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The Effect of a Proposed Training Program Using Different Training Surface Types on the Explosive Strength of the Lower Limbs in Sprint Athletes Aged 14–15 Years

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Abstract
This field study aimed to investigate the effect of a proposed training program on the explosive strength of the lower limbs among sprint athletes aged 14–15 years. The same training program was implemented on two different training surfaces: a sandy surface and a flat, hard surface. The researcher adopted the experimental method due to its suitability for the nature of the study. The study sample consisted of 12 sprinters from the *Tahadi Oued El Alenda Athletics Club*, who were purposively selected. The training program was applied over a period of three consecutive months. The findings revealed that the proposed training program had a positive effect on improving the explosive strength of the lower limbs. Furthermore, the type of training surface significantly influenced the development of lower-limb explosive strength among the participants.
Keywords: Training program; Training surface; Explosive strength; Lower limbs; Sprint athletes.

1. Problem Statement

Based on the researcher's practical experience as an athletics coach, in addition to his continuous review of training methodologies adopted by coaches specializing in youth athletics, he observed an existing problem related to the training process, particularly in the development of the physical fitness components of sprinters, especially in El Oued Province. According to the researcher's knowledge, athletes from local clubs have not achieved satisfactory results in recent regional and national championships. Furthermore, through his role as a coach of the study team, the researcher noticed deficiencies in several physical abilities, particularly the explosive strength of the lower limbs.

Explosive strength is considered one of the most important physical qualities required for 100-meter sprint performance. This observation motivated the researcher to investigate the issue and design a training program specifically aimed at enhancing lower-limb explosive strength. The program was based on carefully selected physical exercises appropriate for the under-15 age category (14–15 years), with suitable repetitions, work-rest intervals, and training loads designed to maximize improvements in explosive power.

Among the wide variety of modern training methods and techniques available to improve athletic performance is training on sandy surfaces. However, the researcher observed that coaches rarely utilize sandy terrains, particularly in regions where such surfaces are naturally abundant. This is despite numerous scientific studies demonstrating the positive effects of sand training on physical performance. El Oued Province is characterized by its extensive sandy landscapes, making this training environment readily available.

Moreover, to the best of the researcher's knowledge, few studies conducted in Algeria have examined the effectiveness of sand-based training in developing lower-limb explosive strength. Combined with the observed weakness in this physical quality among youth 100-meter sprinters in the studied club, these factors encouraged the researcher to propose a specialized training program aimed primarily at improving lower-limb explosive strength while simultaneously maintaining the development of other essential physical abilities.

Accordingly, the main research question is formulated as follows:

- Does the proposed sand-based training program have a positive effect on improving the explosive strength of the lower limbs in 100-meter sprinters aged 14–15 years?

Based on this main question, the following research questions were formulated:

I. Are there statistically significant differences between the pre-test and post-test measurements of lower-limb explosive strength among the study sample?
II. Are there statistically significant differences in the post-test measurements of lower-limb explosive strength between the group trained on sandy surfaces and the group trained on a standard track surface?

2. Research Hypotheses

2.1 Main Hypothesis

The proposed training program has a positive effect on improving the explosive strength of the lower limbs in 100-meter sprint athletes aged 14–15 years.

2.2 Sub-hypotheses

- There are statistically significant differences between the pre-test and post-test measurements of lower-limb explosive strength among the study sample, in favor of the post-test.
- There are statistically significant differences in the post-test measurements of lower-limb explosive strength between the group trained on a sandy surface and the group trained on a standard track surface, in favor of the sandy-surface training group.

3. Concepts and Terminology

Explosive Strength

Qasim Hussein defined explosive strength as "the ability to reach maximum force in the shortest possible time." Similarly, Zaki Mohamed Hussein defined it as "an individual's ability to exert force in the least possible time" (Mohamed Jaber Buraigaa & Ihab Fawzi Al-Badawi, 2005, p. 44).

It has also been defined as "the instantaneous ability of a muscle or muscle group to produce maximum muscular contraction in a single effort within the shortest possible time" (Roz Ghari Imran, 2015, p. 15).

