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Plyometric exercises to develop the muscular power of the swimmer's lower limbs in the start technique
Ejercicios pliométricos para desarrollar la potencia muscular de los miembros inferiores del nadador en la técnica de salida

*Lisbet Guillen Pereira, **Richard Manuel Manangón Pesantez, **Pablo Anthony Rendón Morales, **Mayra Alexandra Beltrán Vásquez
*Instituto Tecnológico Superior Universitario Compu Sur (Ecuador), **Universidad Central del Ecuador (Ecuador)

Abstract. Plyometric exercises generate changes in muscle power, which is appropriate to increase the distance that the swimmer's body reaches before entering the water. Accordingly, the study focused on identifying the empirical value of a system of plyometric exercises for the development of the swimmer's muscular power in the execution of the start technique. A correlational and explanatory or causal investigation is assumed, involving 15 swimmers from the Club Náutico de Quito, with an average age of ±16 years. The proposal was validated through a pre-experiment in the period from February to May 2022 (12 weeks): diagnosis/intervention/evaluation, phases preceded by a research hypothesis. The SQUAT JUMP and ABALAKOV tests were used to measure muscle power. The execution of the start technique was filmed using an intervention protocol, the results of which were analyzed in the Kinovea software (8.24), evaluating the distance reached by the swimmer's body before entering the water. The variables were correlated at both moments of time using the Pearson Correlation Coefficient, confirming a perfect positive linear relationship in the pre-test (.962) and in the post-test .931), verifying H_1 and rejecting H_0. For the comparison of the pre and post-test, the T-Student test was used, showing significant changes (p=.000). It is concluded that the plyometric exercise system develops the muscular power of the swimmer in the execution of the exit technique, increasing the distance that the body reaches before entering the water, verifying H_i.
Keywords: Swimming, Plyometric exercises, Muscular power, Starting technique, entering the water

Resumen. Los ejercicios pliométricos, generan cambios en la potencia muscular, lo que resulta acertado para incrementar la distancia que alcanza el cuerpo del nadador antes de entrar al agua. En concordancia el estudio se centró en identificar el valor empírico de un sistema de ejercicios pliométricos para el desarrollo de la potencia muscular del nadador en la ejecución de la técnica de salida. Se asume una investigación correlacional y explicativa o causal, interviniendo 15 nadadores del Club Náutico de Quito, con edad promedio de ±16 años. La propuesta, fue validada mediante un pre-experimento en el periodo de febrero a mayo del 2022 (12 semanas): diagnóstico/ intervención/ evaluación, fases precedidas por una hipótesis de investigación. Se utilizó el test SQUAT JUMP y ABALAKOV, para medir la *potencia muscular*. Se filmó la ejecución de la técnica de salida utilizando un protocolo de intervención, cuyos resultados se analizaron en el software Kinovea (8.24), evaluando la *distancia alcanzada por el cuerpo del nadador antes de entrar al agua*. Las variables se correlacionaron en ambos momentos de tiempo utilizando el Coeficiente de Correlación de Pearson, confirmándose una relación lineal positiva perfecta en el pre-test (,962) y en el post-test ,931) verificándose H_1 y rechazándose H_0. Para la contrastación del pre y post-test se empleó la T-Student, arrojando cambios significativos (p=,000). Se concluye que el sistema de ejercicios pliométrico desarrolla la potencia muscular del nadador en la ejecución de la técnica de salida, incrementándose la distancia que alcanza el cuerpo antes de entrar al agua, comprobándose H_i.
Palabras claves: Natación, Ejercicios pliométricos, Potencia muscular, Técnica de salida, entrada al agua

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Lisbet Guillen Pereira
guillenp7212@gmail.com

Introduction

Swimming as a sport discipline has developed significantly. At this point, the approach to the management of the athlete's preparation has been strengthened from the benefits derived from research, applied sciences to sport and the incorporation of innovation and technology transfer (Vigo Ibáñez, 2021; Enríquez-Enríquez, Mecina-Zapata, Riveros-Cárcamo, Jerez-Mayorga, Ramírez-Campillo, Chirosa-Ríos & Guede-Rojas, 2023).

Regarding its specificities, it is indicated that in swimming the use of aquatic locomotion techniques predominates, characterized by periodic actions, where the body moves as a result of a cycle of strokes, synchronously combining the upper and lower extremities, to overcome the force drag and propel the body forward (Sammoud, Negra, Bouguezzi, Younes Hachana, Granacher, & Chaabene, 2021).

Due to the characteristics and demands of the competitive act, it is classified as a capacitive sport, which justifies the regulation of physical efforts, energy demands, and the structural and functional involvement of the segments involved in the swimmer's motor act. These elements constitute a reference to manage and handle the preparation of the swimmer, in favor of achieving the desired objective.

On the capacitive management of the efforts in swimming, it is considered that the efficiency of the actions takes place, by virtue of the supposed relationship that can be established between the performance of the action and the energy cost that the demand for its result implied (Víquez Ulate, & Mora Campos, 2011; Enríquez-Enríquez et al., 2023).

