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# Plyometric exercises program in lower limbs to boost the jumping capacity in female basketball players under 12

Programa de exercícios pliométricos em membros inferiores para melhorar a capacidade de salto em até de 12 anos de basquetebol feminino

Programa de ejercicios pliométricos en miembros inferiores para potenciar la capacidad de salto en jugadoras de baloncesto menores de 12 años

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Implementing plyometric exercise programs can effectively enhance the jumping ability of U12 female basketball players, contributing to their overall athletic development and performance improvement. This insight can be useful to policy makers to promote sports, whether in educational institutions or at the government level to promote sports among young people.
**Originality/value:**
The originality of this article lies in presenting real, unpublished empirical evidence on a topic that may be interesting for developing countries that demand the promotion of youth sports.

**ABSTRACT**

**Background:** The benefits of a plyometric program for the healthy athlete, have been demonstrated through studies. Plyometric exercise is one of the most efficient training methods available. Over time, it could be said it will provide the greatest transferability for its application in sports. The exercises can be used to strengthen and improve jumping in athletes of all ages. **Objective:** to implement a plyometric exercise program to boost the jumping ability of U12 female basketball players. **Methods**: the type of longitudinal analytical study, with a quantitative approach, was developed in 16 participants of the Isabel de Godin Educational Unit of Riobamba City, province of Chimborazo, Ecuador. The intervention was carried out twice a week in each of the sportswomen in the under-12 female category. My Jump 2 software was used for the initial and final evaluation, and the Wilcoxon method was used. **Results:** through the My Jump software, there was predominance above the average of 31.3%, the average of 62.5%, and below the average of 6.3% in the hypothesis testing of the My Jump 2 software. The p-value was p<0 (asymptotic significance) so the null hypothesis is rejected. **Conclusions:** it was determined that the exercise program was effective in improving jumping capacity.

**Keywords:** Physical exercise; Lower limbs; Muscular strength; Leap; Basketball.

**RESUMO**

**Contexto**: Os benefícios de um programa pliométrico para o atleta saudável foram demonstrados através de estudos. O exercício pliométrico é um dos métodos de treinamento mais eficientes disponíveis. Com o tempo, pode-se dizer que proporcionará a maior transferibilidade para sua aplicação no esporte. Os exercícios podem ser utilizados para fortalecer e melhorar o salto em atletas de todas as idades. **Objetivo:** implementar um programa de exercícios pliométricos para aumentar a capacidade de salto de jogadoras de basquete sub-12. Métodos: o tipo de estudo analítico longitudinal, com abordagem quantitativa, foi desenvolvido em 16 participantes da Unidade Educacional Isabel de Godin da cidade de Riobamba, província de Chimborazo. A intervenção foi realizada duas vezes por semana em cada uma das esportistas da categoria sub 12 feminina. Para avaliação inicial e final foi utilizado o software My Jump 2 e utilizado o método Wilcoxon. **Resultados:** através do software My Jump houve predomínio acima da média 31,3%, média 62,5%, abaixo da média 6,3% nos testes de hipóteses do software My Jump 2. O valor de p foi p<0 (significância assintótica), portanto a hipótese nula é rejeitada. **Conclusões:** determinou-se que o programa de exercícios foi eficaz na melhoria da capacidade de salto.

