Volume - 14 | Issue - 10 | October - 2025 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

EFFECT OF PLYOMETRIC TRAINING ON LOWER LIMB MUSCLE STRENGTH AND AGILITY AMONG MALE RECREATIONAL LONG JUMP ATHLETES

Physiotherapy & Rehabilitation

Adlakonda Susmitha M.P.T. Sports, SVIMS College Of Physiotherapy, Tirupati, Andhra Pradesh

Dr. A. Viswanath Reddy Associate Professor, SVIMS College Of Physiotherapy, Tirupati, Andhra Pradesh

Dr. K. Madhavi Professor & Principal, SVIMS College Of Physiotherapy, Tirupati, Andhra Pradesh

ABSTRACT

Background: The long jump is one of the most widely practised athletic events in the community. It involves moving the whole body from certain points by running, then jumping, floating in the air, and landing. They require muscle strength, endurance, speed, agility, and power. For upward repulsion, it requires lower limb muscle strength and the ability to move quickly and easily, which requires agility to improve jumping performance. This study primarily focuses on the effect of plyometric training on lower limb muscle strength and agility in male recreational long jump athletes. **Methodology:** An experimental study was conducted on 30 male recreational long jump athletes, aged 17-26 years, who were recruited via convenience sampling and underwent an 8-week intervention, 3 days a week. The isokinetic dynamometer for lower limb muscle strength and the Illinois agility test for agility were measured at baseline and after 8 weeks of intervention to assess lower limb muscle strength and agility. **Result:** After 8 weeks of training, the findings suggest that plyometric training has statistically significant improvement for both lower limb muscle strength and agility, with a p-value of (p=0.00). **Conclusion:** This study concludes that plyometric training has shown significant improvement in lower limb muscle strength and agility among male recreational long jump athletes.

KEYWORDS

long jump athletes, lower limb muscle strength, agility, plyometric training, isokinetic dynamometer, Illinois agility test.

INTRODUCTION

The long jump is a widely practised athletic sport involving running, take-off, flight, and landing[1]. It requires coordinated leg lift and propulsion from one leg to maximise distance, relying on speed, strength, and agility[2,3]. However, injury risk is high, with 98 of 156 athletes affected and an overall injury rate of 62.8%, which may disrupt training and shorten athletic careers[4].

Performance in long jump is divided into four phases: prefix (run-up), repulsion (take-off), drift (flight), and landing[5]. Horizontal speed generated during the prefix provides momentum for the upward force at take-off[6]. Jump distance is measured from take-off to the closest body contact in the sand[7,8]. Techniques include squat, hang, and hitch-kick styles, with strategies such as air walking, floating, or hanging[9]. Lower limb muscle strength is critical for take-off, while imbalances may impair performance or cause injuries. Plyometric and ladder drills are effective for strength enhancement[10,11].

Plyometrics, first developed in Russia and Eastern Europe and introduced in 1975[12], improve strength and explosiveness in various sports[13]. They utilise the stretch–shortening cycle (SSC), where eccentric muscle loading is followed by concentric contraction[14]. The eccentric phase, or countermovement, occurs during loading[15], followed by the concentric rebound or propulsion phase[12]. Exercises include jumps, hops, bounds, throws, and kicks, adaptable from low- to high-intensity drills[16,17].

When combined with strength programs, plyometrics enhance acceleration, vertical jump, leg strength, proprioception, and power[18]. They also improve agility, defined as the ability to move quickly and easily[19], through drills requiring rapid starts, stops, and directional changes[20]. Furthermore, plyometric training reduces injury risk and benefits both athletes and untrained individuals, including youth[16].

MATERIALS AND METHODOLOGY

An informal experimental study was conducted at SVIMS College of Physiotherapy, Tirupati, with ethical approval (IEC No. 1823, 16 April 2025). Thirty male recreational long jump athletes (17–26 years) meeting the inclusion criteria participated. Athletes with recent injuries, joint instability, orthopaedic, neurological, cardiothoracic, systemic conditions, or recent surgeries were excluded.

After obtaining informed consent, baseline measurements of lower limb muscle strength (isokinetic dynamometer) and agility (Illinois Agility Test) were recorded. Participants underwent concurrent training for 8 weeks (3 sessions/week). Then, after the training program, measurements of lower limb muscle strength and agility were recorded as post-test data.