Operational Definition:

Explosive strength refers to the sprinter's ability to generate the greatest possible force in the shortest possible time through a single muscular contraction. It is considered a critical factor in the starting phase of sprinting and one of the key determinants of 100-meter sprint performance.

Youth Category in Athletics

Operational Definition:

The youth category is one of the six officially recognized age groups in athletics. It includes athletes aged 14–15 years, specifically those born in 2003–2004 and registered for the 2017/2018 competitive season.

4. Objectives of the Study

The objectives of this research are determined by two main motivations: the scientific motivation and the practical motivation.

4.1 Scientific Motivation

This study aims to:

- Investigate the effect of a training program proposed by the researcher on improving the explosive strength of the lower limbs among male 100-meter sprinters aged **14–15 years**.
- Compare the effectiveness of training on sandy surfaces with training on standard track surfaces in developing lower-limb explosive strength.
- Examine the possibility of improving explosive strength in the targeted age group. Since strength training for youth athletes has long been a controversial issue among experts and specialists, this study seeks to provide further evidence and clarify this issue.

4.2 Practical Motivation

The practical significance of this study lies in the application of its findings as potential solutions to the identified problem. The results are expected to benefit coaches responsible for athletic training by improving training effectiveness, while also serving as a useful reference for researchers interested in similar topics.

Specifically, this study investigates the impact of a proposed training program performed on different training surfaces on the explosive strength of the lower limbs in 100-meter sprinters by comparing pre-test and post-test performance.

Methodological Framework of the Field Study

1. Research Method

Selecting an appropriate research methodology is one of the most important factors determining the success of scientific research. In the present study, the researcher adopted the **experimental method**, as it was considered the most suitable approach for the nature of the investigation.

An experimental design based on **equivalent groups** was employed. This design consisted of two experimental groups, each of which underwent both pre-testing and post-testing, allowing the researcher to achieve the objectives of the study through a controlled comparison.

2. Population and Sample

Study Population

The target population consisted of **100-meter sprint athletes aged 14–15 years throughout Algeria**.

Accessible Population

The accessible population included **100-meter sprinters aged 14–15 years from El Oued Province**, who were available to participate in the study.

Study Sample

Selecting an appropriate research sample is one of the fundamental steps in scientific research because it ensures the validity of the findings and the possibility of generalizing the results.

The study sample consisted of youth 100-meter sprinters from the Tahadi Oued El Alenda Amateur Athletics Club, aged 14–15 years. This club was selected because the researcher serves as one of its coaches. Moreover, the club is regarded as one of the leading athletics clubs in El Oued Province, having won numerous provincial, regional, national, and international championships in various athletics events. This facilitated access to the participants and provided the researcher with a thorough understanding of the sample's characteristics.

Two homogeneous and equivalent experimental groups were formed with respect to height, body weight, training age, and pre-test results, as verified using the appropriate measurement instruments. The equivalence results are presented in Tables (01) and (02), while the homogeneity results are reported in Tables (03) and (04). Establishing group equivalence helped minimize the influence of external variables that could affect the experimental outcomes.

The final sample consisted of 12 sprinters, divided equally into two experimental groups, with six athletes in each group.

Note: Initially, the study sample included 14 athletes. However, during the intervention, one athlete sustained an injury and another was excluded because of repeated absences. Consequently, the final sample size was reduced to 12 participants.

Equivalence Results of the Study Sample Related to the First Hypothesis

Variable	Mean	Standard Deviation	Coefficient of Variation (Homogeneity)
Pre-test Height	1.58	0.086	5.44%
Post-test Height	1.56	0.070	4.80%
Pre-test Weight	46.08	10.45	22.70%
Post-test Weight	46.47	9.88	21.26%
Pre-test Explosive Strength	23.40	4.58	19.57%

Post-test Explosive Strength	30.54	4.41	20.99%

Table (01). Equivalence results of the study sample.