**Palavras-chave:** Exercício físico; Membros inferiores; Força muscular; Salto; Basquetebol.

**RESUMEN**

**Antecedentes** Los beneficios de un programa pliométrico para el deportista sano han sido demostrados a través de estudios. El ejercicio pliométrico es uno de los métodos de entrenamiento más eficientes disponibles. Con el tiempo se podría decir que proporcionará la mayor transferibilidad para su aplicación en el deporte. Los ejercicios se pueden utilizar para fortalecer y mejorar el salto en deportistas de todas las edades. **Objetivo**: implementar un programa de ejercicios pliométricos para potenciar la capacidad de salto de jugadoras de baloncesto U12. **Métodos**: el tipo de estudio analítico longitudinal, con enfoque cuantitativo, se desarrolló en 16 participantes de la Unidad Educativa Isabel de Godín de la ciudad de Riobamba, provincia de Chimborazo. La intervención se realizó dos veces por semana en cada una de las deportistas de la categoría sub 12 femenina. Para la evaluación inicial y final se utilizó el software My Jump 2 y se utilizó el método Wilcoxon. **Resultados**: a través del software My Jump hubo predominio por encima del promedio 31,3%, promedio 62,5%, por debajo del promedio 6,3% en la prueba de hipótesis del software My Jump 2. El valor de p fue p<0 (significancia asintótica) por lo que se rechaza la hipótesis nula. **Conclusiones**: se determinó que el programa de ejercicios fue efectivo para mejorar la capacidad de salto.

**Palabras clave:** Ejercicio físico; Miembros inferiores; Fuerza muscular; Salto; Baloncesto.

## INTRODUCTION

One of the most used systems to increase power is plyometric work. It is considered a rapid movement and a powerful activator of the cycle when lengthening and shortening the muscle fiber, since a stronger concentric contraction is produced. Power is synonymous with strength in a short period of time. Most of the actions carried out by athletes on the field must be executed with maximum power in the lower body (Girón et al., 2017).

According to the World Health Organization (WHO), 81% of children worldwide do not exercise. It is one of the best gifts you can give a child. It encourages them to leave the couch and go outside to enjoy themselves. Exercising is a good option to prevent possible long-term illnesses such as obesity, heart problems, and back pain. These are some of the consequences of a sedentary lifestyle in children.

There are studies in which two sessions per week are recommended for prepared athletes, but there are also authors who recommend three sessions per week. The countermovement jump (CMJ) is a simple, practical, valid and very reliable measure of lower body power. Performances in the CMJ are related to maximum speed, maximum strength and explosive strength. On the other hand, the horizontal jump (HJ) is one of the most common used to measure explosive strength of the lower body, as it is more accessible. In order to objectively measure performance at height, today there are reliable and valid tools that allow analyzing the CMJ, HJ and others such as the My Jump 2 application (Martínez., 2022).

Movement is the key to all successful sporting action. It is the basis of athletics because all athletes use it to solve problems in sports situations. We can find a great variety of movements. These are related to the qualities of running, jumping and rapid production of force in most common sports. Plyometric training has a direct relationship with the improvement of different dimensions. And this study analyzed, in depth, the influence at early ages (Benítez., 2020).

The research will focus on analyzing the advantages of performing physical activity through the application of a plyometric exercise program. It will be focused on enhancing the jumping capacity of the lower limbs in under-12 basketball players who belong to the Isabel de Godín Educational Unit. It aims at improving their sporting performance on the playing field.

In Ecuador, 76% of people between 5 and 17 years old, as of December 2021, have insufficient physical activity, that is, 3.4 million. "Behind the figures there are real stories, real lives, and from the National Institute of Statistics and Census (INEC), we work hard to tell this reality," it assured. For the Government of "Encuentro", sporting activity must be an indispensable development tool with the power to inspire, unite and above all transform lives. The Ministry of Sports implements several actions to promote physical and recreational activities throughout the country (INEC., 2021).

The practice of basketball has a positive impact on the normal development of children of these ages, physically, psychologically and socially. It is manifested in their behavior inside and outside their environment. This work also reflects the elements of the strategy elaborated and the model on which each of them is implemented to achieve the expected results within the sports massification. The objective is to create a methodological strategy, based primarily on recreational activities that involve children and that serves at the same time to spread this worldwide sporting discipline that teaches fundamentals of mini basketball to children of 8 - 12 years (Porozo., 2022).

Plyometric training is an integral component of training that many fitness specialists use to optimize strength and power performance in various sports. The main characteristic of lower limb plyometric exercises, such as jumping, is the use of the stretch-shortening cycle that allows the muscles to store elastic energy, during a rapid eccentric muscle contraction (Drouzas et al., 2020).

