-limb speed-strength among U17 football players.

16.1 Presentation and Analysis of the Results of the 30-m Single-Leg Hop Test

Table 6. Differences between the pre- and post-test measurements of the control sample in the 30-m single-leg hop test for the right and left legs.

Measurement	Leg	Mean	SD	t-test	df	α	Sig.	Decision
Pre-test	Right leg	7.79	0.86	6.455	7	0.05	0.000	Significant
Pre-test	Left leg	7.62	0.67	3.667	7	0.05	0.008	Significant
Post-test	Right leg	7.62	0.82	6.455	7	0.05	0.000	Significant
Post-test	Left leg	7.50	0.71	3.667	7	0.05	0.008	Significant

Table 6 shows that the control sample obtained a mean of 7.79 and a standard deviation of 0.86 in the pre-test for the right leg, and a mean of 7.62 and a standard deviation of 0.67 in the pre-test for the left leg. In the post-test, the mean reached 7.62 with a standard deviation of 0.82 for the right leg and 7.50 with a standard deviation of 0.71 for the left leg. The t value for the right leg was 6.455 at 7 degrees of freedom and $\alpha=0.05$, with Sig.=0.000. Since Sig.=0.000 < 0.05, there were statistically significant differences between the pre- and post-tests of the control sample in the 30-m single-leg hop test for the right leg. The t value for the left leg was 3.667 at 7 degrees of freedom and $\alpha=0.05$, with Sig.=0.008. Since Sig.=0.008 < 0.05, there were statistically significant differences between the pre- and post-tests of the control sample in the 30-m single-leg hop test for the left leg.

Table 7. Differences between the pre- and post-test measurements of the experimental sample in the 30-m single-leg hop test for the right and left legs.

Measurement	Leg	Mean	SD	t-test	df	α	Sig.	Decision
Pre-test	Right leg	7.60	0.57	4.966	7	0.05	0.002	Significant
Pre-test	Left leg	7.30	0.65	6.349	7	0.05	0.000	Significant
Post-test	Right leg	6.67	0.53	4.966	7	0.05	0.002	Significant
Post-test	Left leg	6.29	0.43	6.349	7	0.05	0.000	Significant

Table 7 shows that the experimental sample obtained a mean of 7.60 and a standard deviation of 0.57 in the pre-test for the right leg, and a mean of 7.30 and a standard deviation of 0.65 in the pre-test for the left leg. In the post-test, the mean reached 6.67 with a standard deviation of 0.53 for the right leg and 6.29 with a standard deviation of 0.43 for the left leg. The t value for the right leg was 4.966 at 7 degrees of freedom and $\alpha=0.05$, with Sig.=0.002. Since Sig.=0.002 < 0.05, there were statistically significant differences between the pre- and post-tests of the experimental sample in

the 30-m single-leg hop test for the right leg. The t value for the left leg was 6.349 at 7 degrees of freedom and $\alpha=0.05$, with Sig.=0.000. Since Sig.=0.000 < 0.05, there were statistically significant differences between the pre- and post-tests of the experimental sample in the 30-m single-leg hop test for the left leg.

Table 8. Differences between the control and experimental samples in the post-test measurement of the 30-m single-leg hop test.

Sample	Leg	Mean	SD	t-test	df	α	Sig.	Decision
Control	Right leg	7.62	0.82	-2.722	14	0.05	0.017	Significant
Control	Left leg	7.50	0.71	-4.084	14	0.05	0.001	Significant
Exp.	Right leg	6.67	0.53	-2.722	14	0.05	0.017	Significant
Exp.	Left leg	6.29	0.43	-4.084	14	0.05	0.001	Significant

Table 8 shows that the control sample obtained a mean of 7.62 and a standard deviation of 0.82 for the right leg, and a mean of 7.50 and a standard deviation of 0.71 for the left leg, whereas the experimental sample obtained a mean of 6.67 and a standard deviation of 0.53 for the right leg and a mean of 6.29 and a standard deviation of 0.43 for the left leg. The t value was -2.722 at 14 degrees of freedom and $\alpha=0.05$, with Sig.=0.017 for the right leg. Since Sig.=0.017 < 0.05, there were statistically significant differences between the control and experimental samples in the post-test of the 30-m single-leg hop test for the right leg. The t value for the left leg was -4.084 at 14 degrees of freedom and $\alpha=0.05$, with Sig.=0.001. Since Sig.=0.001 < 0.05, there were statistically significant differences between the control and experimental samples in the post-test of the 30-m single-leg hop test for the left leg.

