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Original Research Article

Effectiveness of Plyometric Drills in Improving Lower Extremity Strength and Speed among Long Jump Athletes

Allen Thomas Koshy[1], Anila Paul[2], Nizar Abdul Majeed Kutty[3]

[1]Physiotherapist, St. Thomas Hospital, Chethipuzha, Kottayam, Kerala, India
[2]Professor & HOD, Medical Trust Institute of Medical Sciences, College of Physiotherapy, Irumpanam, Kochi, Kerala, India 682309
[3]Senior Lecturer, Department of Physiotherapy, Faculty of Medicine & Health Sciences, University Tunku Abdul Rahman, Malaysia

Corresponding Author: Anila Paul

ABSTRACT

Background: Long jump, being a track and field event, combines speed, strength and agility to ensure performance of athlete. Literature revealed scarcity about relation of lower extremity strength and speed in long jump performance. Current study was designed to investigate the effectiveness of plyometric drills on lower extremity strength and speed among long jump athletes.
Materials and Methods: Thirty subjects from Physical Training Academy were recruited for this experimental study through purposive sampling. Participants were allocated into two groups, experimental group (15 males) and control group (15 males). Pre-test analysis was performed for both groups for Static Strength, Dynamic Strength and speed using Hand Held Dynamometry, Vertical Jump Height Test and 50 Meter Dash respectively. Experimental group received Plyometric Drill in addition to conventional exercise whereas; control group received conventional exercise only for 6 weeks. Post-test analysis was conducted using 't' test at level of significance $p \leq 0.05$.
Results: Statistical analysis of post-test values of both groups expressed significant difference ($p<0.05$) in static strength, dynamic strength (explosive strength) and speed among experimental group compared to control group. Among three outcome measures, static strength reported high significant difference compared to speed and dynamic strength among experimental group. Statistical analysis within the groups reported a significant improvement in dependent variables in both groups.
Conclusion: This study revealed effectiveness of Plyometric exercise in improving static strength, dynamic strength and speed compared to conventional exercise among long jump athletes.

Keywords: Plyometric, Vertical jump test, Long jump, Hand - Held Dynamometer, 50 Meter Dash Test

INTRODUCTION

Long jump is a track and field event in which athletes combine speed, strength and agility in an attempt to leap as far as possible from the takeoff point. Great deal of skill is required in performing the event. The major components of long jump include, the approach, posture through acceleration, length of the runway, take off, action in air and the landing. Speed gained during the approach and the high leap off the board are the fundamentals of success. [1]

During long jump procedure, there are physiological and biomechanical adaptations occurring in the body. During the last few strides before take-off, the athlete uses their visual perception of how far away they are from the board as a basis for adjusting the length of their strides. [2] The long jump generally requires training in a variety of areas such as: speed work, jumping, over distance running, weight training and plyometric training. Speed is key factor in long jump. Studies suggest that as the run up speed increase, the jump distance and take off speed increases. [3] Several literatures suggest that knee extensors lay a pivot role in long jump as the highly stretched extensor muscles are able to generate the required vertical momentum during the take-off phase. [4]

Plyometric drills usually involve stopping, starting and changing direction in an explosive manner. These types of training include repeated rapid stretching and contraction of muscle to improve power which is referred to as "explosive-reactive" power training. [5] Plyometric is considered to be the missing link between weight training (strength) and athletic performance (speed) with particular emphasis on the speed of activity. [6] It is the method of choice when improving the vertical jump ability and leg muscle speed-strength and power. [7]

In plyometric drills, there is rapid concentric contraction in the muscle after a rapid eccentric lengthening of the muscle fiber under load which enhances the force generated by the muscle. Plyometric training elicits a variety of physiological adaptations, both structural and neural. It produces varied training effects depending on the nature of the training program. It is usually determined by the desired sport-specific performance enhancement. [8]

Several investigations have been performed in professional and semi-professional athletes on effect of plyometric training in various types of sports events. Few studies are reported on the run up speed and explosive strength among athletes. There is a scarcity of literature regarding the effect of plyometric drills on speed and lower extremity strength among long jump athletes. The present study attempts to fill up this void in literature.

The aim of this study was to investigate the effectiveness of plyometric exercise on static and dynamic strength and speed among long jump athletes.

MATERIALS AND METHODS

An experimental study was designed among thirty subjects within the age group of 18 to 25 years. The subjects were recruited by purposive sampling technique based on inclusion and exclusion criteria from a physical training academy. Females and subjects with recent musculoskeletal injuries, cardiovascular and neurological deficits were excluded. Subjects who could perform 30 sec single leg stance balance test and full free weight squat 5 times within 5 seconds were only included for this study.

The outcome measures were, speed which was measured by 50 m Dash test, static strength was measured using modified Hand Held Dynamometry - KERN MAP (version 12) and explosive strength was measured by vertical jump height test. The materials used were Hand Held Dynamometer, cones, stop watch/timer, measuring tape and markers.