Basketball, in the interior of the province of Chimborazo, has been showing considerable acceptance among children, youth and adults. It has been promoted, has become increasingly competitive, and has developed athletes from a very early age- school and high school children. For some time now, they have obtained positive achievements in this discipline, so it is considered that the plyometric exercise program in under-12 female basketball players will be the most appropriate to improve jumping power.

In relation to training methods, plyometrics is one of the most used systems to improve muscle strength. This methodology refers to a wide range of exercises that use jump-based training. In this sense, there have been numerous studies that have used plyometric training to develop muscle power (Barahona et al., 2019).

Muscular power (MP) is relevant in basketball, although its relationship with physical and competitive performance is not clear, when it manifests itself at different loads. Objective: to analyze the relationship between MP at various loads with physical and competitive performance in basketball players. In 20 players (age 18.2 ± 5.1 years, weight 80.1 ± 13.7 kg, height 185.6 ± 4.4 cm) maximum strength was measured through 1RM and MP from 40% to 80% of 1RM in the middle squat; 20 m dash race, long jump, Illinois test with and without the ball and game statistics with Final Assessment (VAL). There is a

relationship between MP, physical and competitive performance depending on the load and it should be considered for basketball training (García-López et al., 2021).

Muscle mass, bone mass and fat percentage in rugby players are significantly positively related to the power of SJ and CMJ jumps. However, there are no significant relationships between explosive strength and physical performance parameters such as agility and maximum cyclic speed. Therefore, these results contribute to the research references in this form of rugby which is relatively new, as well as to its training processes (García-Chaves et al., 2021).

Muscle force production is the ability of the muscle to be in a state of active tension through a contraction, regardless of the amount of force applied to overcome a load. Traditional strength training programs and plyometric training, performed separately or in combination, are the most used methods to improve conditional aspects of basketball (Izquierdo., 2022).

Basketball is one of the most played sports at high school, university, professional and amateur levels. It combines acyclic actions and jumps during games, with high, medium and low intensities. For this reason, the power of the lower body in the vertical jumps used by athletes to gain offensive and defensive rebounds and make mid-distance and 3-point shots, are a fundamental part of the development of this sporting modality. Consequently, the plyometric training method can be decisive for increasing power levels in jumping capacity during competition (Martínez et al., 2020).

Plyometrics consists of the rapid stretching of a muscle with an eccentric action immediately followed by a concentric or shortening action of the same muscle and connective tissue. This training method is used to increase strength and explosiveness. It includes a wide range of jumps, jumps and bilateral and unilateral jumps. This program constitutes an effective training solution to improve different skills related to the power of the lower limbs (Pardos et al., 2021).

It can be recommended as an optimal form of physical conditioning to improve vertical jumps and sprints in young athletes. In addition, it must be considered which the most appropriate plyometric training for each age range is. And to do so, we can rely on movement patterns, technique, volume, frequency, intensity, and required energy systems (Falces et al., 2021).

In both types of jumps, positive correlations were found between APP and VJ, RPP and VJ, as well as between APP and RPP. The results obtained by the SSTG in CMJ and SJ were an interesting training alternative to develop greater APP and RPP also among young athletes. Different plyometric training methods should be tested, with less impact on the ground to obtain greater results in VJ with lower RPE and DOMS responses to prevent injuries among young athletes (Fonseca et al., 2022).

Various investigations have examined the variables of force application, power, speed and displacement of the center of mass related to increases in jump height. Likewise, previous research demonstrated that a similar jump height could be achieved through different combinations of these biomechanical variables in the vertical jump. Knowledge of imbalances in the biomechanical variables that explain vertical jump performance could be important for the individualization of training. It is also necessary to understand the effects of different training methods on the mechanics of the vertical jump (Sánchez-Sixto et al., 2017).