Equivalence Results of the Study Sample Related to the Second Hypothesis

Variable	Group	n	Mean	Standard Deviation	*t*-value	Significance	Decision
Height	Sand Group	6	1.55	0.070	-0.60	0.55	Not significant at α = 0.05
	Track Group	6	1.59	0.100			
Weight	Sand Group	6	45.88	11.64	-0.06	0.95	Not significant at α = 0.05
	Track Group	6	46.26	10.24			
Training Age	Sand Group	6	3.16	1.47	+0.39	0.70	Not significant at α = 0.05
	Track Group	6	2.83	1.47			
Explosive Strength	Sand Group	6	23.28	5.30	-0.09	0.93	Not significant at α = 0.05
	Track Group	6	23.53	4.25			

Table (02). Equivalence between the two experimental groups prior to the implementation of the training program.

Abbreviation

- **Grp.** = Group

Homogeneity of the Study Sample

Homogeneity Results of the Sandy-Surface Training Group

Variable	Mean (Sand Group)	Standard Deviation	Coefficient of Variation (Homogeneity)
Pre-test Height	1.55	0.07	4.51%
Post-test Height	1.59	0.10	6.26%
Pre-test Weight	45.88	11.64	25.37%
Post-test Weight	45.88	10.94	23.84%
Pre-test Explosive Strength	23.28	5.30	22.77%
Post-test	34.23	6.46	19.39%

Explosive Strength			

Table (03). Homogeneity results of the sandy-surface training group.

Homogeneity Results of the Track-Surface Training Group

Variable	Mean (Track Group)	Standard Deviation	Coefficient of Variation (Homogeneity)
Pre-test Height	1.59	0.10	6.28%
Post-test Height	1.60	0.10	6.25%
Pre-test Weight	46.26	10.24	22.13%
Post-test Weight	47.05	9.70	20.42%
Pre-test Explosive Strength	23.53	4.25	18.06%
Post-test Explosive Strength	26.85	4.00	14.89%

Table (04). Homogeneity results of the track-surface training group.

Based on the results presented in **Tables (03) and (04)**, as well as the statistical analysis of the measured variables, both the sandy-surface group and the track-surface group demonstrated a satisfactory level of homogeneity across all measured variables, including **pre- and post-test height, pre- and post-test body weight, and pre- and post-test explosive strength**. This conclusion is supported by the coefficients of variation, all of which were below **30%**.

These findings indicate that the explosive strength test used in the present study was appropriate for both groups without concern for substantial individual differences among participants. Consequently, the influence of external variables on the experimental outcomes was minimized, allowing for better control of the research variables. Ensuring sample homogeneity is essential because heterogeneity among participants may negatively affect the validity of the study results.

3. Research Variables

The variables investigated in the present study are as follows:

Independent Variable

The **independent variable**, also referred to as the **experimental variable**, was the **training program proposed by the researcher**.

Dependent Variable

The **dependent variable** is the variable that changes as a result of the influence of the independent variable. In this study, the dependent variable was the **explosive strength of the lower limbs** of the study participants.

4. Scope of the Study

The scope of this research includes the temporal, human, and geographical dimensions.

Temporal Scope

The proposed training program commenced on **Saturday, December 2, 2017**, and was implemented over a period of **three months**, concluding on **Thursday, March 1, 2018**. The **pre-test** was administered on **November 26, 2017**, while the **post-test** was conducted on **March 3, 2018**.

Human Scope

The participants consisted of **male 100-meter sprint athletes**, aged **14–15 years**, from the **Tahadi Oued El Alenda Amateur Athletics Club** in **El Oued Province**.

Geographical Scope

The field study was conducted in **El Oued Province, Algeria**, specifically at the **Oued El Alenda Athletics Complex** and the adjacent **sand training field**. The athletics complex belongs to the club and is equipped with the facilities and equipment necessary to conduct the training program and testing procedures efficiently.

5. Instruments Used in the Study

The primary research instrument consisted of a physical performance test.

Countermovement Jump (CMJ) Test

Purpose of the Test

The Countermovement Jump (CMJ) test was used to assess the explosive strength of the lower limbs.