In the same way, the chained evaluation of the technique is necessary, as a more tangible element of the execution, with the intention of substantiating and justifying the requirements for planning and dosage, of the swimmer's preparation; in addition to the demands of physical efforts.

As the starting point of competitive performance, the structural and functional demands point towards the involvement of the lower segments, where muscular power and explosive force in the swimmer's legs constitute the trigger that optimizes the execution of the action on the starting platform. and the distance the body reaches before entering the water; accordingly, an impact on the efficiency, speed and economy of movement is promoted (Sánchez Lastra, Martínez Lemos, Díaz, Villanueva, & Ayán, 2020).

Therefore, it´s understood that the technical efficiency of exiting and entering the water is shown when the technical gesture is performed smoothly and fluidly, minimizing resistance and noise in the water at the time of executing the action. However, the displacement of the body before entering the water will basically depend on the muscular power of the lower limbs, which ensure a rapid and effective recruitment of the muscle fibers and the muscles involved in the biomechanical chain of action of exit (Maglishio, 2003; Ordonhes, Silva, Oliveira, de Souza, & Cavichiolli, 2021; Moura, Neiva, Faíl, Morais, & Marinho, 2021).

From this approach, the speed at the start, as a starting point for competitive performance, depends on the muscular power and the explosive force of the swimmer, associated with the lower segments; without ceasing to give value to the placement of the posture, which requires that it be adopted in accordance with the technical requirements: head raised, shoulders back, to allow a more fluid and controlled entry into the water, synchronized with the stroke cycle to maximize propulsión (Timing) ((Ramírez, 2015; Fernández Suárez, Iglesias-Fernández, & Salguero del Valle, 2019).

It should be noted that muscle power (P=f*V), as a determining capacity in the swimmer's starting action, it allows resistance to be overcome through a high speed of contraction (Fonseca, Lopes, Castro, de Santos, dos Lima, Oliveira Filho, de Nunes & Vale, 2022), and generate energy rapidly, without the need for oxygen, through glycogen breakdown and lactic acid metabolism (Bosco, Luhtanen, & Komi (1983), their training and development guarantees intense and brief physical activities.

Muscle power training ensures performance improvement in capacitive sports, which includes swimming. This type of training allows us to optimize the generation of glycogen phosphorylase and phosphofructokinase (PFK), In the same way, the decrease in intramuscular pH is delayed, guarantees the increase in phosphagen reserves (ATP y CP), and optimizes the rate of energy production via the glycolytic pathway (Zatsiorsky, 1995).

In the same way, explosive force is identified as a determining capacity in swimming. Its development ensures the rapid movement of the swimmer in the wáter (Detánico, 2011; Ramírez, 2015), Since the changes derived from its development increase coordination at the intermuscular and intramuscular level (Bompa, 1999; Verkhoshansky & Siff, 2004; Vilela, Caniuqueo-Vargas, Ramirez-Campillo, Hernández-Mosqueira, & da Silva, 2021).

About the topic Bompa (1999), maintains that intermuscular coordination can be enhanced through the use of light loads, however, he states that the development of intramuscular coordination can only be displaced using exercises with heavy loads and a high explosive load of the motor gesture, long-term isometric exercises, and explosive mixed work using light loads, combined with symmetrical exercises developed until rejection, with high loads (Martínez-Rodríguez, Mira-Alcaraz, Cuestas-Calero, Pérez-Turpín, & Alcaraz, 2017; Falces Prieto, Raya González, Sáez de Villarreal, Rodicio Palma, Iglesias-García, & González Fernández, 2021).

For his part Verkhoshansky & Siff (2004), justify the use of plyometric exercises as a resource of high practical value to develop muscle power, harmonizing the development of speed and strength (p.3).

In plyometric work, the serial elastic components of the muscles play a determining role, as do the proprioceptors or sensors, responsible for pre-establishing muscle tension and transmitting the sensory production associated with reactive muscle extension, activating the muscle extension reflex (Verkhoshansky & Siff, 2004; Asadi, Arazi, Young, & Saez de Villarreal, 2016; Leicht, Doma, & Boullosa, 2022; Illera Delgado, Martinez Aranda, & Gea García, 2022).

From this perspective, he classifies plyometric exercises into two groups, considering the level of intensity, height, and length of the exercises:

1. Group 1: Low-impact plyometric exercises: skipping, jumping with low and short steps, double-legged jumps, rope jumps, bench jumps of different heights, simple rebounds
2. Group 2: High impact plyometric exercises: long jumps, triple jump, jumps with alternating long and short steps, double-legged or single-legged jumps, rebounds, rope or bench jumps, bench jumps, throws with medium (objects)

Among the most widely used methods to develop muscular power are the plyometric method, used to improve the contractile force of the musculature through jumps, isokinetic methods, which improve dynamic force and power through movement, diet regimen methods. concentric contraction, eccentric contraction regimen method, and isometric contraction regimen methods (Tequiz Rojas, Gálvez Eras, Chicaiza Jácome, Carchipulla Enríquez, Cañadas Gómez de la Torre, & Arteaga Chicaiza, 2020; Fonseca, et al., 2021; Ho, Wong, Yong, & Fang 2022).