Isokinetic Dynamometer [21]:

Thigh muscle strength was measured using an isokinetic dynamometer in isometric mode. After a detailed explanation of the test and a general warm-up period, athletes were seated with their hips at 90° flexion, and their trunks, hips, and thighs secured with straps. The device axis was aligned with the knee joint, and the lower limb was fixed at 65% of leg length. Gravitational correction and visual feedback were provided. Knee flexor and extensor strength were tested at 30°, 60°, and 90° ROM using multi-angle isometrics, with 15 seconds of rest between contractions.

Illinois Agility Test [22]:

Agility was tested in a 10 m × 5 m cone course. After warm-up and practice trials, athletes performed three timed trials, with 2–3 minutes rest between. Starting prone, they ran a set course touching cones at turns and finishing 10 m past the last cone; times were averaged.

STUDY PROTOCOL[23]:

Athletes in the group did a warm-up for 10 minutes, which included neck, shoulder, and trunk movements; lunges (forwards, side-to-side, and backwards); and stretching exercises of bilateral quadriceps, hamstrings, iliotibial band, and calf muscles. The training protocol is as follows for a period of 8 weeks, 3 days a week, with a duration of 35 to 50 minutes, including warm-up and cool-down.

In the **first week**, the session lasts 20 minutes and includes 135 jumps. The exercises are side-to-side ankle hops, jump and reach, and front cone hops. Each exercise is performed for 3 sets of 15 repetitions with 2 minutes of rest, at a low intensity.

In the **second week** (25 minutes, 180 jumps), the workout includes side-to-side ankle hops, standing long jump, lateral jump over a barrier, and double-leg hops. All is done for 3 sets of 15 repetitions with 2 minutes of rest, also at a low intensity.

In the **third week**, the duration increases to 30 minutes with 150 jumps. The session involves side-to-side ankle hops, standing long jump, lateral jump over a barrier, double-leg hops, and lateral cone hops. Each drill is performed for 2 sets of 15 repetitions with 3 minutes of rest, at a moderate intensity.

The **fourth week** follows the same plan as the third week (30 minutes, 150 jumps, moderate intensity).

In the **fifth week** (30 minutes, 150 jumps), the training includes diagonal cone hops, standing long jump with a lateral sprint, lateral cone hops, single-leg bounding, and single-leg lateral jumps. Each exercise is completed for 2 sets of 15 repetitions with 3 minutes of rest, at a moderate intensity.

In the **sixth week**, the session increases to 35 minutes and 180 jumps. The exercises are diagonal cone hops, standing long jump with lateral sprint, lateral cone hops, cone hops with a 180° turn, single-leg bounding, and single-leg lateral jumps. Each is performed for 2 sets of 15 repetitions with 3 minutes of rest, at a high intensity.

The **seventh week** repeats the sixth week's program with the same duration, number of jumps, exercises, and intensity.

Finally, in the **eighth week** (25 minutes, 150 jumps), the program includes diagonal cone hops, hexagon drill, cone hops with a change-of-direction sprint, double-leg hops, and single-leg lateral jumps. Each exercise is done for 2 sets of 15 repetitions with 3 minutes of rest, at a high intensity.

RESULTS

The data were entered into a Microsoft Excel spreadsheet, tabulated, and subjected to statistical analysis using SPSS software version 22. All the descriptive statistical data were presented in the form of mean and standard deviation, and graphically represented. Since the sample was normally distributed, a paired t-test was performed to compare the pre- and post-values to assess the training efficacy.

DEMOGRAPHIC DATA:

The demographic data was collected before the pre-test. It included age, height, weight, and BMI. The mean age was 22.73 ± 1.413 years, with a mean height of 168.07 ± 6.214 cm, weight of 63.43 ± 10.595 kg, and BMI of 22.33 ± 3.174

Table 1: Pre & Posttest Values Of Isometric Strength Of Knee Flexors And Extensors At 30°, 60°, And 90° ROM

ROM (°)	Muscle Group	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	Mean Difference	T Value	P Value
30°	Flexors	66.10 ± 2.057	80.53 ± 2.300	14.433	-116.443	0.00
30°	Extensors	118.33 ± 2.18	139.17 ± 2.705	20.833	-163.262	0.00
60°	Flexors	70.27 ± 2.067	85.30 ± 2.020	15.033	-198.968	0.00
60°	Extensors	123.03 ± 2.593	146.20 ± 2.929	23.167	-214.306	0.00
90°	Flexors	67.47 ± 1.676	81.83 ± 1.895	14.367	-141.514	0.00
90°	Extensors	119.57 ± 2.515	139.17 ± 2.817	19.600	-159.121	0.00