Plyometric training (PT) is a type of strength training widely used in team and individual sports to improve sport-specific performance. Plyometric exercises have been shown to be an effective method of improving a number of physical qualities, such as strength and jump height, running economy, agility, running speed and endurance. The exercises involved in PT are characterized by explosive muscle extension and contraction. These specific exercises consist of three phases: (1) the pre-activation phase (eccentric phase); (2) the amortization phase (isometric phase); and (3) the shortening phase (concentric phase) (Ramírez – de la Cruz et al., 2022).

Vertical jumping ability is a determining variable in sports performance, required in most of its technical gestures. The explosive movements and vertical jumps associated with countermovements are intended to generate the power necessary to overcome the opponent, so these skills should be encouraged before training or competition. General physical performance, vertical jump, lower extremity strength and power improve with chronological age (Mancilla et al., 2023).

The objective of the study was to evaluate the effects of a plyometric training program on the muscular power of girls practicing basketball. The participants were subdivided according to the degree of maturation into: control group (CG=48 with degree of maturation 2=11; 3=19; 4=19) and work group (GT=30 with degree of maturation 2= 10; 3=10; 4=10). Both groups performed 3 weekly basketball training sessions, adding 3 sessions of plyometric exercises to GT that included zigzag, linear and depth jumps. For the pre- and post-training evaluation, the Squat Jump, Movement Jumps, Drop Jump and Abalakov tests were used. The statistical T-student test for significance pre and post training ($p < 0.05$) and also the analysis of the magnitude of the effect were used (Vilela et al., 2021).

Plyometrics is a type of training that consists of performing exercises designed to increase the intensity, power and

speed in the muscles that make up the lower body, through muscle contraction and stretching. Plyometric exercises are known for being explosive actions performed in short periods of time, which combine strength with speed. This type of exercises involve a rapid transition in the muscular state, from a concentric to an eccentric contraction and consequently inducing neuromuscular changes that facilitate and improve the power and speed of congruent movement structures (Soto., 2023).

Many jumping interventions have been performed in children and adolescents in order to improve bone-related variables and thus ensure healthy bone development during these periods and later in life. This systematic review aims to summarize and update current knowledge on the effects that jumping interventions can have on mass, structure and metabolism. Jump interventions during childhood and adolescence improve bone mineral content, density, and structural properties without side effects (Gómez-Bruton et al., 2017).

Short plyometric training sessions as part of the strength and conditioning program were found to improve VJ performance in basketball players. Based on the studies reviewed, five limitations associated with the testing protocols and strength and conditioning programs used in the studies were described. They included the use of multiple testing protocols and the lack of experimental studies. Three recommendations were suggested for basketball and strength and conditioning coaches, one of which was to include plyometric training in the annual training program (Ziv et al., 2010).

Individualized training regarding the difference with their optimal strength-speed profile has been shown to be a useful tool that improves vertical jump performance by adapting the type of loads according to the player's needs. This will allow us to carry out much more efficient training, optimizing work time to the maximum in addition to being an evaluation method that allows us to control the long-term process of athletes (Ramos et al., 2022).

Explosive power is considered an important factor in competitive events. Therefore, strategies such as complex training (CT) and plyometric training (PLT) are effective in improving explosive power. However, it is still unclear which of the two strategies can allow greater improvements in explosive power. Additionally, more than 10 weeks of training may be more beneficial for power improvement. (Wang et al., 2023).

Plyometric training is an effective method to prevent injuries in female athletes. It is an effective form of training to improve performance in female athletes. The benefits of plyometric training on performance are greater for longer duration interventions over a 10-week period. The study revealed that plyometric training likely had a moderate effect on jump height performance (Stojanović et al., 2017).

Basketball is an athletic court game sport played by five players from two sports teams each. Therefore, the objective of this study is aimed at measuring the potential impact of combining plyometric exercises and Pilates along with the effectiveness of these exercise regimens individually in increasing vertical jump performance in basketball players (Chouhan et al. , 2022).

## METHODOLOGY

The study will have a quantitative methodology since data will be collected to help us numerically verify the results of this study, and reach conclusions about the quality of the exercise program. It is longitudinal in nature since we will analyze the data collected at the beginning and at the end of the execution of the study in our population. It will help verify the changes achieved with the plyometric exercise program used. 16 girls of an age range of 10-12 years will participate, for a period of 16 weeks. There will be 2 sessions per week.

