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# ENHANCING STRENGTH CAPACITY FOR TRIATHLON COMPETITORS

**Andrei Vladimir MARICA[1], Marius STOICA[2*], Adina Andreea DREVE[2]**

[1] Polytechnic Secondary School, Bucharest, Romania
[2] National University of Physical Education and Sports, Faculty of Physical Education and Sport, Bucharest, Romania
*Corresponding author: mariusstoica08@yahoo.com

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***Abstract.*** *Triathlon is a sport that combines three different disciplines: swimming, cycling and running. Athletes have to cover varying distances in each discipline and move quickly from one to the next, making triathlon an extremely demanding sport. This research aims to develop and implement a training program with athletic means in order to optimize the strength capacity of triathletes. This paper sought to identify statistically significant differences between the results recorded by the participants, i.e. the performance of athletes at the beginning and end of the study, following an experimental intervention. The present research was carried out with the participation of 3 male athletes, aged between 20 and 36 years (m = 26), from the triathlon sports branch, with over 4 years of competitive experience, competitor in the National Championship. Strength evaluation was conducted using the Optojump system in the case of the participants who performed one test: Left and Right Leg Jumps (5 jumps). Statistical analysis using the Wilcoxon signed-rank test showed significant differences between the initial and final results for explosive strength, indicating that the improvements were not random but were due to the experimental intervention. The training program had a significantly positive impact on the participants' strength capacity and overall performance.*

***Keywords****: strength; triathlon; athletics.*

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## Introduction

Triathlon is an endurance sport comprising sequences of swimming, transition from swimming to cycling (T1), cycling, transition from cycling to running (T2) and running over varying distances (Bentley et al., 2002). Since becoming an Olympic sport, triathlon has evolved significantly (Millet et al., 2007). The drafting event allowed for 1.5 km swimming, 40 km cycling and 10 km running debuted at the 2000 Sydney Olympics. Since then, research has focused more on the influence of one discipline on the other than on the effects of drafting in swimming and cycling (Millet et al., 2007; Millet et al., 2010).

Training prescription decisions in triathlon, as in many other sports, are based on experience, anecdotal reports and scientific evidence. However, since each athlete is unique and may react differently to training stimuli, applying research findings to personalized training programs can be challenging (Bouchard et al., 2011) The decisions a coach makes about training and competition preparation will be influenced by the balance between effort and rest, the number of injuries and illnesses, and the level of adaptation to training. Additionally, the feedback that athletes themselves provide is often the best source of information for optimizing training (Coyne et al., 2018).

Coaches can create personalized training plans for each athlete using systematic athlete monitoring, evidence-based knowledge, and anecdotal experiences. Endurance training improves vascular and muscular adaptations, leading to better endurance (Beattie et al., 2014). Recent findings suggest that performance in endurance sports depends on exercise efficiency. Aerobic metabolic rate or oxygen consumption at a given speed is what is referred to as work efficiency and is defined as the oxygen consumption required to maintain a submaximal speed (Sandbakk et al., 2012; Denadai et al., 2017). For optimal performance in many sports, a combination of strength and endurance training is required. It is well known that incorporating strength training into an endurance training program can significantly enhance endurance performance (Hickson et al., 1988). Strength exercises increase muscular strength and power. Strength development can be linked to the ability of well-trained athletes to maintain high intensity during endurance exercise without impairing aerobic performance (Denadai et al., 2017).

Combination training that combines endurance and strength training in a single program, has long been recognized as effective. Coaches believe that athletic performance is enhanced when non-sport-specific strength training (NST) is added to sport-specific training. Strength exercises involving non-specific movements, such as squats, deadlifts and leg presses, are all included in NST (Burnie et al., 2018). Studies have shown that strength training in a specific sport improves endurance. For example, including hill sprints in endurance training programs reduces the cost of running. In addition, including NST in training sessions has similar effects. For example, performing maximal strength exercises prior to endurance cycling and endurance training improves 20 km time trials while reducing the amount of cycling expended (Barnes et al., 2013).

The effect of NST on endurance performance suggests that endurance athletes can better utilize the submaximal forces they have developed during training (Silva et al., 2014). Strength training should have a wide range of intensity, frequency and exercise volume to achieve the best results. In addition, the exercises should have similar kinetics and pattern to the sport in question (Murlasits et al., 2018; Bazyler et al., 2015). Muscle exhaustion occurs when the muscle cannot sustain the necessary force-generating capability due to voluntary effort (Kataoka et al., 2022). Maintaining optimal muscle function during and after exercise is crucial for coaches and high-performance athletes to prevent injuries and sustain peak performance. Various strategies have been used to facilitate the best possible muscle performance.