Scoring Procedure

Immediately after each trial, the results were displayed directly on a computer screen. The recorded variables included flight time, jump height, power, and other performance indicators. The measurements were read directly from the display, and the device automatically calculated the average value of the participant's jumps (Mohamed Zeroual, 2017/2018, p. 126).

Test Administration

The Myotest device was attached to the athlete using a specially designed belt positioned around the waist at the center of the body. Before testing, the athlete's body weight and the number of jumps were entered into the device. Upon hearing the auditory signal emitted by the device, the athlete performed the countermovement jumps according to the predetermined number of repetitions. In the present study, each participant performed three consecutive jumps, and the device automatically calculated the average performance value.

Figure (1). Procedure for administering the Countermovement Jump (CMJ) test.

Anthropometric Measurements Used in the Study

Body Weight

Body weight is one of the most frequently measured anthropometric variables in scientific research. It is considered a simple measurement that can be obtained with a high degree of accuracy and serves as a composite indicator of overall body size. When the participant is able to stand independently, they are instructed to stand upright in the center of the weighing scale, ensuring that body weight is evenly distributed on both feet. Participants should wear as little clothing as possible during the measurement.

In the present study, body weight was measured to establish **homogeneity and equivalence** between the two experimental groups.

Body Height

Body height is measured while the participant stands upright against a vertical surface, with the heels, buttocks, and back touching the measuring board. The head should be positioned so that the eyes and ears are aligned in the Frankfort horizontal plane, while the heels remain together on the baseboard. The participant is instructed to take a deep breath and hold it while the measurement is recorded to the nearest millimeter (Mohamed Nasr El-Din Radwan, 1997, pp. 90–91).

In the present study, body height was measured to ensure homogeneity and equivalence between the two experimental groups.

6. Statistical Methods

Statistical analysis was employed to verify the study hypotheses and interpret the findings. The following statistical techniques were used:

- Arithmetic mean
- Standard deviation
- *t*-test for differences
- Level of significance (*p*-value)
- Effect size
- Homogeneity analysis
- Equivalence analysis
- Degrees of freedom

7. Equipment Used in the Study

The following equipment was used to conduct the physical tests and implement the training program:

- Athletics track
- Whistle
- Marker cones
- Electronic stopwatch
- Medical weighing scale
- Measuring tape

Figure (02). Examples of the equipment used in administering the tests.

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Presentation and Analysis of the Study Hypotheses

1. Presentation and Analysis of the First Hypothesis

First Hypothesis:

There are statistically significant differences between the pre-test and post-test measurements of lower-limb explosive strength among the study participants in favor of the post-test.

Table (05). Comparison of Lower-Limb Explosive Strength Between the Pre-test and Post-test

Measurement	n	Mean	Standard Deviation	*t*-value	Significance (*p*)	Effect Size	Decision
Pre-test	12	23.40	4.58	5.84	0.000	0.86	Significant at α = 0.01
Post-test	12	30.54	6.41				

Table (05). Results of the comparison between the pre-test and post-test measurements of lower-limb explosive strength.