The first two weeks will be dedicated to the evaluation using the medical history, signing of informed consent, and My Jump 2 jumping software. The following 12 weeks will be used to carry out the plyometric exercise program, and the last 2 weeks will be dedicated to carry out a final evaluation.

The study will be non-probabilistic for convenience. It belongs to the line of research: interventions, techniques and treatment protocols.

### Research location

The research project was developed in the Isabel de Godín Educational Unit, which is located in the city of Riobamba, province of Chimborazo.

### Population

The population will be 16 female participants from the under-12 basketball team. They are part of the "Isabel de Godín Educational Unit".

**Data collection**

The research project was carried out in a period of 16 weeks, in which a plyometric exercise program will be applied, working in 2 sessions per week, in times of 1 hour per session. It will begin by applying the clinical history of each one of the under-12 female basketball players.

**Inclusion criteria**

- Female participants aged 10 to 12 years.
- Participants of any type of ethnicity (indigenous, mestizos, Afro-Ecuadorian).

**Exclusion criteria**

- Participants who present some type of injury or surgery, at the musculoskeletal level, of lower limbs in the last six months to a year.
- History of pathological illness, which makes it impossible to perform any type of physical effort.
- Participants who present joint pathologies, bone contusion, chondral lesions or others that prevent individual participation.

**Use of techniques and instruments**

Later in the third week, work will be carried out by carrying out the initial evaluation of each of the basketball players, applying the **My Jump 2 Software**. It is a practical, revolutionary and scientifically validated application to measure vertical jump performance. It´s the only one to include the optimal force-velocity profile that we recently validated. It was scientifically validated with a professional force platform and the results were published in the prestigious Journal of Sports Sciences. My Jump showed good validity for CMJ height ($r= 0.995$, $p< 0.001$). The results of the present study showed that CMJ height can be assessed easily, accurately and reliably using a specially developed Android system application (Balsalobre et al., 2015).

From the fourth week, until the fifteenth week, the plyometric exercise program will be applied, with each of the basketball players in 10-minute periods for each exercise to be worked on.

In week sixteen, the final evaluations will be carried out, through the application of the aforementioned software, to check if there were significant changes with the initial evaluations.

**Data analysis plan**

The statistical data software SPSS will be used as a work tool, which provides researchers with the ability to consult data, quickly formulate hypotheses and execute procedures to clarify the relationships between variables.

**Materials**

1. My Jump 2 Software. Use your device's high-speed camera to record slow-motion videos of your jumps. Then, you just have to select the takeoff and contact images and My Jump 2 will give you an accurate, valid and reliable vertical jump value, just like force or infrared platforms do. In addition, it calculates the force, speed and power profile of the jumps, as well as other important variables such as contact time, stiffness or the reactive force index in a simple but precise way.
2. Aurik brand tubular training leagues. They are a fragment of latex, shaped like a cord that incorporates handles at the ends, with an approximate length of two meters or more, although they can be found in different sizes depending on the needs of each athlete.
3. Stanley brand tape measure. Measuring instrument formed by a thin flexible and self-rolling metal tape.
4. Camry brand Digital Scale. Indicates the weight in pounds or kilos and has automatic ignition when you step on the scale.

**What procedures or activities must be carried out or will be carried out in the investigation**

- The individual will participate freely and voluntarily in the intervention, in the first and second week data will be collected through the medical history.
- Later in the third week, work will be carried out by carrying out the initial evaluation of each of the basketball players, applying the Salto My Jump 2 software, to evaluate the power of the lower limbs. The vertical jump test is used to measure muscle power in the lower body. This procedure describes the method used to measure vertical jump height directly.