There is some evidence that non-sport-specific strength training (NST) improves endurance performance, but it remains unclear which type of NST is best suited for specific endurance disciplines. While endurance, plyometric, maximal, and explosive training types are considered most effective (Sammoud et al., 2019), there is ongoing debate about whether different types of loads (dynamic or isometric, maximal or endurance, explosive or plyometric) might be more beneficial for certain sports (Potdevin et al., 2011). In swimming, some studies support plyometric strength training, while others support maximal strength training. Explosive force training in running sports seems to be more advantageous due to faster muscle activation, whereas heavy force training is less effective (Keiner et al., 2019). Over the course of a season, triathlon training should be complemented by a well-organized strength training program. This will help the athlete to develop sufficiently in the long term, reduce the risk of injury and maximize their performance in competition. Most top triathletes now combine their extensive training (mainly aerobic, swimming, cycling and running) with different forms of strength training (e.g. simultaneous training). Due to the long duration of triathlon events (e.g., about 20 minutes for a top athlete in the mixed relay, compared to 8-9 hours for top Ironman athletes), and the way they affect both muscular strength and aerobic endurance, it is essential for improving performance in competitive triathlons.

A recent meta-analysis has highlighted the benefits of strength training, supporting its use alongside sport-specific aerobic training in middle- and long-distance events, regardless of sport or skill level (Berryman et al., 2018). For example, during the swim leg of a triathlon, upper-body muscle strength and power should lead to greater ability to generate propulsive force in the water, which means the race can be longer and more frequent, as well as faster in open water (Mujika & Crowley, 2019). Therefore, incorporating strength exercises both on land and in the water can significantly improve triathlon performance (Crowley et al., 2017).

Lower-body training can improve cycling ability and time trial performance by reducing oxygen consumption, heart rate, blood lactate concentration, and perceived exertion during prolonged cycling, as well as by achieving maximum torque earlier during pedalling (Aagaard et al., 2011; Rønnestad et al., 2015). Plyometric and explosive strength training can improve running performance and running economy (Rønnestad et al., 2011). Triathletes who incorporate a heavy-weight training program in conjunction with regular endurance training have shown improvements in maximal aerobic speed, running economy, and jumping power (Paavolainen et al., 1999). This combination helps prevent fatigue during submaximal cycling (Saunders et al., 2006; Millet et al., 2002). Recent meta-analyses confirm the benefits of strength training on fitness and performance in both cycling and running (Hausswirth et al., 2010; Balsalobre-Fernandez et al., 2016). Periodized heavy strength programs designed to increase maximal strength (e.g., 2-3 sets of 4 to 10 maximal repetitions), targeting sport-specific muscle groups and movements, and focusing on performing the concentric phase of lifts at the desired maximal speed, have the greatest impact on performance over 12 to 24 weeks (Rønnestad & Mujika, 2014). While maximal oxygen consumption and other markers of aerobic endurance are not negatively affected, endurance performance improvements may be attributed to the delayed activation of less efficient type II fibres, improved neuromuscular efficiency, conversion of type IIX fibres to more fatigue-resistant type IIA fibres, or increased musculo-tendon stiffness (Berryman et al., 2018; Lauersen et al., 2014).

## Methodology

### *Scope*

The present study aims to develop and implement a training program using athletic means to optimize the strength capacity of athletes participating in triathlon.

*Hypothesis*

The implementation of a specific program proposed by us, based on athletic means, will lead to a significant improvement in strength capacity among triathlon athletes.

*Participants*

This research was conducted with the participation of three male athletes, aged between 20 and 36 years (M = 26), all from the triathlon sports branch, with over four years of competitive experience, and participating in the National Championship (Table 1).

Table 1. *Research participants*

| Subject | Age (years) | Event | Competitive experience (years) |
|---|---|---|---|
| 1 | 22 | triathlon | 5 |
| 2 | 20 | triathlon | 4 |
| 3 | 36 | triathlon | 12 |

*Instruments*

A new and accurate method to assess athletic performance, specifically jumping abilities and reaction time, is the Optojump test. The test involves the participant standing at one end of the measurement zone and jumping five times on the left foot and five times on the right foot. To ensure consistent results, it is crucial that the subject jumps in the same manner during both phases. For every leap, the photodetectors log data on jump height, air time, ground contact time, and other relevant information. A shorter ground contact time indicates greater muscular elasticity and reflex capability. Ground contact time is the amount of time the foot is in touch with the ground between hops. The amount of time the subject spends in the air is called air time, and a larger period suggests a higher leap. Gravity and air time are used to compute jump height; a higher height denotes more explosive power.

