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Original Article

# Enhancing Lower Body Strength Through Plyometric Training: a Twelve-Week Study on University Students

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**Abstract**

In this study, we aim to investigate the effects of a 12-week plyometric training program on lower body strength development in university students. By examining the outcomes of this training intervention on measures such as jump height, force production, and neuromuscular recruitment capacity, we seek to provide valuable insights into the efficacy of plyometrics as a training modality for enhancing athletic performance and strength development among young adults. Subjects under research were 12 students - boys in the 2nd academic, which included in a trial group, aged between 19- 20 years, selected voluntarily. Each lesson took between 50-75 minutes, three days a week. The results show that the subjects improved in height and force of the jump scores, having a value comprised between 2,23 and 2,98%. Through this research we shown that if we use plyometric training, we can develop lower body strength.

## 1. Introduction

Plyometric training has garnered substantial attention in sports science for its effectiveness in enhancing athletic performance, particularly in developing lower body strength and power. Defined as exercises that involve explosive movements, plyometrics utilize the stretch-shortening cycle of muscle contractions, (Carvalho, Mourão, & Abade, 2014) which facilitate improvements in speed, strength, and overall physical performance. A muscle can produce more contractile force when the muscle is optimally stretched before the desired movement (Whitehead, Scheett, McGuigan, & Martin, 2018; Bosco, Komi, & Ito, 1981; Bosco, & Viitasalo, 1982).

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Individuals engaged in sports of various ages gain advantages from plyometric conditioning (Faigenbaum et al., 2007; Sayers, & Gibson, 2010; Ingle, Sleap, & Tolfrey, 2006). Lower-body plyometric conditioning comprises three stages within each action: eccentric muscle engagement, amortization, and concentric muscle engagement. Common plyometric activities encompass jumps in place, standing leaps, repeated hops and jumps, bounding, box drills, and depth jumps. Isotonic resistance conditioning generally employs alternating phases of eccentric and concentric muscle actions to induce joint movement and shift weights as a training stimulus (Butnariu, 2012; Haff, & Tripplet, 2016).

Research on plyometric training has demonstrated its efficacy in developing lower body strength, agility, and athletic performance across a diverse range of populations, including athletes, fitness enthusiasts, and rehabilitation patients. Numerous studies have shown that incorporating plyometric exercises into training programs can result in significant gains in muscular power, jump height, sprint speed, and overall sports performance (Oxfeldt, Overgaard, Hvid, & Dalgas 2019; Cojanu, &Visan, 2017).

Moreover, plyometric training has been found to be particularly beneficial for improving the explosive capabilities of fast-twitch muscle fibers, which play a crucial role in activities requiring rapid and forceful movements. (De Villarreal, Requena, & Newton, 2010) By targeting these specific muscle fibers through plyometric exercises, athletes can enhance their ability to generate high levels of power and speed, ultimately translating into improved performance on the field, track, or court.

Workforce development is an essential goal of any sports training. (Grosu, Popovici, & Mihaiu 2010). Plyometrics is a well-known concept and practiced by many coaches and trainers. Plyometric training has been shown to be one of the most effective methods for improving explosive power (Fleck, & Kraemer, 2004).

These findings underscore the importance of plyometric training as an effective strategy for enhancing lower body strength in various populations, particularly within the context of university students who may be seeking to improve their athletic performance or participate in recreational sports.

## 2. Material and methods

The research used the next *methods*: measurement and testing method, educational experiment, statistical - mathematical method of data processing, comparative analysis and graphical method.

Following the special field of interest conclusions, we have selected control tests that can underline the structure and content of the training level of the students tested all the way through our research. Inside our experiment and in order to evaluate the strength implied the selection of 6 trials, out of which 6 asked for the Kistler Quatro Jump Bosco Protocol Version 1.0.9.2. measurement platform, enabling us to appreciate the training level of the trial group members.

Six samples were selected to assess muscle training: Jump height in Squat Jump (hSJ) (jump starting the squat - bending ½) , Jump height in Squat Jump height with additional weight, body weight (hSJbw), Countermovement Jump (CMJ), Bent Leg Jump Continuous Reference (CJbref) Continous Jump Straight Legs (CJs) and Continous Jump Bent Legs (CJb 30s) for the lower body through which we evaluated the level of training and progress of the experimental groups according to the means used in the preparation.