- My Jump 2 Jump Software procedure. The operation is simple, we simply record a jump with the app, select the images of the takeoff and landing of the jump and automatically (using algorithms) the height of the vertical jump is calculated (from the time of flight), in addition to the levels of strength, power and speed. The results of the present study show that the My Jump 2 application is a valid and reliable tool for evaluating drop jump performance (Haynes et al., 2019).
- From the fourth week, until the fifteenth week, the plyometric exercise program will be applied, with each of the under 12 female participants, in periods of 10 minutes for each exercise to be worked on.

In week sixteen, the final evaluations will be carried out, by applying the aforementioned test, to check if there were significant changes with the initial evaluations.

**Exercises**: Squat Jump (SJ). Jumping without countermovement is executed starting from a semi-flexed position, with a 90° angle at the knee joint, which is maintained for four seconds. From this position, the participant jumps vertically trying to reach the highest possible height, without making any type of movement. It is recommended to perform the SJ keeping both hands at hip level and the trunk as straight as possible.

1. Starting position: Bend your knees at a 90° angle; The hands, hips and trunk must be placed vertically. Added impulses from the upper extremities and trunk must be avoided.

2. Execution: One participant is evaluated at a time, 2 attempts of 2 jumps are executed in a row per athlete, with a 3-minute pause between each one.

Six series were performed per session, with 5 repetitions and 1 minute of rest between each series.

Countermovement Jump (CMJ). The participant must stand, then begins the gesture by performing a preparatory counter-movement with which she descends until reaching the same initial position of the Squat Jump. From this position, the direction of the movement is reversed to perform a jump with the greatest possible force. taking advantage of the enhancing effect due to the active lengthening of the thigh extensor muscles.

1.Initial position: Standing with your hands on your waist and your trunk vertical.

2. Execution: From this position, rapid flexion-extension of the knees is performed, to perform a vertical jump as high as possible, keeping the hands on the hips and the trunk vertical.

Five series were performed per session, with 3 repetitions and 2 minutes of rest between each series. Drop Jump (DJ) Jump with a previous fall, consists of performing a jump immediately after falling from a certain height

1. Starting position: Standing at a height of 10, 20, 30, 40, 50 centimeters, according to the capacity of each participant.

2. Execution: Take a step forward, letting yourself fall, then land and perform a vertical jump with as much force as possible.

Three series were performed per session, with 5 repetitions, at a height of 40 cm. 1 minute rest between each series.

**Statistical analysis**

The SPSS program version 29.0 was used. The results were expressed in tables with frequencies and percentages. The statistical normality test was carried out to certify the normality of the variables, for which the Shapiro-Wilk test was used, which corresponds to small samples less than 30, the Wilcoxon test was selected, a non-parametric test for quantitative variables that do not They present a normal distribution, to compare a before and after of related samples, where the asymptotic significance must be $p<0.005$. With this result, the null hypothesis is rejected.

**Bioethical Considerations**

This project has the approval of the "Ethics Committee for Research on Human Beings of the Faculty of Health Sciences, Technical University of Ambato", with the code 020-CEISH-UTA-2023. This research is approved and complies with the ethical, methodological and legal requirements. The methodology was socialized and the informed consent was signed. It detailed the research process.

## RESULTS AND DISCUSSION

Once the intervention has been carried out and the final data of the tests applied have been collected, the results obtained are the following:

**Table 1.** Sociodemographic characteristics of the under 12 female participants of the "Isabel de Godín Educational Unit"

| Variable | | Frequency | Percentage (%) |
|---|---|---|---|
| Age | 11 | 10 | 62.5 |
| | 12 | 6 | 37.5 |
| | **Total** | 16 | 100 |

**Note**. Own elaboration with the research data (2023)

The study was carried out on 16 participants. The minimum age was 11 years and the maximum 12. They are distributed by age ranges: from 11 to 12 years. In the 11-year-old range, 10 girls were found, representing 62.5%, and in the 12-year-old range, 6 girls were found, representing 37.5%.