The Optojump test, which consists of five jumps on each foot, yields important information about a subject's leg symmetry, explosive power, coordination, and agility. To assess and enhance athletic performance, coaches, physiotherapists, and athletes need to know this information.

*Procedure*

In the present research, written informed consent was obtained from athletes included in the study. Subjects participated on a voluntary basis, with no coercion involved, and without suffering any penalty. Participants were informed that they could withdraw from the study at any time and that the results obtained from the assessments would be used in a research paper.

Participants' anonymity was respected, and their data were treated with strict confidentiality.

The research was conducted between December 2022 (initial testing) and May 2023 (final testing). The training programs were implemented at specialized sports facilities for running, 25-meter swimming pools, and cycling circuits to ensure optimal conditions for bicycle training.

*Training program*

The triathlon strength training program was created to focus on building muscle strength and endurance, which are necessary for improving performance in the swimming, cycling, and running disciplines throughout the training season that runs from December to April. Strength training is essential for maximizing muscle function, lowering fatigue risk, and enhancing movement efficiency, all of which improve overall triathlon competition performance. The program ensures that participants are well-prepared and in balance for competitions by emphasizing the physical adaptation required to handle the demands of triathlons.

We present an example of a micro-cycle:

**Day 1: Cycling - Strength Training**

Warm-up:

- 10 minutes of easy cycling to prepare muscles and joints.

Main Workout:

- Sets and Reps:
    - Set 1: 3 sets x 5 reps of 500 meters cycling at moderate intensity, at 70% of 1RM (Repetition Maximum).
    - Set 2: 3 sets x 4 reps of 300 meters cycling at high intensity, at 80% of 1RM.
    - Set 3: 3 sets x 5 reps of 500 meters cycling at moderate intensity, at 70% of 1RM.

Rest:

- 2-3 minutes rest between sets for passive recovery.

Cool-down:

- 5 minutes of easy cycling to bring heart rate down and relax muscles.

**Day 2: Swimming - Strength Training**

Warm-up:

- 200 meters of easy swimming to warm up muscles and prepare for the main workout.

Main Workout:

- Sets and Reps:
    - Set 1: 4 sets x 200 meters swimming at moderate intensity.
    - Set 2: 6 sets x 100 meters swimming at high intensity.
    - Set 3: 4 sets x 50 meters swimming at maximum intensity.

Rest:

- 3 minutes between sets, 1 minute between series.

Cool-down:

- 100 meters of easy backstroke swimming to cool down and relax muscles.

**Day 3: Running - Strength Training**

Warm-up:

- 10 minutes of light jogging to warm up muscles and increase body temperature.

Main Workout:

- Sets and Reps:
    - Set 1: 4 sets x 800 meters of running at a moderate pace.
        - After each set: 10 squats and 10 push-ups.
    - Set 2: 5 sets x 400 meters of running at a moderate pace.
        - After each set: 10 standing long jumps.
    - Set 3: 4 sets x 150 meters of sprinting at maximum pace.
        - After each set: 10 high knees.

Rest:

- 5 minutes rest between sets for complete recovery.

Cool-down:

- 5 minutes of light jogging to lower heart rate and relax muscles.

**Day 4: Strength and Stabilization Training**

Strength Exercises: Perform 3-4 sets of 10-12 repetitions for exercises such as squats, weight lifts, push-ups, planks, etc.

- Rest: Take a 1- or 2-minutes rest between sets to allow for recovery and preparation for the next set.

**Day 5: Combined Training** (cycling and running), here's how you should approach dosing and intensity:

- Warm-up: 10 minutes of easy cycling to prepare muscles and cardiovascular system.
- Sets and repetitions:
    - Set 1: 4 sets x 10 minutes of cycling at a moderate pace, immediately followed by 10 minutes of easy running.
    - Set 2: 3 sets x 8 minutes of cycling at a high pace, immediately followed by 8 minutes of running at a moderate pace.
- Rest: 5 minutes between sets to allow for recovery and preparation for the next set; 1 minute between each cycling and running bout.
- Cool-down: Conclude the workout with 5 minutes of easy cycling to gradually reduce pace and facilitate recovery.