It should be noted that high-intensity plyometric exercises, associated with jumps, promote an increase in muscle tension, which implies an increase in the recruitment levels of the neuromuscular units in the action or in the opposition process of the traction of the muscles the gravitational forcé (Vargas, & Salazar, 2015).

All the aforementioned referents constitute the support of an adequate management of the swimmer's sports performance, which is affected if it is not planned and dosed correctly. The ignorance of the management of the preparation, generates mistakes in obtaining the sports form. Inadequate dosage of the components of the load and selection of contents, methods and procedures distort the direction

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and strengthening of muscular chains that guarantee the execution of the swimmer's start and the movement of the body before entering the water.

At this point it should be noted that Ecuador has excelled in the results of open water swimming, however, the results of this sport in Olympic pools are very limited internationally. Despite the fact that there is an important development of the sport, the technical force that supports the preparation process of the athletes, is not right, in the management of the sports performance of the swimmers and, to a lesser extent, the development of their physical abilities.

Accordingly, the solution alternatives (Medina Rojas, 2015; Apolo, Rubio Villalba, Burbano Benavides, & Yar Saavedra, 2017; Párraga Ruales, 2021; Briones Zapata, 2022; Guamán Yumiceba, & Reinoso Acosta, 2020) do not satisfy the knowledge needs associated with the selection and dosage of the contents, methods and means that favor the development of those capacities that condition and determine the competitive performance of the swimmer in each of the phases, which does not exclude the development of power muscle from plyometric work, as an alternative to guaranteeing a positive and effective transfer from the execution of the swimmer's starting technique to the displacement of the body before entering the water.

In accordance with the above, this study focused on *identifying the empirical value of a system of plyometric exercises for the development of muscular power of the swimmer's lower limbs in the start technique.*

Methodology

Material and method

The study declares a type of experimental research, (pre-experiment), with a minimum degree of control (Hernández Sampieri, Fernández Collado, & Baptista Lucio, 2014); defined by the particularities of the subjects with whom we worked (high-performance swimmers), accordingly a pre-test/post-test design with a single group is assumed.

The study starts from the evaluation of the initial state of the objective variables (O_1: pre-test), initially determining the possible correlation; In a second moment, the intervention is carried out (X: implementation of a system of plyometric exercises) and it concludes with the evaluation of the state of the correlation of the variables as a result of this intervention (O_2=: Post-test), which It allowed us to demonstrate the type of existing correlation, the directionality of the correlation between the variables, in addition to the practical value of the proposal in improving muscle power.

To satisfy the requirements of the research objective, two dependent variables were identified, on which the statistical analysis, correlation and experimentation were focused:

1. Muscular power of the swimmer's lower limbs
2. Distance reached by the swimmer's body before entering the water

The power variable was built with an aggregation model of the means of the SJ and AB data. In the same way, the DRBW variable was built with the aggregation of the means of the attempts made by subjects.

Sample design

The Nautical Club of high-performance swimming of the city of Quito participated in the study, which contributes 19 subjects for the investigation, which represent 100% of the population. The procedure required working with a part of this population, for which a non-probabilistic sample design was assumed based on criteria, considering the inclusion of athletes between the ages of 13 and 22, swimmers preselected for the national games in 2022 and a proven experience of ±4 years in the sport of swimming.

As a result, the resulting sample size was 15 subjects (74.94% of the paper population), three (3) are women (20%) and 12 belong to the male sex (80%), with an average age of ±16 years, and a sports experience of ± 7 years. In order to develop the declared methodological dynamics, informed consent was obtained from the 15 subjects who intervened, with whom the procedures, the requirements of the tests and the intention of the study were shared.

Research design

The research was carried out in a period from February to May of the year 2022, in the stage of special preparation of the group under study (Intervention) following the experimental logic of: $G – O_1$-- X---O_2

G= Group

O= Proof of the state of the group, with respect to the independent variable

X= Intervention

In agreement, the following methodological theoretical model for the investigation was followed.

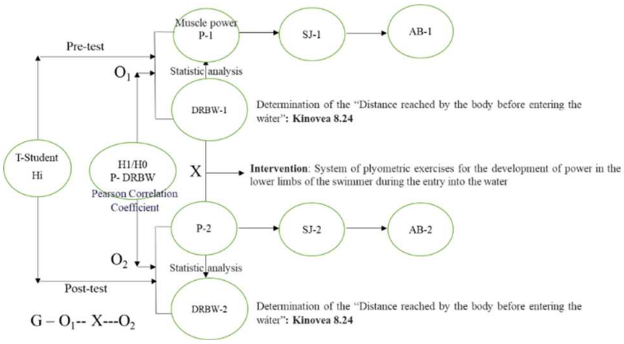

Figure 1. *Methodological tract assumed for the research for both moments of time*
Note: H_i: Research hypothesis; H_1: Statistical hypothesis; H_0: Statistical hypothesis; P: muscle power; DRBW: Distance reached by the body before entering the wáter; SJ: Squat Jump; AB: Abalakov jump

The modeling, simulation and the structural systemic method were used in the construction of the proposal (Plyometric exercises), which is aligned with the needs declared in the problematic situation.