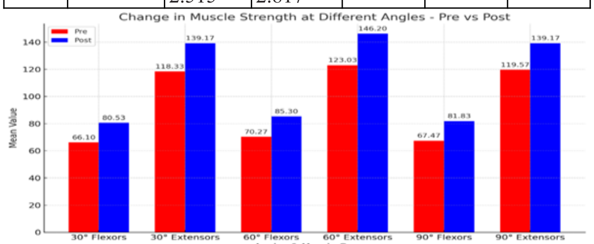

Figure 1: Graphical representation of pre- and posttest values of isometric strength of knee flexors and extensors at 30°, 60°, and 90° ROM

The pre-test mean values of isometric muscle strength of knee flexors at 30°,60°, and 90° were 66.10 ± 2.057, 70.27 ± 2.067, and 67.47 ± 1.676, and the post-test mean values were 80.53 ± 2.300, 85.30 ± 2.020, and 81.83 ± 1.895 with mean differences of 14.433, 15.033, and 14.367.

The pre-test mean values of isometric muscle strength of knee extensors at 30°,60°, and 90° were 118.33 ± 2.18, 123.03 ± 2.593, and 119.57± 2.515, and the post-test mean values were 139.17±2.705, 139.17±2.705 and 139.17 ±2.817 with mean differences of 20.833, 23.167, and 19.600.

The paired t-test revealed t-values of -116.443, -198.968, and -141.514 for flexors and -163.262, -214.306, and -159.121 for extensors, both with p-values of 0.00, indicating highly statistically significant improvements in muscle strength due to the intervention.

Table- 2: - Pre & Posttest Values Of Agility In Seconds

VARIABLE	PRE VALUES (MEAN ± SD)	POST VALUES (MEAN ± SD)	MEAN DIFFERENCE	T VALUE	P VALUE
AGILITY	17.660 ± 0.267	16.340 ± 0.281	1.320	94.990	0.00

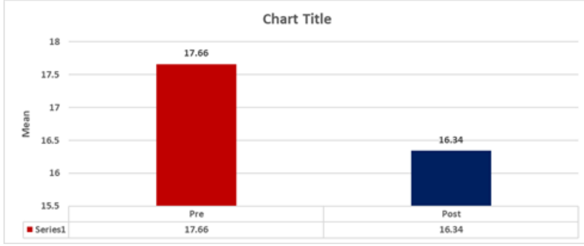

Figure 2: Graphical Representation Of Pre- And Post-test Values Of Agility In Seconds.

Agility improved significantly from 17.66 ± 0.27 s to 16.34 ± 0.28 s (mean difference 1.32, t = 94.99, p = 0.00). Before the intervention, no significant differences were observed in agility or isometric lower limb strength, but both showed significant post-intervention gains (p = 0.00).

DISCUSSION:

This study aimed to determine the effect of plyometric training on lower limb muscle strength and agility among male recreational long jump athletes. This study included the athlete's age, height, weight, and BMI. 70% of athletes were under normal BMI.

Markovic & Mikulic (2010) found that plyometric training enhances musculoskeletal and neural adaptations, increasing twitch peak torque, rate of torque, and maximal shortening velocity of muscle fibres, alongside whole muscle strength gains after ≥10 weeks of training [24,25]. These improvements are linked to neural mechanisms such as pre-activation and reflex facilitation during the stretch–shortening cycle (SSC) exercises [26]. Training also induces structural and functional changes, including altered knee extensor muscle architecture, tendon stiffness, and single-fibre mechanics [27]. Malisoux et al. (2010) reported a 12–13% improvement in leg extensor strength and power, with gains in force, fibre diameter, and shortening velocity [28]. SSC function, whether slow (>0.25s) or fast (<0.25s), benefits from pre-stretch mechanisms, which enhance concentric force output through elastic energy storage, potentiation, and reflex contributions [28, 29]. Elnaggar et al. confirmed significant quadriceps and hamstring strength gains in plyometric groups, attributing improvements to enhanced inter- and intra-muscle coordination [30]. Furthermore, plyometric training improved horizontal jump performance by 4.1% (range: 1.4–7.0%) across multiple studies in both athletes and non-athletes [31].