**Day 6: Swimming Training**

- Warm-up: 200 meters mixed strokes to prepare muscles and joints.
- Main Set: Swim 2000 meters at a low intensity to build endurance and technique refinement.

**Day 7: Recovery Day**

- Objective: Focus on active recovery to facilitate muscle repair and enhance recovery.
- Activities:
    - Light stretching session to improve flexibility and reduce muscle tension.

- Low-intensity activities such as walking or gentle cycling for 20-30 minutes to promote blood flow.
- Hydration and nutrition focus to replenish energy stores and support recovery processes.

## Results

*Descriptive statistics*

The main descriptive statistical indicators were calculated for the results obtained in the assessment tests, both at the initial and at the final assessment. We present the values of the main statistical indicators: mean (m), standard deviation (S) and coefficient of variability (Cv), in the case of the initial results and the final scores obtained by the participants, for the coefficients: flight time, power and contact time, both on the left and right foot (N = 6, in this case, each participant having 2 values for this test).

Table 2. *Descriptive statistics - explosive force assessment for both legs (initial and final test)*

| Statistical indicators | I.T. (left + right) | | | F.T. (left + right) | | |
|---|---|---|---|---|---|---|
| | Flight Time | Power | Contact Time | Flight Time | Power | Contact Time |
| N | 6 | 6 | 6 | 6 | 6 | 6 |
| Mean | 0,388 | 14,78 | 0,891 | 0,410 | 14,82 | 0.695 |
| Standard deviation | 0,04 | 2,81 | 0,22 | 0,03 | 1,98 | 0,13 |
| Cv | 0,11 | 0,19 | 0,24 | 0,08 | 0,13 | 0,18 |

Table 2 illustrates the values of the main descriptive statistics indicators for the research group for the explosive force assessment test (Optojump - Left and Right Leg Jumps), for the initial and the final test. The calculated indices showed that:

- For the initial test, in terms of flight time, the participants obtained on average 0.388 seconds, S = 0.04, Cv = 0.11, indicating that homogeneity is ensured;

- Concerning the power coefficient, the mean of the results was 14.78, S = 2.81, and Cv = 0.19, the homogeneity being assured;

- Regarding the contact time, the mean of the results was 0.695, the standard deviation = 0.13, and Cv was 0.18.

- In the final test, regarding the flight time, the participants obtained on average 0.410 seconds, S = 0.03, Cv = 0.08, which indicates that homogeneity is ensured;

- Regarding the power coefficient, the mean result was 14.82, S = 1.98, and Cv = 0.13;

- Concerning the contact time, the mean result was 0.891, the standard deviation = 0.22, and Cv was 0.24 (homogeneity of values assured).

*Inferential statistics*

Using the Wilcoxon test for two dependent samples (Predoiu, 2021), we have investigated the existence of statistically significant differences between the results obtained at the beginning of the study and the scores registered at the final testing (after the athletic intervention), regarding the explosive strength (left-leg jumping and right-leg jumping - Optojump).

Table 3. *Results - single-leg jumping (initial vs. final test results) - Wilcoxon test*

| Wilcoxon test values | Initial vs. final test comparison Optojump - Left and Right leg jumping | | |
|---|---|---|---|
| | Flight time | Power | Contact time |
| Test value (W) | 0 | 0 | 0 |
| Z | -2.201 | -2.201 | -2.201 |
| p | < 0,05 | < 0,05 | < 0,05 |
| r | 0,89 | 0,89 | 0,89 |

*Note:* r = effect size.

Statistical analysis of the data, presented in Table 3, revealed the following:

- For the coefficients: flight time, power and contact time, there are statistically significant differences ($p < 0.05$) between the values of the initial and final tests.
- The effect size was $r = 0.89$ (for flight time, power and contact time), which indicates that the intervention program applied to the research participants had a very strong impact on the results recorded by them.