Presentation of the proposal

The exercise system was created as a result of a thorough systematic review of the object of study. The elements and components that are part of the proposal solve the limitations identified in the diagnostic phase.

Its design considered the theory of systems, understood as a set of interrelated and interconnected units, oriented towards the fulfillment of objectives, taking into account its integration with the environment (Olivera Betrán, 2006). In the same way, he considered as important the structural and functional characterization of the execution of the start of the swimmers, an action in which several kinematic chains intervene, from the extensor muscles of the lower limbs of the swimmer: anterior group of the thigh (sartorius and quadriceps femoris, rectus femoris, vastus medialis, vastus lateralis, and vastus intermedius), posterior thigh group: hamstrings (semimembranosus, semitendinosus, and biceps femoris), pelvic muscles: gluteus maximus, gluteus medius, and gluteus profundus (Villordo, 2022).

The design took into account the assumptions established by Garrido Chamorro, & González Lorenzo (2004) to build a proposal oriented to the development of muscular power through the plyometric method. The authors indicate that it is necessary to plan and dose considering age, body weight, previous strength condition, sport-related requirements, sport experience, previous injuries, jumping surface, warm-up, progressions, recovery, frequency.

In accordance with the planning, dosage and application of the exercise system, it was carried out according to the age of the swimmer, the experience in the sport, the technical and physical level of the swimmer and the requirements of the preparation process for the fundamental competitive event, which that justifies the individualization of sports training as a principle.

The deployment of the proposal was located within the stage of special preparation, and provides: contents, methods, means, forms, procedures, and dosage proposal and evaluation system. This was deployed for a period of 12 weeks (by virtue of the physiological and functional changes that are desired to be achieved), by the swimmers. Accordingly, it focuses on developing the muscular power of the lower limbs through exercises developing the stretch-shortening cycle to favor the positive and effective transfer of the execution of the swimmer's starting technique to the movement of the body before entering the water.

Table 1.
Plyometric system for swimmers

Preparation process stage: special preparation stage Sport: swimming Plyometric exercise system Dry training Objective: contribute to the development of the muscular power of the lower limbs of the swimmer to optimize the execution of the start technique Duration of the intervention: 12 weeks				
Exercises	Methods	Procedures	Media	Dosage
Jumps in place looking for height, with the legs together, the center of gravity is lowered. The body is flexed at the hips and knees on the rebound	Repetition	In the place Individual Scattered	None	From 3-4 series 1 min/ 3 min High intensity Characteristic of movement: fast and explosive Intensity: high
Jump rope	Repetition	In the place Individual Scattered	Rope	From 3-4 series 30 sec/ 1.50 min Movement characteristic: continuous Intensity: high
Vertical jumps without displacement, bringing the knees to the chest in the dynamics of each jump	Repetition	In the place Individual Scattered	None	From 3-4 series 4-5 repetitions Intensity: high Movement characteristics: fast and explosive
Vertical jump without displacement, bringing the knees to the chest in the dynamics of each jump and seeking to support the knees with the hands before the feet return to the ground	Repetition	Individual Scattered	None	From 3-4 series 4-5 repetitions Movement characteristic: continuous Intensity: moderate/ intensity: high Full breaks
Umps against movement, moving forward, continuously	Repetition Continuous standard	Front row Wave procedure	None	From 2-5 series 4-7 repetitions Moderate intensity Characteristic of movement: fast and explosive
Drops jump (jumps with fall): jumps from the box and falling to the ground, the rebound is used to execute the next jump to the box.	Repetition Continuous standard	Scattered In the place	Drawers	From 3-4 series 4-7 repetitions Moderate intensity
Simple rebounding exercises	Repetition Continuous standard	Scattered In the place	None	From 2-4 series 4-7 repetitions Characteristic of the movement: continuous / fast and explosive Intensity: moderate/ intensity: high Full breaks
Multijumps varying progressively or regressively by changing the height of the jump or the direction	Varied standard	Route Individual	Cones Ula-ula Strings	From 3-4 series 30 sec/ 1.50 min Moderate intensity Movement characteristic: continuous 5-minute macropause
Barrier jumps: the jump is executed with the legs together and it is about	Repetition	Route Individual	Drawers, Obstacles	3-4 repetitions Moderate intensity

overcoming the height, which varies progressively during the tour			Barriers	5-minute macropause I work continuously
Jumps forward without impulse: horizontal jumps with the legs together, the total distance of the jumps is varied	Repetition	Front row Wave procedure	None	6-7 repetitions Characteristic of the movement: continuous / fast and explosive Intensity: high Full breaks
Jumps in diagonal: it is executed with the legs together in a zig-zag, varying the total distance of the jumps	Varied standard Repetition	Front row Wave procedure	None	3-4 repetitions Characteristic of the movement: continuous / fast and explosive Intensity: high Full break
Deep jumps, executed with the legs together from the floor to the box, with momentum	Repetition	Route Individual	Drawer	3-4 sets / 4-5 repetitions Moderate intensity
Vertical jump with external load, seeking a height of more than 20 cm	Continuous standard	Scattered, in place	Support with lead for the ankles Weight bar with discs	3-4 sets / 4-5 repetitions 30%-50% of the imr Moderate intensity
Vertical jump with external load, seeking a height of more than 20 c	Continuous standard	Scattered, in place	Support with lead for the ankles Weight bar with discs	2-5 repetitions 70%-90% of the imr Characteristic of the movement: continuous / fast and explosive intensity: high