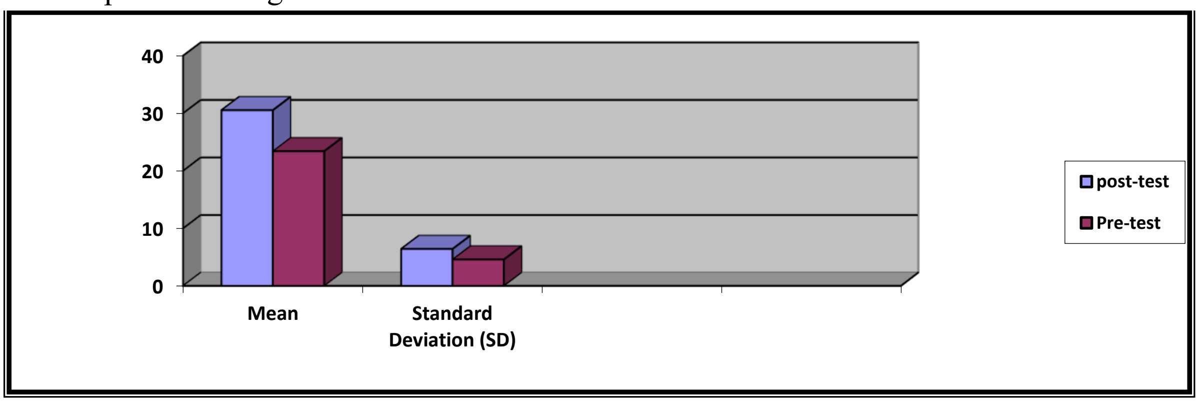

Figure (03). Comparison of lower-limb explosive strength between the pre-test and post-test measurements.

Analysis of the First Hypothesis

The results presented in Table (05) and Figure (03) indicate that the pre-test mean score was 23.40 with a standard deviation of 4.58, whereas the post-test mean increased to 30.54 with a standard deviation of 6.41. The calculated t-value was 5.84, which was statistically significant at the 0.01 significance level ($p < 0.01$).

These findings indicate statistically significant differences between the pre-test and post-test measurements in favor of the post-test. The practical significance of these differences was further confirmed by the effect size (E.Size = 0.86), which represents a large effect according to Pearson's criteria adopted in this study. This demonstrates that the proposed training program had a substantial positive impact on the athletes' explosive strength performance.

Accordingly, the first specific hypothesis was accepted.

Presentation and Analysis of the Second Hypothesis

Second Hypothesis:

There are statistically significant differences in the post-test measurements of lower-limb explosive strength between the group trained on sandy surfaces and the group trained on the standard track surface, in favor of the sandy-surface group.

Table (06). Comparison of Lower-Limb Explosive Strength Between the Two Experimental Groups

Group	n	Mean	Standard Deviation	*t*-value	Significance (*p*)	Effect Size	Decision
Sand Group	6	34.23	6.46	2.37	0.039	0.59	Significant at α = 0.05
Track Group	6	26.85	4.00				

Table (06). Post-test comparison of lower-limb explosive strength between the two experimental groups.

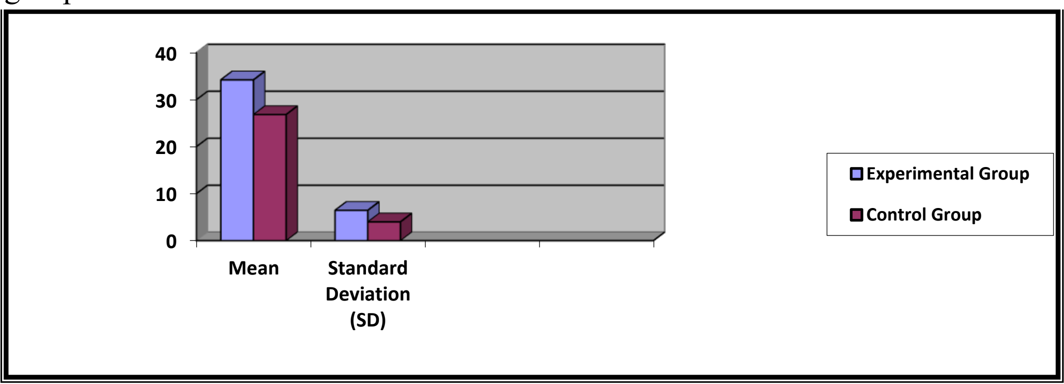

Figure (04). Comparison of lower-limb explosive strength between the sandy-surface and track-surface groups.

Analysis

The results presented in Table (06) and Figure (04) show that the sand-training group achieved a mean score of 34.23 with a standard deviation of 6.46, whereas the track-training group obtained a mean score of 26.85 with a standard deviation of 4.00. The calculated t-value was 2.37, which was statistically significant at the 0.05 significance level.

These findings demonstrate statistically significant differences in lower-limb explosive strength between the two groups in favor of the athletes who trained on the sandy surface. The practical significance of this difference was confirmed by the effect size (E.Size = 0.59), which represents a large practical effect according to Pearson's classification adopted in the present study.