The 6 tests effectuated offered us data both with regards to the height and force of the jump as to the neuro-motric recruitment capacity (rapid fibers), voluntary effort, tiredness, lateness effect or muscular elasticity.

The data was analysed with the help of the Microsoft Excel, 2003.

The t (Student test) was used in our research to determine the significance of the averages; the test was compared with the t value from Ficher's table at the 0.05 level of significance, as well as to that of 0,01 and 0,001, with the freedom degrees equal to n.

*Purpose of the study*. This research is aimed to increase lower body strength using plyometric training for the students of Faculty of Physical Education and Sport.

*The research hypothesis*. The implementation of plyometric exercises in student training will result in notable improvements in lower body strength development, thereby creating the foundation for a more advanced training approach relative to standard techniques.

*The content and methodology of force training through programs based on plyometrics exercises*

The academic experiment conducted during 12 weeks consisted in the application of plyometric programs based on plyometric exercises; the subjects were 12 students of Polyethnic Bucharest, Pitesti University Center included in an trial group. The most central aspect of muscular training was represented by the exercise selection, as by the elaboration of the training programs.

The plyometric training per session varied in between 50 and 75 minutes, function of the preparation period. The plyometric training began with a 5–10 minute warm-up, increasing intensity. Then followed the strength development exercises for 40-45 minutes in order to increase intensity and the ending was represented by 5 minutes stretching exercise. The in between series pause was of 30-45 seconds, respectively of 1-2 days.

## 3. Results and Discussions

*Bosco Protocol* can evaluate the components: tests exclusivities, non-plyometric (SJ and SJbw) and plyometric expansion (CMJ) tests the power of the thigh (CJbref), (CJB) reactivity tests (CJs) and measurement alactacide anaerobic capacity (CJb 30s) and data on neuromotor recruitment capacity (fast fibers), volunteer effort, fatigue, stretching or muscle elasticity as is shown in table 1 and 2.

**Table 1.** *Evolution of the jump height and force of the jump factor in initial-final testing*

| Nr. | NAME | hSJ | | hSJbw | | hCMJ | |
|---|---|---|---|---|---|---|---|
| | | TI | TF | TI | TF | TI | TF |
| 1. | B.A. | 37.4 | 41.8 | 14.2 | 17.0 | 38.6 | 42.7 |
| 2. | C.H. | 38.3 | 41.6 | 12.9 | 13.4 | 39.8 | 42.0 |
| 3. | T.D. | 38.9 | 41.8 | 14.8 | 16.3 | 41.9 | 43.8 |
| 4. | B.I. | 43.2 | 47.9 | 17.3 | 20.0 | 45.0 | 48.9 |
| 5. | U.A | 36.0 | 40.8 | 14.5 | 18.2 | 38.0 | 42.3 |
| 6. | P.C. | 41.7 | 46.6 | 15.2 | 16.5 | 43.9 | 48.0 |
| 7. | A.I. | 39.8 | 41.0 | 15.1 | 15.5 | 42.8 | 43.5 |
| 8. | P.L. | 36.1 | 38.2 | 14.0 | 15.3 | 37.7 | 39.3 |
| 9. | L.A. | 45.5 | 49.3 | 18.2 | 21.7 | 47.0 | 51.9 |
| 10. | G.V. | 46.0 | 47.4 | 15.6 | 17.0 | 48.1 | 50.2 |
| 11. | C.I. | 43.2 | 43.5 | 18.1 | 20.9 | 44.6 | 48.9 |
| 12. | D.R. | 43.7 | 45.4 | 18.2 | 19.6 | 45.3 | 47.0 |
| | Mediate - x | 40.81 | 43.77 | 15.67 | 17.61 | 42.72 | 45.70 |
| | Standard deviation - S | 3.53 | 3.45 | 1.82 | 2.5 | 3.53 | 3.92 |
| | CV % | 8.65 | 7.89 | 11.64 | 14.19 | 8.28 | 8.59 |
| | Calculated t -test | | 6,422 | | 6,042 | | 7,338 |
| | t critical<br>p=0.05= 2.179<br>p = 0.01=3.055<br>p=0.001=4.318 | | <0.001 | | <0.001 | | <0.001 |