Plyometric training produced a statistically significant improvement in agility (p=0.00). Evidence from multiple studies supports this effect. Spurrs et al. reported consistent agility gains (+1.5–10.2%) across various agility tests, such as the T-test, Illinois test, and shuttle runs [32]. Agility, which involves rapid whole-body movement and direction change, benefits from plyometric training through reduced ground contact time, improved muscle force output, and greater movement efficiency [33]. Miller (2006) also found significant agility improvements in athletes following a 6-week plyometric program, likely due to neural adaptations and motor recruitment changes [19]. Mechanisms include increased muscle elasticity, joint mobility, faster muscle contraction, dynamic balance, and neuromuscular adaptations [34, 35]. Enhanced motor unit recruitment and improved coordination between CNS signals and proprioceptive feedback further explain agility gains [36].

Overall, the evidence presented in this research supports that plyometric training holds promise as an effective method to enhance agility and lower limb muscle strength among recreational male long jump athletes.

CONCLUSION

 PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

This study concludes that plyometric training is effective in improving lower limb muscle strength and agility in long jump athletes. Hence, the alternate hypothesis was accepted, and the null hypothesis was rejected.

LIMITATIONS AND RECOMMENDATIONS

Limitations

The study was limited by a small, male-only sample, a narrow age range, a single geographic location, and no long-term follow-up, restricting its generalizability to all long jump athletes.

Recommendations

Future research should include a larger, more diverse sample and explore these fitness components in athletes from other sports.