Procedure for the evaluation of muscular power

To measure the power of the lower limbs of the swimmers, the SQUAT JUMP (SJ) test was selected from the Bosco Test, which measures anaerobic power and explosiveness of the lower limbs, and the ABALAKOV jump test (AB), which measures vertical impulse capacity and the maximum power of the lower limbs. The selection was justified under the criteria of the physical demands of the starting technique in swimming and the muscular chain that intervenes structurally in the action. The selected measurement tool was the digital platform, used in a large number of studies with a similar intention (Trinidad Morales, & Lorenzo Calvo, 2012; Casanova Machek, & Gamardo Hernández, 2017; Fernández Suárez et al., 2019; Corbí-Santamaría, Jiménez-Velayos, Corbí-Santamaría, & García-López, 2018; Guillen Pereira, Rodriguez Torres, Capote Lavandero, Rendón Morales, Lagla Melendres, & Rosas Mora, 2021; Alonso-Marco, & Romero-Naranjo, 2022).

In the SJ test, the swimmer, on the digital platform, had to perform a vertical jump, starting from the 90° leg flexion position, without any type of rebound or countermovement. Subject recorded three attempts and the best mark was taken. According to Bosco, et al (1983) the average values of the SJ for men are shown around 33,49 cm and 26,31 for women, cut-off points that were considered as referents for the analysis. Another criterion to consider are the averages that contribute Garrido Chamorro, González Lorenzo, Expósito, Sirvent Belando, & García Vercher (2011) for the discipline of swimming, according to the authors, the average is 23,64 cm in women and 30,31 cm in men.

In the AB test, the swimmer, on the jumping platform, could help himself with his arms to gain momentum, performs a semiflexion of the legs at 90° at knee level, followed by an extension. During the flexion action, the trunk had to remain as straight as possible, to avoid its possible interference in the result of the movement of the lower limbs. Subject recorded three attempts and the best mark was taken. Bosco, et al (1983) indicates, for the AB test, that the average values, in men, are usually located at 21,46 cm and 19,21 cm in women, on the other hand Garrido Chamorro, et al (2011), refer that, for this test, in the sport of swimming, the female sex shows a reference average of 27,99 cm and in men 41,75 cm.

Procedure for measuring the distance reached by the swimmer's body before entering the water

In a second moment, the complete execution of the swimmer's exit phase was filmed, a result that was used to measure the distance reached by the body before entering the water. For the filming of the execution of the exit technique, an evaluation protocol was created, which was previously socialized with the subjects involved. The performance of three starts actions (three attempts) was established, characterized by being executed as strong and explosive as possible, for which it was necessary to establish a passive rest between each action as part of the procedure, which could range between 4 and 6 minutes.

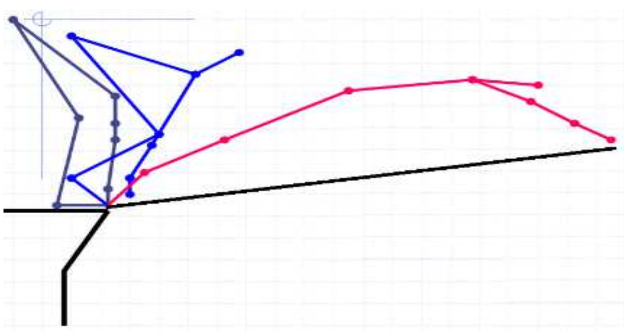

Figure 2. Measurement example in Kinovea Software. Fuente: Kinovea Software: 8.24

The results of the filming were analyzed, individually, using the free video analysis software: Kinovea in its version 8.24, widely used in various biomechanical studies of sports (Fernández Suárez et al., 2019; Corbí-Santamaría et al., 2018; Alonso-Marco, & Romero-Naranjo, 2022; Flores-Leon, Leyton Quezada, Martínez Hernández, Salazar Reinoso, & Berral de la Rosa, 2022; De la Fuente Caynzos, 2023).

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To measure the distance reached by the swimmer's body before entering the water, two distal extreme points were defined (the tips of the fingers of the hand, and the tips of the toes of the feet), as shown in the figure (2), it should be noted that the best value of each attempt was taken as the result of each swimmer.

Procedure for verification of the practical value of the proposal

The results (Pre-test and Post-test) were analyzed using descriptive statistics, considering position and dispersion values: maximum, minimum, mean, standard deviation. The collected data was subjected to a normality test (Shapiro Will: for a sample of less than 50) with the intention of identifying whether or not the data returned follow a normal distribution and to identify the type of hypothesis test to be used. For the inferential analysis, the SPSS 24.0 was used, with the intention of checking the "p" value.