**Table 2**. Weight Kilograms (kg)

| Variable (Kg) | Frequency | Percentage (%) |
|---|---|---|
| 31 | 4 | 25.0 |
| 32 | 2 | 12.5 |
| 33 | 4 | 25.0 |
| 41 | 2 | 12.5 |
| 42 | 2 | 12.5 |
| 43 | 2 | 12.5 |
| **Total** | 16 | 100 |

**Note**. Own elaboration with the research data (2023)

According to the weight in Table 2, four (4) of the participants were found with 31 (kg) being 25.0%, 2 participants were found with 32 (kg) representing 12.5%, 4 participants were found with 33 (kg) representing 25.0%, 2 participants were found with a weight of 41 (kg) being this 12.5%, 2 participants were found with a weight of 42 (kg) being this 12.5%, 2 participants were found with a weight of 43 (kg) being this 12.5%.

**Table 3**. Size in centimeters (cm)

| Variable (cm) | Frequency | Percentage (%) |
|---|---|---|
| 140 | 2 | 12.5 |
| 143 | 7 | 43.8 |
| 145 | 2 | 12.5 |
| 146 | 3 | 18.8 |
| 150 | 1 | 6.3 |
| 152 | 1 | 6.3 |
| **Total** | 16 | 100 |

**Note**. Own elaboration with the research data (2023)

According to Table 3, the height in (cm) of two (2) of the participants were found with a height of 1.40, this being 12.5%, 7 participants were found with a height of 1.43, this being 43.8%, 2 participants were found with a height of 1.45, this being 12.5%, 3 participants were found with a height of 1.43, this being 18.8%, 1 participant was found with a height of 1.50, this being 6.3%, and 1 participant was found with a height of 1.52, this being 6.3%.

**Table 4**. Jump Height (cm) Pre and Post Test in under 12 female basketball players

| Jump height qualifier | Initial jump rating | | Final jump rating | |
|---|---|---|---|---|
| | Frequency | Percentage (%) | Frequency | Percentage (%) |
| Above Average = 41-50 | | | 5 | 31.3 |
| Average = 31-40 | 5 | 31.3 | 10 | 62.5 |
| Below Average = 21-30 | 9 | 56.3 | 1 | 6.3 |
| Poor = 11-20 | 2 | 12.5 | | |
| **Total** | 16 | 100.0 | 16 | 100.0 |

**Note**. Own elaboration with the research data (2023)

The results obtained in the pre-Test were the following: 5 participants were in the average indicator which represented 31.3%, 9 participants were in the indicator below the average which represented 56.3%, and 2 participants They were found in the poor indicator which represented 12.5%.

The results obtained in the post-Test were the following: 5 participants were in the indicator above the average which represented 31.3%, 10 participants were located in the average indicator which represented 62.5%, and 1 participant was found in the indicator below the average which represented 6.3%.

**Table 5.** Normality tests

| | Kolmogorov-Smirnova | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | **Statistical** | **df** | **Next.** | **Statistical** | **df** | **Next.** |
| **Initial Jump Height(cm)** | ,300 | 16 | ,000 | .794 | 16 | .002 |
| **Final Jump Height(cm)** | .355 | 16 | ,000 | .746 | 16 | .001 |

**Note**. Own elaboration with the research data (2023)

**Table 6.** Hypothesis testing test: My Jump 2 software (for jump height interpretation)

| **Test statistics** | |
|---|---|
| | **FinalJumpHeight - InitialJumpHeight** |
| **Z** | -3,900b |
| **Asymptotic sig. (bilateral)** | ,000 |

a. Wilcoxon signed rank test
b. It is based on negative ranges.

**Note**. Own elaboration with the research data (2023)

The hypothesis testing test was carried out through the Wilcoxon ranges at a significance level of 5%, where the probability values corresponded to p= 0.000, with which the null hypothesis is rejected. That is, the program was Effective to improve the jumping height of the lower limbs.

In sports, training through plyometric exercises for under-12 girls' categories who practice basketball, different studies show that it is essential to increase power in jumping capacity. In the present research work it was evident that after the initial evaluations developed, they presented an increase in the power of the jumping ability of the lower limbs.