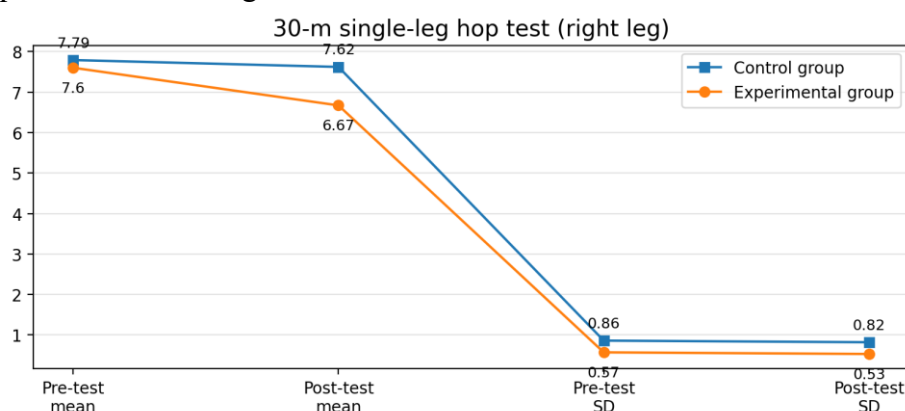


Figure 1. Differences in the arithmetic means and standard deviations between the control and experimental samples in the pre- and post-tests of the 30-m single-leg hop test for the right leg.

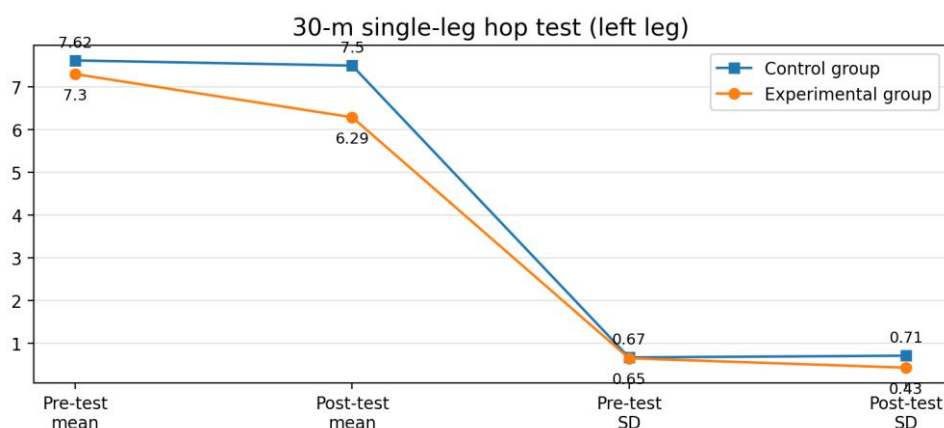


Figure 2. Differences in the arithmetic means and standard deviations between the control and experimental samples in the pre- and post-tests of the 30-m single-leg hop test for the left leg.

16.2 Presentation and Analysis of the Results of the 30-Second Swedish Bench Jump Test

Table 9. Differences between the pre- and post-test measurements of the control sample in the 30-second Swedish bench jump test.

Measurement	Mean	SD	t-test	df	α	Sig.	Decision
Pre-test	23.75	3.28	-3.989	7	0.05	0.005	Significant
Post-test	25.00	2.82	-3.989	7	0.05	0.005	Significant

Table 9 shows that the control sample obtained a mean of 23.75 and a standard deviation of 3.28 in the pre-test, whereas the post-test mean was 25.00 with a standard deviation of 2.82. The t value was -3.989 at 7 degrees of freedom and $\alpha=0.05$, with Sig.=0.005. Since Sig.=0.005 < 0.05, there were statistically significant differences between the pre- and post-tests of the control sample in the 30-second Swedish bench jump test.

Table 10. Differences between the pre- and post-test measurements of the experimental sample in the 30-second Swedish bench jump test.

Measurement	Mean	SD	t-test	df	α	Sig.	Decision
Pre-test	21.25	3.37	-10.273	7	0.05	0.000	Significant
Post-test	28.25	3.05	-10.273	7	0.05	0.000	Significant

Table 10 shows that the experimental sample obtained a mean of 21.25 and a standard deviation of 3.37 in the pre-test, whereas the post-test mean reached 28.25 with a standard deviation of 3.05. The t value was -10.273 at 7 degrees of freedom and $\alpha=0.05$, with Sig.=0.000. Since Sig.=0.000 < 0.05, there were statistically significant differences between the pre- and post-tests of the experimental sample in the 30-second Swedish bench jump test.

Table 11. Differences between the control and experimental samples in the post-test measurement of the 30-second Swedish bench jump test.

Sample	Mean	SD	t-test	df	α	Sig.	Decision
Control	25.00	2.82	2.206	14	0.05	0.045	Significant
Exp.	28.25	3.05	2.206	14	0.05	0.045	Significant

Table 11 shows that the control sample obtained a mean of 25.00 and a standard deviation of 2.82, whereas the experimental sample obtained a mean of 28.25 and a standard deviation of 3.05. The t value was 2.206 at 14 degrees of freedom and $\alpha=0.05$, with Sig.=0.045. Since Sig.=0.045 < 0.05, there were statistically significant differences between the control and experimental samples in the post-test measurement of the 30-second Swedish bench jump test.