The results of the normality test pointed towards the use of the parametric T-Student test (mean difference test) for dependent samples, which allowed verifying the existence of significant changes in the objective variables as a result of the intervention (System of plyometric exercises).

Accordingly, the study was preceded by the following research hypothesis:

H_i: A system of plyometric exercises develops the swimmer's muscular power for the execution of the start technique.

Procedure used for the correlation of variables

To determine the correlation of the dependent variables: Muscular power of the swimmer's lower limbs and Distance reached by the swimmer's body before entering the water, the Pearson Correlation Coefficient was used, which is a parametric test to measure dependency. linear, which expresses the correlation between two quantitative random variables and their directionality, an analysis that was preceded by a statistical hypothesis

H0: There is no correlation between the muscular power of the lower limbs and the distance reached by the swimmer's body before entering the water at both moments of time.

H_1: There is a correlation between the muscular power of the lower limbs and the distance reached by the swimmer's body before entering the water at both moments of time.

For the correlated analysis, the following criteria were considered:

- When the value is less than zero (0), it indicates that there is a negative correlation, that is, that the two variables are associated in the opposite direction, or when it is exactly -1, it means that they have a perfect negative correlation.
- When the value is greater than zero (0), it indicates that there is a positive correlation, accordingly the variables would be associated in a direct sense, or the closer the value is to (+1), the higher its association will be, denoting a perfect positive linear relationship.
- When the correlation is shown at zero (0), or close to zero, it would indicate that there is no linear relationship between the two variables.

Results

Results of the tests in the Pre-test

The SJ test showed values that oscillated between 19,60 cm and 33,20 cm, with an average of 26,97 cm, and a standard deviation of 4,72., which is indicative of the heterogeneity of the data. At this point it should be noted that in the female sex (3 cases), the average was lower (26,81 cm) than the male sex (26.96), however the lowest values of the SJ were recorded at the age of 15 and 18 years respectively, both in the female sex.

If we take as reference the average values for the test, defined by Bosco, et al (1983), it is possible to state that the male sex is ±6,53 below the ideal average (33,49 cm) for this sex with 26,96 cm, unlike the female sex, which is located ± ,50 above the cut-off point established by the authors for this test (26,31 cm) with an average of 26,81 cm. A similar contrast is evident when analyzing the cut-off points offered by Garrido Chamorro, et al (2011) for the discipline of swimming., which indicates that the development of muscular power in the legs of the swimmers, in the first moment of time, is not adequate to achieve an optimal displacement of the swimmer's body before entering the water.

Table 2.
Global average of the tests in the pretest

Subjects	Sex	Jump test: Pre-test		Jump test: Post-test		Overall result DRBW	
		SJ	AB	SJ	AB	DRBW: Pre-test	DRBW: Post-test
1	M	29,2	33	32,1	40	3,15	3,77
2	F	22	27,4	25,5	32,1	3	3,15
3	M	21	25	31,1	37,4	2,78	3,45
4	M	31,1	40,8	33	42,9	3,54	3,82
5	F	20,4	29,2	36,3	44,1	2,78	3,76
6	M	27,4	32,1	36,3	45	3,23	3,95
7	M	28,2	35,2	32,1	37,4	3,38	3,43
8	F	19,6	23,8	27,4	41,8	2,64	3,5
9	M	32,1	40	28,2	45,3	3,54	3,86
10	M	33,2	44,1	39,6	50,2	3,91	4,02
11	M	25	30	24,4	32,1	3,02	3,05
12	M	31,1	34,2	28	39	3,45	3,63
13	M	24,6	30	28	36,3	3,09	3,36
14	M	26,4	33,1	28	39	3,35	3,46
15	M	33,2	40,8	31,1	49	3,52	3,86

Note: M: male; F: female sex; SJ: Squat Jump; AB: Abalakov jump; DRBW: Distance reached by the body during entry into the water

The AB jump showed a range of values between 23,80 cm and 44,1 cm, with a mean of 33,25 cm, standard deviation of 6,05., which contrasts with the heterogeneity of the data. Note that the female sex exhibits an average (33,26 cm) that is ±14.05 cm above the cut-off point (19,21 cm) established by Bosco, et al (1983) for this test; however, according to the author, the male sex is ±11,78 cm above the average for this sex (21,46 cm) with a mean of 33,24 cm. In the same way, a limitation can be seen in the state of the objective variable.

Table 3.
Descriptive statistics: Overall result

		N	Minimo	Maximo	Mean	Standard Desviation
Overall result Pre-test	Overall_result_SJ	15	19,60	33,20	26,9667	4,72360
	Overall_result_AB	15	23,80	44,10	33,2467	6,05049
	Overall_result_DRBW	15	2,64	3,91	3,2253	,34844
Overall result Post-test	Overall_result_SJ	15	24,40	39,60	30,7400	4,28599
	Overall_result_AB	15	32,10	50,20	40,7733	5,42250
	Overall_result_DRBW	15	3,05	4,02	3,6047	,29046
	N valid (per list)	15				

Note: SJ: Squat Jump; AB: Abalakov; DRBW: Distance reached by the body before entering the water