These results indicate that training on a sandy surface had a substantial positive influence on the development of lower-limb explosive strength. Consequently, the second specific hypothesis was supported.

Discussion of the Research Hypotheses

Discussion of the First Hypothesis

The findings presented in Table (05) and Figure (03), based on the Countermovement Jump (CMJ) test, revealed statistically significant improvements in lower-limb explosive strength between the pre-test and post-test measurements of the study sample. These improvements favored the post-test and were further supported by a large effect size (E.Size = 0.86), indicating that the proposed training program produced a substantial improvement in performance.

Accordingly, the first specific hypothesis—which stated that statistically significant differences would exist between the pre-test and post-test measurements of lower-limb explosive strength in favor of the post-test—was confirmed. These findings are consistent with those reported by Samir Khairi (2000) and several other previous studies.

The researcher attributes these improvements primarily to the carefully designed exercises incorporated into the proposed training program. The program included scientifically selected and systematically organized exercises specifically intended to develop lower-limb explosive strength in youth sprinters. This finding is consistent with the principles of sports training, which emphasize that scientifically planned and well-structured training programs lead to positive physiological adaptations and improved athletic performance.

In this regard, Saad Mohsen Ismail (1996, p. 98) stated that *regardless of differences in scientific and practical backgrounds, experts agree that a training program developed on sound scientific principles will inevitably lead to improved athletic performance through proper organization and programming of the training process*. Similarly, Mohamed Sayed Abdel Rahim Khalil (2016, p. 17) emphasized that *training programs designed according to scientific principles are more likely to achieve optimal levels of athletic performance*. Furthermore, Muhannad Abdul Sattar (2001, p. 89) noted that *training exercises incorporated into scientifically designed programs improve athletes' physical and technical performance when appropriate training loads, individual differences, and suitable training conditions are taken into consideration under the supervision of qualified coaches*.

The researcher carefully considered all the essential components involved in program design, which contributed substantially to the effectiveness of the proposed training intervention.

In addition, the researcher attributes the observed improvements to the proper application of fundamental principles of sports training, particularly the systematic regulation of training volume, intensity, and density, as well as the selection of appropriate training methods. These factors played an important role in enhancing lower-limb explosive strength among the participants. As stated by Ismail Abdul Jabbar et al. (2010, p. 197), *the proper regulation of training load leads to improvements in the functioning of body systems and consequently enhances physical fitness components, thereby contributing to higher athletic performance*. Conversely, poorly regulated training loads may result in performance decline and reduce the effectiveness of the training program.

Discussion of the Second Hypothesis

Based on the results presented in Table (06) and Figure (04), which compared lower-limb explosive strength between the group trained on a sandy surface and the group trained on a standard track surface, statistically significant differences were found between the two groups in favor of the sandy-surface training group. The practical significance of these differences was confirmed by the effect size (E.Size = 0.59), which indicates a large practical effect of the training program. Accordingly, the second hypothesis was supported. These findings are consistent with the studies of Haider Faeq Al-Shamma (2013), Jumaa Mohammed Awad, Yarub Abdul-Baqi, and Labib Zoban Musaykh (2005), Franco (2007), and Rafi Hussein Mahmoud Asfour (2011).

The researcher attributes these differences to several factors.

First, the effectiveness of sand-surface training played a major role in improving lower-limb explosive strength among the study participants. According to Haider Faeq Al-Shamma (2013, p. 21), *sand is one of the best natural training environments because it enhances athletes' physical, technical, and physiological performance, while also improving balance, movement accuracy, and the execution of complex motor skills such as jumping*. Strength is considered one of the physical fitness components that benefits most from training on sand.

Al-Shamma (2013, p. 265) further emphasized that most studies on sand-surface training conclude that muscular strength, in all its forms, is the physical quality that improves the most through this type of training. He also noted that coaches in countries such as Jamaica and the United States, which dominate international sprint events, frequently use sand-surface training because of its effectiveness in developing strength endurance, explosive strength, speed-strength, general strength, and particularly the muscles of the lower limbs, which are essential for sprint performance.