**Table 2.** *Evolution of the jump height and force of the jump factor in initial-final testing*

| Nr. | NAME | hCJbref | | hCJs | | hCJb 30s | |
|---|---|---|---|---|---|---|---|
| | | TI | TF | TI | TF | TI | TF |
| 1. | B.A. | 36.9 | 39.1 | 33.1 | 35.5 | 28.2 | 30.3 |
| 2. | C.H. | 37.5 | 39.2 | 32.6 | 35.7 | 32.7 | 33.8 |
| 3. | T.D. | 37.9 | 39.4 | 40.0 | 42.5 | 30.9 | 32.6 |
| 4. | B.I. | 40.0 | 43.3 | 37.3 | 40.1 | 33.0 | 37.3 |
| 5. | U.A | 34.3 | 36.0 | 31.8 | 33.6 | 27.1 | 29.7 |
| 6. | P.C. | 39.4 | 41.8 | 37.4 | 40.0 | 30.8 | 33.9 |
| 7. | A.I. | 37.1 | 39.3 | 34.6 | 35.9 | 30.5 | 32.9 |
| 8. | P.L. | 33.5 | 34.6 | 32.8 | 35.0 | 27.1 | 29.8 |
| 9. | L.A. | 41.2 | 43.9 | 38.5 | 41.4 | 36.3 | 39.2 |
| 10. | G.V. | 45.1 | 47.5 | 39.3 | 42.5 | 36.4 | 39.0 |
| 11. | C.I. | 41.2 | 44.0 | 35.9 | 40.4 | 34.9 | 36.5 |
| 12. | D.R. | 37.4 | 40.1 | 44.7 | 46.9 | 33.7 | 35.9 |
| | Mediate - x | 38.45 | 40.68 | 36.5 | 39.12 | 31.8 | 34.24 |
| | Standard deviation - S | 3.17 | 3.61 | 3.80 | 3.98 | 3.26 | 3.37 |
| | CV % | 8.25 | 8.87 | 10.42 | 10.18 | 10.27 | 9.84 |
| | Calculated t -test | | 12,267 | | 11,364 | | 10,278 |
| | t critical<br>p=0.05= 2.179<br>p = 0.01=3.055<br>p=0.001=4.318 | | <0.001 | | <0.001 | | <0.001 |

*Jump height in Squat Jump* (hSJ) (jump starting the squat - bending ½) - During the experiment the group average hSJ indicator increase from 40.81 to 43.77 at the initial testing to final testing with a *significant difference* of 2.96, t critical = 4,318 <t calculated = 6.422, $p < 0.001$. Null hypothesis is rejected. Homogeneity of results remains very good, Cv = 8.65% to 7.89% at initial testing and final testing.

**Tabel 3.** *Comparative result analyze initial – final hSJ*

| $H_0$ Null hypothesis | $H_1$ Alternative hypothesis | α | df | t calculated | t critical |
|---|---|---|---|---|---|
| $m_1 = m_2$ | $m_1 \# m_2$ | 0.001 | 2,96 | 6,422 | 4,318 |
| critical t < t calculated. Statistically the two different test results significantly. This rejects null hypothesis and accepts alternative hypothesis. | | | | | |

*Jump height in Squat Jump height with additional weight, body weight* (hSJbw) - the group average hSJbw indicator increase from 15.67 to 17.61 in initial testing to final testing with a *significant difference* of 1.94, t critical = 4,318 <t calculated = 6.042**,** $p < 0.001$. The null hypothesis is rejected. Homogeneity of results remains very good, CV = 14.19% to 14.19% at initial testing and final testing.