It was found that the results of the DRBW in the pretest ranged between 2,64 and 3,91 (meters/cm) with a standard deviation that reveals that the results are close to the central mean (±3,2253) due to the low heterogeneity of the data (±,34844). In the female sex, the central mean was 3,1078 cm and in the male sex it was 3,106. In general, the standard deviation shows that the results were concentrated around the central mean. The result is consistent with the state of muscle power

Statistical analysis of the post-test

Table (4) shows the values of the SJ jump, these ranged between 24,40 cm and 39,60 cm, with an average of ±30,74 cm, and a standard deviation of ±4,29 cm, which which indicates dispersion in the data in relation to the central mean. At this point it should be noted that in the female sex the mean was ±30,64 cm in relation to the male sex (±30,74), with a standard deviation of ,10. In general, higher values are observed than in the pretest, with an improvement of ±3,78 in the power of the jump, which is a positive reference derived from the intervention.

The AB jump yielded a data range of 32,10 cm and ±50,20 cm, with a standard deviation of ±5,42. However, the mean of the results (±40,77), exhibited an improvement of ±4,38, in relation to the first moment, which results in the change being positively significant. The female sex revealed an average jump of ±40,82 cm, exhibiting an increase of ±9,41 from pretest to posttest (23,25%); the mean value in the male sex was ±40,77 cm, showing a displacement of ±9,27 cm in relation to the pre-test, and an increase of 22,74%.

The average in the two jumps, from the pre-test (30,11 cm) to the post-test (35,76 cm), revealed a positive displacement of the overall mean of muscular power by ±5.65 cm in the swimmers, which represents an improvement of 18,75% in 12 weeks.

For its part, the DRBW in the post-test yielded an average of ±3,60 cm; In agreement with the mean of the first moment, the result showed an improvement of ,37 cm, which represents an increase in the DRBW values of 11,76%. In this sense, the female sex increased the distance by ,37 cm, which represents an improvement of 11,36% in relation to the pre-test and the male sex displaced the values by ,38 cm, which shows an improvement of 11.85% in relation to the first moment

Table 4.
Descriptive statistics: Muscle power y DRBW Pre-test/Post-test

	N	Minimum	Maximum	Mean	Dev. Desviation
Muscle power_ Pre-test	15	21,70	38,65	30,1067	5,30138
Muscle power_ Post-test	15	28,25	44,90	35,7567	4,50527
DRBW _ Pre-test	15	2,64	3,91	3,2253	,34844
DRBW_Post-test	15	3,05	4,02	3,6047	,29046
N valid (per list)	15				

Note: DRBW: Distance reached by the body before entering the water

Results of the correlation of the variables: the Pearson Correlation Coefficient

To verify the relationship between the two (2) variables, it was necessary to use the Pearson Correlation Coefficient. By correlating Muscular Power and the Distance reached by the swimmer's body before entering the water (DRBW); it was possible to appreciate that the significance value (*p*) was ,000< ,05, as the default value for both moments of time, which indicates a strong correlation.

The results of the Pearson correlation coefficient between the variables were greater than zero in the pre-test (,962) and in the post-test (,931). In this sense, it is possible to state that since the value is greater than zero (0) at both moments of time, there is a positive correlation, accordingly the variables are associated in a direct sense, since the value of (+1) is close, it is demonstrated that the association is strong

Table 5.
Pearson's correlation coefficient between la Muscle power y DRBW Pre-test/Post-test

		Muscle power Pre-test	DRBW _Pre-test
Muscle power_Pre-test	Pearson Correlation Coefficient	1	,962**
	Sig. (bilateral)		,000
	N	15	15
DRBW_Pre-test	Pearson Correlation Coefficient	,962**	1
	Sig. (bilateral)	,000	
	N	15	15
		Muscle power Post-test	DRBW _Post-test
Muscle power_Post-test	Pearson Correlation Coefficient	1	,931**
	Sig. (bilateral)		,000
	N	15	15
DRBW_Post-test	Pearson Correlation Coefficient	,931**	1
	Sig. (bilateral)	,000	
	N	15	15

**. The correlation is significant at the ,001 level (bilateral).
Note: DRBW: Distance reached by the body before entering the water

Upon verifying a directly proportional correlation between the variables, (p= ,000) H_0 is rejected and H_1 is verified (statistical hypothesis), demonstrating that there is a strong and almost perfect positive linear correlation between the resulting value of the muscular power of the limbs swimmer's legs and the distance reached by the swimmer's body before entering the water at each point in time.

When the parametric assumptions are met, derived from the Shapiro Will test (p=,000), the T-Student test is used, which allowed the evaluation of significant changes in the objective variables as a result of the intervention. In this sense, an improvement in the global average of muscular power is verified, from the first to the second moment (p=,000), in this sense the means of muscular power differ from the first to the second moment, reflected in a displacement of the mean overall DRBW from pre to post test (p= ,000).