Similarly, Rafi Hussein Mahmoud Asfour (2011, p. 5) stated that *training on sandy surfaces serves as a form of resistance training that strengthens the leg muscles and increases lower-limb explosive power*.

The researcher also explains these findings by the mechanical differences between sandy and hard surfaces. Sand and synthetic track surfaces possess different physical characteristics, particularly with respect to friction and resistance. Because the foot sinks into the sand during movement, athletes encounter greater resistance and must generate more muscular force to overcome it. This increased resistance requires the recruitment of a larger number of muscle fibers, ultimately leading to greater gains in muscular strength and explosive power.

In this regard, Mohamed Hassan Allawi (1979) explained that muscular strength increases as the body becomes capable of recruiting a greater number of muscle fibers. As the intensity of resistance increases, additional muscle fibers are activated, resulting in greater force production (Haider Mahdi Abdul Sahib, 2000, p. 66).

Furthermore, running and jumping on sand create a less stable movement environment because of the reduced support and instability of the sand particles. Catherine Wells (1971) and Miller and Nelson (1973) noted that insufficient friction makes maintaining balance considerably more difficult (Abdul Mohsen Mohamed Gamal El-Din & Sayed Mohamed Abu Shami, p. 58). The loose structure of sand therefore requires athletes to exert greater muscular effort to maintain stability while performing movements.

Likewise, Hassan (1998) argued that the amount of mechanical work performed on sandy surfaces differs from that performed on hard surfaces because of the greater resistance encountered by the athlete. Consequently, athletes expend more effort, a phenomenon that can be explained by Newton's Third Law of Motion, which states that *for every action there is an equal and opposite reaction* (Rafi Hussein Mahmoud Asfour, 2011, p. 5).

As a result, sprinters training on sand are required to produce greater explosive force to maintain balance and overcome the resistance created by the sinking of the feet into the sand during movement.

Finally, the researcher believes that the superiority of sand-surface training is also associated with its positive effects on other physical and physiological capacities, leading to a transfer of training adaptations. According to Abdel Baset Mohamed Abdel Halim, Ashraf Abdel Aziz Ahmed (2006), and Atef Sayed Ahmed (1999), *training on sand improves the efficiency of vital body systems—including the respiratory, cardiovascular, and muscular systems—as well as anaerobic capacity. Previous studies have demonstrated that training in sandy environments positively influences performance in running, jumping, and race walking events* (Mohamed Adel Amin El-Sheikh, 2015, p. 12).

Moreover, Haider Faeq Al-Shamma (2013, pp. 267) stated that *strength training on sand enhances the ligaments and articular cartilage of the ankle and knee joints because of the increased mechanical stress required to overcome the resistance of the sandy surface*. Improved musculoskeletal function consequently contributes to better movement performance and greater lower-limb explosive strength.

Recommendations and Future Research

Based on the findings of the present study, the following recommendations are proposed:

- Develop scientifically designed and standardized training programs to improve athletic performance across different sports.
- Encourage coaches to incorporate sand-surface training into their programs to enhance explosive strength across various sporting activities, particularly those requiring high levels of muscular power.
- Encourage sports clubs to organize specialized training camps that utilize sandy environments for sports relying heavily on muscular strength in its various forms.
- Conduct additional studies to investigate the effects of sand-surface training on other physical fitness components.
- Encourage coaches and sports authorities to invest in and utilize natural sandy areas for athletic training, as they are inexpensive and provide substantial training benefits.

- Replicate the present study using athletes from different competitive levels and age groups.
- Encourage future researchers to consider the findings of this study when conducting related research.

General Conclusion

The findings of the present study lead to the following conclusions:

- The proposed training program had a positive effect on improving the explosive strength of the lower limbs among the study participants.
- Training on sandy surfaces was more effective than training on a standard track surface in developing lower-limb explosive strength.
- Lower-limb explosive strength, as well as sprinting speed, can be effectively developed in athletes aged 14–15 years.

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