**Tabel 4.** *Comparative result analyze initial – final hSJbw*

| $H_0$ Null hypothesis | $H_1$ Alternative hypothesis | α | df | t calculated | t critical |
|---|---|---|---|---|---|
| $m_1 = m_2$ | $m_1 \# m_2$ | 0.001 | 1,94 | **6,042** | **4,318** |
| critical t < t calculated. Statistically the two different test results significantly. This rejects null hypothesis and accepts alternative hypothesis. | | | | | |

*Jump height in the Counter Movement Jump* (hCMJ) (jump against movement) - this indicator averages increase from 42.72 to 45.70 in initial testing to final testing with a difference of 2.98 resulting in a *significant* change, t critical = 4,318> t calculated = 7.338, $p > 0.01$. Null hypothesis is rejected. Homogeneity of performance remains very good CV = 8.28% to 8.59% on initial testing and final testing.

**Tabel 5.** *Comparative result analyze initial – final hCMJ*

| $H_0$ Null hypothesis | $H_1$ Alternative hypothesis | α | df | t calculated | t critical |
|---|---|---|---|---|---|
| $m_1 = m_2$ | $m_1 \# m_2$ | 0.001 | 2,98 | **7,338** | **4,318** |
| critical t < t calculated. Statistically the two different test results significantly. This rejects null hypothesis and accepts alternative hypothesis. | | | | | |

*Jump height in Continuous Jump with Bent Legs Reference* (hCJbref) (jump with legs folded continuous reference) - this indicator averages increase from 38.45 to 40.68 in initial testing to final testing with a difference of 2.23 causing a *significant* change, t critical = 2.179 <t calculated = 12.267, $p < 0.001$. Null hypothesis is rejected. Homogeneity performance remains very good CV = 8.25% to 8.87% at initial testing and final testing.

**Tabel 6.** *Comparative result analyze initial – final hCJbref*

| $H_0$ Null hypothesis | $H_1$ Alternative hypothesis | α | df | t calculated | t critical |
|---|---|---|---|---|---|
| $m_1 = m_2$ | $m_1$ # $m_2$ | 0.001 | 2,23 | **2,638** | **2,179** |
| critical t < t calculated. Statistically the two different test results significantly. This rejects null hypothesis and accepts alternative hypothesis. | | | | | |

*Jump height in Continuous with Straight Legs (hCJs)* (jumping with legs stretched continued) involves evaluating muscle elasticity of leg extensors, jump technique and tolerance to spread the impact and amount of fibers. - rapid increase in this indicator averages from 36.5 to 39.12 in initial testing to final testing with a difference of 2.62 resulting in a *significant* change, t critical = 4.318> t calculated = 11.364**,** *p> 0.01*. Null hypothesis is rejected. Homogeneity performance remains good CV = 10.42% to 10.18% at initial testing and final testing.

**Tabel 7.** *Comparative result analyze initial – final hCJs*

| $H_0$ Null hypothesis | $H_1$ Alternative hypothesis | α | df | t calculated | t critical |
|---|---|---|---|---|---|
| $m_1 = m_2$ | $m_1$ # $m_2$ | 0.001 | 2,62 | **11,364** | **4,318** |
| critical t < t calculated. Statistically the two different test results significantly. This rejects null hypothesis and accepts alternative hypothesis. | | | | | |

*Jump height in ContinuousJump with Bent Legs (hCJb 30 sec)* (continuous jumping legs bent 30 sec) - this indicator averages increased from 31.8 to 34.24 at the initial testing to final testing with a difference of 2,44 resulting in a *significant* change, t critical = 4.318> t calculated = 10.278, p> 0.01 Null hypothesis is rejected. Homogeneity performance remains very good CV = 10.27% to 9.84% at initial testing and final testing.

**Tabel 8.** *Comparative result analyze initial – final hCJb 30 sec*

| $H_0$ Null hypothesis | $H_1$ Alternative hypothesis | α | df | t calculated | t critical |
|---|---|---|---|---|---|
| $m_1 = m_2$ | $m_1$ # $m_2$ | 0.001 | 2,44 | **10,278** | **4,318** |
| critical t < t calculated. Statistically the two different test results significantly. This rejects null hypothesis and accepts alternative hypothesis. | | | | | |

In figure no.1 is showed the dynamics for the evolution of height and force of the jump indicators.