In relation to the research of (Khlifa R et al., 2018), the purpose of it was to examine the effect of a plyometric training protocol with or without added load on the improvement of vertical jump capacity in basketball players. Twenty-seven players were randomly assigned to 3 groups: a control group (no plyometric training), a plyometric training group (PG), and a loading plyometric group. Before and after the 10-week training program, all athletes were tested for the 5-jump test (5JT), squat jump (SJ), and countermovement jump (CMJ). The PG and LPG groups performed 2 and 3 training sessions per week, during the first 3 and the last 7 weeks, respectively. The results showed that SJ, CMJ and 5JT demonstrated significant improvement, only in the PG and LPG groups. The best effects for jumps were observed in LPG ($p < 0.01$), which showed significantly greater differences than PG ($p < 0.05$). In conclusion, loads added to the plyometric training program can result in increased vertical and horizontal jump performance in basketball players.

The exercise program was carried out over a period of 16 weeks, with 16 girls in the under-12 basketball category. In the article by (Ramírez et al., 2022). 32 studies were included, with a total of 818 basketball players. Significant ($p < 0.05$) small to large effects of PJT were evident in vertical jump power (ES = 0.45), countermovement jump height with (ES = 1.24) and without arm swing (ES = 0.88), squat jump height (ES = 0.80), drop jump height (ES = 0.53), horizontal jump distance (ES = 0.65), linear sprint time at distances ≤10 m (ES = 1.67) and >10 m (ES = 0.92), change of direction execution time at distances ≤40 m (ES = 1.15) and >40 m (ES = 1.02), dynamic balance ( ES = 1.16) and static (ES = 1.48) and maximum force (ES = 0.57).

The program had 3 stages, each with its respective exercises, which are easy for the participants to perform. The materials used were a wooden box, measuring tape, digital scale, stopwatch, and training bands. The exercises were described in a simple way and are easy to perform. The research results highlight the great usefulness of performing the exercises, they are considered very beneficial for improving power and jumping. It is important to mention that the execution and progression of exercises, through series and repetitions appropriately, contribute to improving power and jumping.

The software used in this research in the pre-test and post-test in the female participants showed a significant change. After the intervention of the exercise program, the post test was carried out where great progress was evident in the participants. The SPSS Statistics 22 program was used. The Wilcoxon method was used for the initial and final comparison in power and jump, a value of 0.000 which confirmed that there was a significant change, increasing the power and jump of the lower limbs.

(Bogataj Š et al., 2020). In their research, high reliability (ICC > 0.89) could be observed for all intermediate conditions of all measures. Very large correlations were observed in the total sample between My Jump 2 app and OptoJump for SJ (r = 0.97, p = 0.001), CMJ (r = 0.97, p = 0.001). The Bland and Altman plot depicting the limits of agreement for the entire My Jump 2 sample shows that most data points fall within the 95% CIs. The results of this study suggest that the My Jump 2 application is a valid, reliable and useful tool for measuring jumping performance in primary school children.

## CONCLUSIONS

According to the results obtained that verify the effectiveness of the research, it was concluded that the plyometric exercise program helped increase the power in jumping capacity in under-12 basketball players. The exercises are simple and were performed by the athletes without any inconvenience.

### Main limitations of the study and future research

Although the study demonstrates the efficacy of a plyometric exercise program in improving the jumping ability of U-12 female basketball players, several limitations deserve consideration. First, the relatively small sample size of 16 participants from a single educational unit in the city of Riobamba may limit the generalizability of the findings to a broader population of athletes. In addition, the duration and frequency of the study intervention, conducted twice a week, may not capture long-term effects or optimal training protocols for sustained improvement. Furthermore, relying on the My Jump 2 software for assessment, while providing objective data, may overlook other important performance metrics or qualitative aspects of jumping ability. Future research could address these limitations by conducting multicenter studies with larger and more diverse participant samples, exploring varied durations and frequencies of intervention, and incorporating comprehensive assessments to provide a more nuanced understanding of plyometric training outcomes in young athletes.

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## Contribution of each author to the manuscript:

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