REFERENCES

1. Fraser BJ, Blizzard L, Tomkinson GR, Lycett K, Wake M, Burgner D, et al. The great leap backwards: changes in the jumping performance of Australian children aged 11–12 years between 1985 and 2015. J Sports Sci. 2019;37(7):748–54.
2. Yusutria, M. A Profesionalisme Guru Dalam Meningkatkan Kualitas Sumber Daya Manusia. Curricula: Journal of teaching and learning. 2017; 2(1).
3. Iswandi, F., & Purnomo, E. Hubungan Sprint Dan Daya Ledak Otot Tungkai Terhadap Hasil Lompat Jauh gaya jongkok. Jurnal pendidikan dan pembelajaran. 2013; 2(4).
4. Park J, Cheon W. Comparison of body composition, physical fitness, and knee joint isokinetic muscular function of middle school soccer players by grade. Kinesiology. 2020;5(2):21-9.
5. Michailidis, Y., Tabouris, A., & Metaxas, T. Effects of plyometric and directional training on physical fitness parameters in youth soccer players. International journal of sports physiology and performance. 2019;14(3): 392–398.
6. Stojanović, E., Ristić, V., McMaster, D. T., & Milanović, Z. Effect of plyometric training on vertical jump performance in female athletes: A systematic review and meta-analysis. Sports medicine. 2017; 47(5): 975–986.
7. Wakai, M., & Linthorne, N. P. Optimum take-off angle in the standing long jump. Human movement science. 2005; 24(1): 81–96.
8. Karcher, C., & Buchheit, M. Shooting performance and fly time in highly trained wing handball players: Not everything is as it seems. International journal of sports physiology and performance. 2017;12(3): 322–328.
9. Eddy Purnomo. Dasar-Dasar Gerak Atletik. Yogyakarta: Alfamedia; 2011.
10. Ihsan. N. The analysis of the physical condition will be conducted on the pencak silat construction training centre students (PPLP) of West Sumatra. International seminar of sport culture and achievement; 2014.
11. Jacobs, C, Uhl, T. L., Seeley, M, and Goodrich, L. Strength and fatigability of the dominant and nondominant hip abductors. J athl train. 2005; 40(3): 203–206.
12. Chu DA, Plummer L. The language of plyometrics. Strength Cond J. 1984;6(5):30–1.
13. Baechle, T.R. and Earle, R.W. Essentials of strength training and conditioning. 2nd edition. Champaign, IL: National Conditioning Association; 2000.
14. Y. C. Wang and N. Zhang, "Effects of plyometric training on soccer players. Exp. Ther. Med. 2016; 12(2). 550–554.
15. Bosco C, Komi PV, Ito A. Prestretch potentiation of human skeletal muscle during ballistic movement. Acta physiol scand. 1981;111(2):135–40.
16. H. Arazi and A. Asadi, "The effect of aquatic and land plyometric training on strength, sprint, and balance in young basketball players," J. Hum. Sport exercise. 2011; 6(1): 101-111.
17. E. S. S. de Villareal, B. Requena, and R. U. Newton. Does plyometric training improve strength performance? A meta-analysis. J. Sci. Med. Sport. 2010; 13(5); 513-522.
18. B. S. Bal, P. J. Kaur, and D. Singh. Effect of a short-term plyometric training program on agility in young basketball players. Brazilian J. Bio motricity. 2011; 5(4): 271-8.
19. G. Aloui et al. Effects of plyometric and short sprint with change-of-direction training in male U17 soccer players. Appl. Sci. 2021; 11(11): 5510.
20. Miller, J.M., Hilbert, S.C., and Brown, L.E. Speed, quickness, and agility training for senior tennis players. Strength and conditioning. 2001; 23(5): 62-66.
21. Undheim MB, Cosgrave C, King E, et al. Isokinetic muscle strength and readiness to return to sport following anterior cruciate ligament reconstruction: is there an association? A systematic review and a protocol recommendation. Br J Sports Med. 2015;49(20): 1305. Doi: 10.
22. Roozen, M. Illinois agility test. NSCA's performance training journal. 2004; 3(5): 5-6.
23. Fischetti F, Vilardi A, Cataldi S, Greco G. Effects of plyometric training program on speed and explosive strength of lower limbs in young athletes. Journal of physical education & sport, 2018;18(4).
24. Komi PV, Stretch-shortening cycle. In: Komi PV. Editor. Strength and power in sport, 2nd ed. Oxford: Blackwell Science;2000: 184-202.
25. Grosset JF. Piscione J., Lambertz D. et al. Paired changes in electromechanical delay and musculoskeletal stiffness after endurance or plyometric training. Eur J appl physiol 2009; 105(1): 1673-83.
26. Blazevieh AJ. Gill ND. Bronks R. et al. Training-specific muscle architecture adaptation after 5-wk training in athletes, Med Sci Sports Exerc. 2003 Dec; 35 (12): 2013-22.
27. Malisoux L, Francaux M, Theisen D. What do single-fibre studies tell us about exercise training? Med sci sports exerc. 2007 Jul; 39 (7): 1051-60.
28. Ettema GJ, van Soest AJ. Huijing PA. The role of series elastic structures in prestretch-induced work enhancement during isotonic and isokinetic contractions. J Exp Biol 1990 Nov; 154: 121-36.
29. Walshe AD. Wilson GJ. Ettema GJ. Stretch-shorten cycle compared with isometric preload: contributions to enhanced muscular performance. J Appl Physiol 1998 Jan; 84(1): 97-106.
30. Craig, B.W. What is the scientific basis of speed and agility? Strength and conditioning. 2004; 26(3): 13-14.
31. R. K. Elnaggar, M. F. Elbanna, W. S. Mahmoud, and B. A. Alqahtani. Plyometric exercises: Subsequent changes of weight-bearing symmetry, muscle strength, and walking performance in children with unilateral cerebral palsy. J. Musculoskeletal. Neuronal interaction. 2019; 19(4): 507-515.
32. Spurrs RW. Murphy AJ. Watsford ML. The effect of plyometric training on distance running performance. Eur J appl physiol 2003 Mar; 89 (1): 1-7.
33. Markovic G. Jukic I. Milanovic D. et al. Effects of sprint and plyometric training on muscle function and athletic performance. J Strength Cond Res. 2007 May; 21(2): 543-9.
34. Sheppard JM, Young WB. Agility literature review: classifications, training, and testing. J Sports Sci 2006 Sep; 24 (9): 919-32.
35. Potteiger JA, Lockwood RH, Haub MD, et al. Muscle power and fibre characteristics following 8 weeks of plyometric training. J Strength Cond Res. 1999 Aug; 13(3): 275-9.
36. Vidhi R. Dave, Amit Kumar Singh. Comparison of ladder training versus plyometric training on agility and speed among Vadodara cricket players: An experimental study; Indian Journal of physiotherapy and occupational therapy. 2024 June; 18(2).2