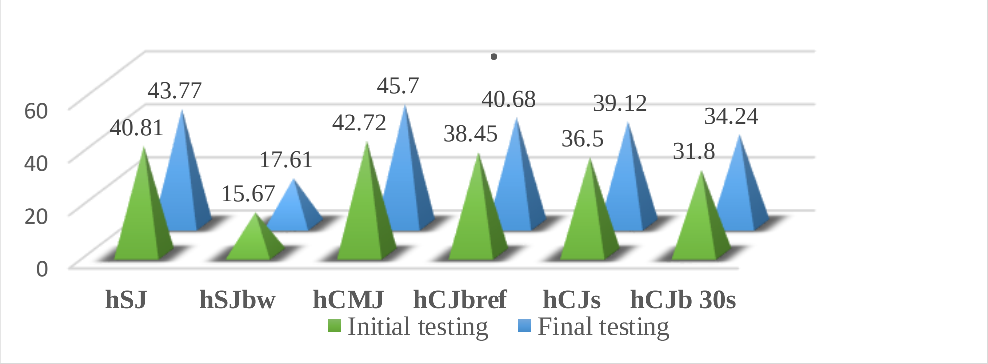


**Figure 1.** *Dynamics for the evolution of height and force of the jump indicators*

***Discussions***

Numerous studies have demonstrated the benefits of plyometric training in various populations. For instance, a meta-analysis (Potoupnis, Papadopoulos, & Tsarouhas, 2020) reviewed 23 studies and concluded that plyometric training significantly improves vertical jump height and overall athletic performance among athletes. The study emphasized that the incorporation of plyometric exercises in traditional strength training significantly enhances muscular power output.

Furthermore, the effects of different plyometric training regimens on athletic performance in university-level athletes, indicated that a structured plyometric program over a period of 8 to 12 weeks can lead to substantial improvements in lower body strength and explosiveness. Specifically, the study highlighted those exercises like depth jumps and bounding greatly contributed to increases in vertical jump performance and sprinting speed. (Markovic, & Mikulic, 2010).

In another study, the effects of a 12-week plyometric training program specifically targeting university students. Their results showed significant improvements in lower body strength measures, including squat strength and explosive jump distance, suggesting that even untrained individuals can harness the benefits of this dynamic training method. (Aranda, Jimenez, & Cuellar, 2021)

Unlike typical strength training exercises that involve long, slow movements designed to increase muscular strength and mass, plyometric exercises involve quick, explosive movements designed to increase speed and power. (Abernethy, Wilson, & Logan, 1995)

## 4. Conclusions

The Bosco Protocol applied on the force measurement platform:

- *The height of the Squat Jump* (hSJ) shows a significant difference of *2,96* (pre = 40,81, post = 43,77).

-*The height of the Squat Jump with additional weight, body weight* (hSJbw) shows a significant difference of 1.94 ( pre = 15.67, post = 17.61).

-The height of the *Counter Movement Jump* (hCMJ) (jump against movement) determines a significant change, with a difference of *2,98* (pre = 42.72, post = 45.70).

- The height of the *Continuous Jump with Bent Legs Reference (hCJbref)* (continuous jump with bent legs reference)- shows a significant difference of *2.23* (pre = 38.45, post = 40.68).

-The height of the *Continuous Jump with Straight Legs (hCJs)* **(**continuous jump with straight legs)- determines a significant change, with a difference of *2.62* (pre = 36.5, post = 39.12).

-The height of the *Continuous Jump with Bent Legs (hCJb30 sec)* (continuous jump with bent legs 30sec)- shows a significant difference of *2.44* (pre = 31.8, post = 34.24).

The null hypothesis is thus rejected and the alternative one is accepted.

Subjects who participated in our research for 12 weeks, and performed training sessions with plyometric exercises, have a significant increase in the height and force of jumping indices.

The study hypotheses are centred on elements belonging to the work hypotheses, which they confirm by means of the results obtained.

I predict this is the training method of the future.

Plyometric work should be done prior to any strength or hypertrophy training. For better balance, increased speed, and more agility, we recommend incorporating these fun and challenging plyometric exercises into your weekly workouts.

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