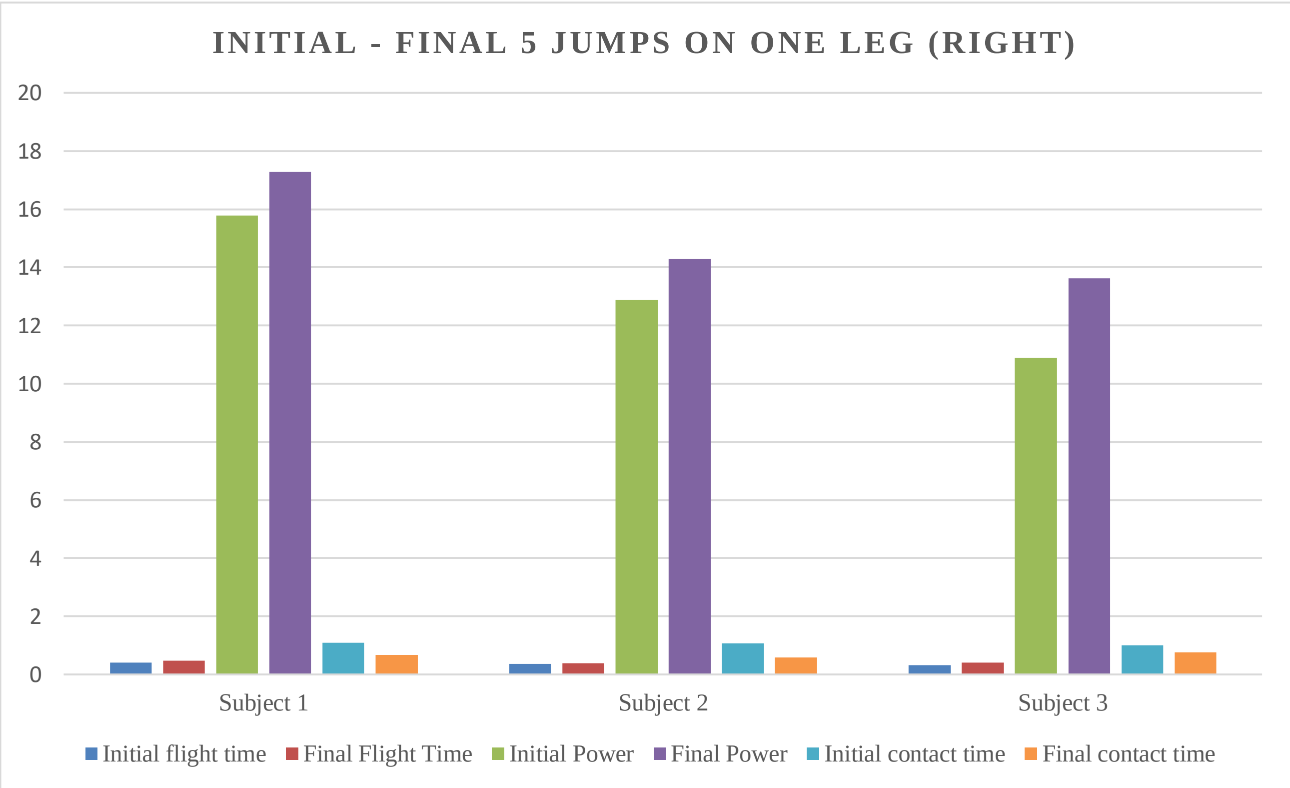


Figure 1. Optojump results - right leg jumping (initial and final test)