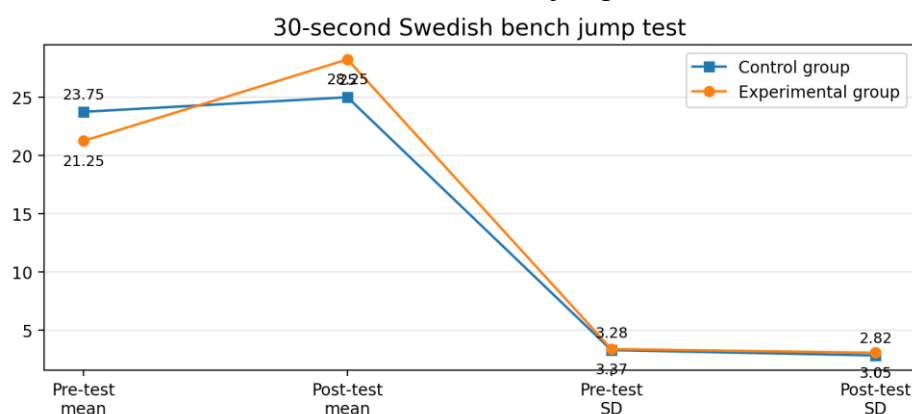


Figure 3. Differences in the arithmetic means and standard deviations between the control and experimental samples in the pre- and post-tests of the 30-second Swedish bench jump test.

17. Discussion and Interpretation of the Hypothesis Results

There are statistically significant differences in the post-test results of the experimental and control groups, in favor of the experimental group, in the development of lower-limb speed-strength among U17 football players.

The statistical analysis of the speed-strength test results revealed statistically significant differences in the measurements of the 30-m single-leg hop test between the experimental and control groups after the experiment, in favor of the experimental group. This is clearly shown in Figures 1 and 2, which illustrate the statistical differences between the mean results of the 30-m single-leg hop test in the pre- and post-tests for the right and left legs of the research samples.

Statistically significant differences also appeared in the measurements of the 30-second Swedish bench jump test between the experimental and control groups after the experiment, again in favor of the experimental group. This is shown in Figure 3, which illustrates the statistical differences between the mean results of the 30-second Swedish bench jump test in the pre- and post-tests of the two research samples. The researcher attributes the clear improvement among members of the experimental sample in the quality of speed-strength, as reflected in the 30-m single-leg hop and 30-second Swedish bench jump tests, to the training program that was applied using the ballistic training method. This program contributed to improving the speed-strength of the lower limbs in football players under 17 years of age. By contrast, the control sample did not record comparable improvement, because standardized training programs based on scientific principles were not used. The researcher considers these statistical results to be consistent with the results of previous studies, which supports the following important points:

- This is consistent with the findings of the study by Abd al-Salam Jaber Hussein (2011), which confirmed that the ballistic training method has an effect on improving speed-strength in volleyball players.
- It is also consistent with the findings of Jafar Hussein Ali (2017), who concluded that the ballistic method brought about development in muscular strength and leg speed.
- It is consistent as well with the results of Taghreed Mahdi Kazem (2018), which confirmed that the use of ballistic training has a positive effect on the development of speed-strength.
- The study by Ahmed Walhan Hamid Al-Rubaiee (2012) also indicated that ballistic training had a positive effect on speed-strength in the legs.

In light of the above, it may be said that the standardized training program based on the ballistic training method led to an improvement in lower-limb speed-strength among the players of the experimental group to whom the program was applied. Accordingly, the researcher concludes that the second hypothesis was confirmed.

Conclusions

Based on the results obtained in relation to the objectives of the research, in light of the method used and within the limits of the sample and its characteristics, the following conclusions were reached:

- The standardized training program based on the ballistic training method, which was applied to the experimental sample, had a positive and effective impact on developing lower-limb speed-strength in U17 football players.
- The results demonstrated statistically significant differences between the control and experimental samples in the post-test of the single-leg hopping test, and this is attributable to the exercises applied to the experimental sample through the implemented program.
- The results also demonstrated statistically significant differences between the control and experimental samples in the post-test of the Swedish bench jump test, and this is attributable to the exercises applied to the experimental sample through the implemented program.

Recommendations

- It is necessary to pay attention to the physical aspect in football across the different age categories because of its importance in developing and controlling the skill aspect.
- Similar studies should be conducted to identify the physical abilities associated with football skills across the various systems in order to raise the level of performance and achieve success.
- Studies of this type should be given attention and employed especially in training formation across different sports, and particularly in football for the various age categories.
- Attention should be paid to the use of modern and standardized training methods to develop and improve the different physical qualities of football players.

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