Table 6.
Paired Samples Test: Significance of Changes

		Mean	Dev. Desviation	Desv. average error	95% confidence interval of the difference		t	gl	Sig. (bilateral)
					Lower	Superior			
Par1	Muscle Power_Pre-test – Muscle Power_Post-test	-5,65000	4,72414	1,21977	-8,26614	-3,03386	-4,632	14	,000
Par2	DRBW_Pre-test – DRBW_Post-test	-,37933	,30996	,08003	-,55099	-,20768	-4,740	14	,000

Note: DRBW: Distance reached by the body before entering the water

Accordingly, it is possible to state that the plyometric exercise system develops the muscular power of the swimmer's lower limbs in the execution of the start technique, which is reflected in the displacement of the distance that the body reaches before entering the water, verifying the research hypothesis Hi, as the significance is less than the predetermined value ($p< .05$).

Discussion of the results

The present paper statistically demonstrated the practical value of a system of plyometric exercises for swimmers from the Club Nautico de Quito, which welcomes high-performance athletes. The findings demonstrated the existence of a strong and direct correlation between the muscular power of the lower limbs and the distance reached by the body before entering the water. It is verified that the improvement of this last variable is due to the intervention process, in which the declared proposal was applied to favor, from plyometrics, the development of the muscular power of the lower limbs in the start technique.

On the subject Fernández Suárez, et al (2019), develop a kinematic analysis of the start in swimming, they affirm that the execution of a good start can contribute up to 25% in the final result of a speed test. The findings of this study are used by Guamán Yumiceba, & Reinoso Acosta (2020) to justify the importance of the plyometric method in swimming and propose a system of plyometric exercises aimed at developing the explosive strength of the lower limbs in the exit technique the crawl style.The authors deploy the intervention in the child and youth categories and conclude that the proposal has a high practical value, since it promotes significant changes in muscle power; position that coincides with the results of the present study.

In the same vein, Taladriz Blanco, de la Fuente Caynzos, & Arellano Colomina, (2017) carry out an analysis of the evolution of ventral swimming outlets. The findings found in the study corroborate the existence of several investigations that agree on the advantages of jumping work to develop the muscular power of the lower limbs.

They indicate that the research consulted addresses the start technique and focuses mainly on the application of training systems to develop explosive strength, resistance training with different practical methods, power training, power and strength training followed by resistance training. Speed and speed training methods. According to the authors, the studies prove the effectiveness of plyometric work, by evaluating the performance of vertical jumps in which they include the SQUAT JUMP and ABALAKOV, among others.

The research carried out by Garrido Chamorro, et al (2011), establishes global cut-off points and by sex in the swimming discipline, these are obtained as a result of the application of various jump tests (SQUAT JUMP, ABALAKOV, DROP JUMP, COUNTER MOVEMENT JUMP and WATIOS), the findings presented demonstrate the impact of the jumps in the capacitive development of several sports within which the discipline of swimming is enunciated. The authors carry out a global analysis of muscular power, pointing out that the results presented in swimming, at the time of the study, are due to the fact that "the use of the plyometric method was not part of the usual swimming training".

This position agrees with that of Pradas Valverde, Falcón, Moreno Azze, & Pradas (2022), who justify the need to develop plyometric training to enhance explosive strength and induce performance in the swimmer's start phase. The authors corroborate the efficacy of the effects of plyometric training on the performance of the start technique in teenager athletes. The findings reported in the study affirm that plyometric training improves the height of the vertical jump favoring the performance of the swimming start.

In a purposeful way, the authors state that plyometrics could be an effective training method to improve the performance of some of the kinematic parameters involved in swimming start. They argue that the plyometric method favors an increase in the distance of the horizontal jump, an improvement in the angles of execution of the exit technique and a decrease in the times of entry into the water (Pradas Valverde et al., 2022), arguments that contrast with those declared in the study.

Conclusions

The theoretical references consulted, were demonstrated the practical value of plyometric exercises to develop the muscular power of the lower limbs of swimmers, in general it is corroborated from the theory that training on land, and with the plyometric method generates changes at a structural level and functional, which allows optimizing the performance of the swim at the time of departure.

Thanks to this analysis, it has been possible to guarantee the validity of the data analyzed at both moments of research, which showed the correlation between the resulting value of the muscular power of the swimmers' legs and the distance reached by the body before entering the water at both moments of time, showing a linear relationship, perfect positive, verifying the statistical hypothesis of the study (H_1).

It was verified that plyometric exercises system, improves the muscular power of the lower train in the swimmer and in agreement, the distance reached by the body before entering the water, as a result of a positive transfer from the development of capacity to the execution of starting swimmer´s technique. Verifying the research hypothesis (H_i).

Study limitations

The study recognizes the limitations that derive from the use of pre-experiments as research designs, due to their minimal control and the difficulties that arise for their generalization.

It is recognized that the design is not suitable for establishing causality, since there is no comparison group, making it vulnerable to the possibility of control and internal validity. In this sense, it was not possible to select a control group since we worked with a particular population, with specific characteristics of the scenario under study (high-performance swimmers from the Club Nautico de Quito). Despite the declared limitations, the study provides new knowledge and scientific evidence that allows working on the improvement of capacity in the sport of swimming.

Future investigations

To carry out a longitudinal study in time to evaluate the impact of plyometric exercises, the development of the muscular power of the lower limbs in swimmers in the start technique, by modality and styles.

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