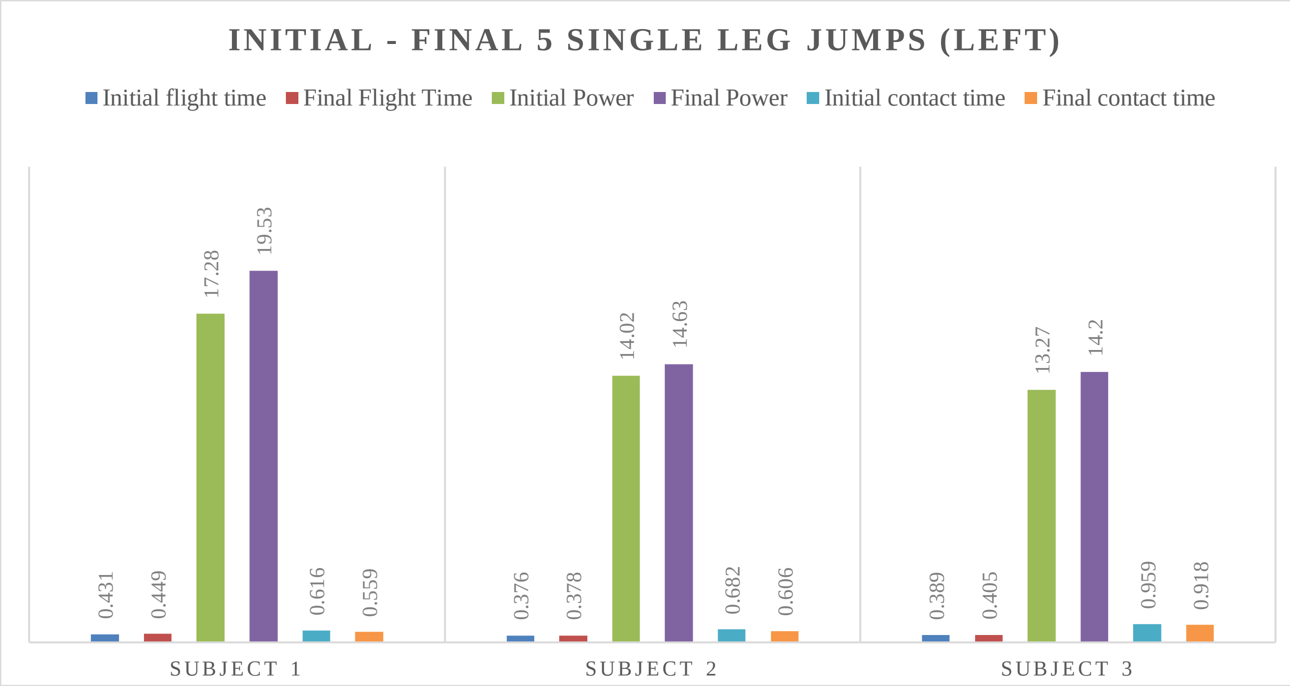


Figure 2. Optojump results - left leg jumping (initial and final test)

## Discussions and conclusion

In triathlon, an endurance sport that combines swimming, cycling, and running, studies emphasize the crucial significance of integrated and interdisciplinary training regimens that combine both strength and endurance components (Berryman et al., 2018). Strength training is a fundamental aspect of a well-structured triathlon program, as event durations can vary significantly, ranging from 20 minutes for mixed relay races to 8-9 hours for Ironman events.

According to some interesting studies (Aagaard et al., 2011; Rønnestad et al., 2015), adding strength training to particular aerobic training regimens can improve performance by lowering blood lactate concentration, heart rate, and oxygen consumption during extended cycling and running. This enables triathletes to sustain high performance over extended periods. General muscle strength development is enhanced by including non-triathlon-specific strength exercises, such as squats and deadlifts, which positively impact cycling and running performance. For triathlon athletes aiming for long-term development, it is essential to follow a regular strength training program that features specific exercises of varying intensity. This facilitates effective neuromuscular adaptations, promotes the transformation of muscle fibres into more fatigue-resistant types, and improves musculotendinous stiffness, all while preserving optimal aerobic capacity (Leveritt et al., 1999).

During a training program, we believe that combining strength and endurance training is vital for preventing fatigue during competition. This approach allows athletes to maintain speed and high performance during long swimming, cycling and running events. In the current study, following the proposed training regimen, both flight and power were significantly increased in the right and left leg jump tests, indicating that the training effectively enhanced the explosive strength of the triathletes. The intervention program had a significant impact on participants' performance, as indicated, also, by the very high effect size index.

Our findings demonstrate that triathletes benefit from an athletic training program that incorporates strength training. These results align with research highlighting the significance of personalized and integrated training programs (Issurin, 2008). Regular training programs that combine various types of training —strength, endurance, and flexibility—are essential for maximizing performance and minimizing injury risk. Moreover, elite athletes tend to use well-structured and integrated training programs to maximize their potential. According to a study by Seiler and Tønnessen (2009), an integrated and multidisciplinary approach that merges strength with endurance, flexibility, and sport-specific skills is crucial for training triathletes. Training programs that employ multiple methods are more effective in improving overall athletic performance (Mujika & Padilla, 2001). For example, a training program that includes cycling, running, and swimming is beneficial for triathletes, enabling them to maximize their potential in competitions.

The study findings are consistent with literature emphasizing that plyometric and strength training are essential for the development of explosive capacity in athletes. Plyometric exercises improve the performance of vertical jumps and other types of explosive force (Markovic & Mikulic, 2007). In addition, plyometric training has the potential to improve athletic performance across various sports by increasing explosive force (Ramirez-Campillo et al., 2014).

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**Informed Consent Statement:** The participants provided their written informed consent to participate in this study.

**Data Availability Statement:** Data can be made available upon request to the contact author.

**Conflicts of Interest:** The authors declare no conflicts of interest.

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