Procedure:

Two group pre test – post test design was adopted to determine the effects of plyometric drills on lower extremity strength and speed among long jump athletes. Ethical approval was obtained from the Institutional Ethics Committee. Study was conducted among the athletes from Sainik Physical Training Academy by purposive sampling technique. Thirty subjects (30 males, within the age group of 18-25 years) who fulfilled inclusion and exclusion criteria were recruited for the study. Selected subjects were allocated into experimental and control groups with 15 subjects in each group. The independent variables were plyometric drills and conventional exercise whereas the dependent variables were speed and lower extremity strength.

Different academies were approached for the study. Some academies rejected the proposal of doing the study as they wanted to keep the privacy of the athletes and also were not willing for any outside source to interfere in their training sessions. Required athletes were selected from a physical training academy that consented to participate in the study. The athletes were given prior instructions about the study during the interactive session and also they were given an overview on the training program. Prior consent was taken from each individual before the commencement of training. The training duration was for 6 weeks with 2 sessions per week. Pre-test assessment was conducted one day before the training started and post-test assessment on last day of training program.

Athletes were assigned into two groups: Group A (control group) and Group B (experimental group), on the basis of fulfilling the inclusion criteria. Both the groups received conventional exercises, whereas Group B received plyometric training in addition to conventional exercise. Initial warm ups were given prior to training. Warm ups included jogging and dynamic stretching and bounding.

Technique of Application

After warm up exercises, conventional training was provided for athletes. Conventional exercise included, standing broad jump, weighted squat, body weight running, sprinting up and down the stairs, single leg hopping, single leg bounding and straight sprint. [1] After conventional training for both groups, plyometric training was implemented for athletes of Group B (experimental group). Plyometric training included 6 weeks of training, 2 sessions per week. Each week, intensity of the training increases from low to high. As intensive training executed, a period of 48 to 72 hours gap was provided in between weekly sessions. [1, 9]

Table 1: Plyometric training

Week 1		
Technique	Sets / Repetition	Intensity
Two foot ankle hops	2 x 15	Low
Forward skip	2 x 15	Low
Double leg vertical jump	5 x 5	Low
Week 2		
Two Foot Ankle Hops	2x15	Low
Standing Long Jump	5x6	Low
Lateral cone Hops	2x15	Medium
Double leg tuck Jumps	2x10	Medium
Week 3		
Two foot ankle hops	2x12	Low
Standing long jump	4x6	Low
Lateral cone hops	2x12	Medium
Double leg tuck jump	2x10	Medium
Double Butt Kick	3x8	Medium
Week 4		
Diagonal Hops	4x8	Low
Double Tuck Jump	2x10	Medium
Lateral cone hops	2x10	Medium
Double leg butt kick	3x6	Medium
Single leg vertical jump	3x5	High
Week 5		
Diagonal Cone Hops	3x7	Low
Standing long jump with lateral sprint	4x5	Medium
Lateral cone hops	4x6	Medium
Single leg Bounding	2x5	High
Front cone Hops	2x10	Medium
Week 6		
Diagonal cone Hops	2x7	Low
Hexagon Drill	2x12	Low
Double leg Hops	3x8	Medium
Lateral cone Hops	3x8	Medium
Single Leg Bounding	3x5	High

Post-test evaluation for static strength, explosive strength and speed were conducted after completion of 6 weeks of training. Statistical analysis was done using SPSS software 16 version.

RESULTS

Table 2: Analysis of pre and post test data for Quadriceps muscle static strength, Hamstring muscle static strength, Explosive strength and speed within control group

Parameter		Mean	SD	Mean difference	t	Significance level (p-value)
Quadriceps right	Pre	10.42	1.17			
	Post	10.60	1.16	0.17	5.49	$p<0.05$
Quadriceps left	Pre	11.42	1.02			
	Post	11.58	0.99	0.16	5.22	$p<0.05$
Hamstrings right	Pre	10.12	1.13			
	Post	10.34	1.02	0.22	2.71	$p<0.05$
	Pre	10.72	1.33		2.32	$p<0.05$
Hamstrings left	Post	10.80	1.30	0.07		
Vertical jump height	Pre	30.20	5.53			
	Post	32.40	5.92	2.20	5.78	$p<0.05$
	Pre	7.97	0.40			
Speed	Post	7.93	0.42	0.03	2.69	$p<0.05$

The age group considered for this study was 18 to 25 years for both control group (mean age 19.1 ± 4.85) and experimental group (mean age 20.2 ± 1.03) with 15 males in each group. All participants were adherent to the study throughout project duration. Outcome measures used were Handheld Dynamometry for static muscle strength, Vertical jump height test for dynamic muscle strength and 50 meter dash test for measuring speed.

Analysis of pre and post test data in control group revealed that, t value for quadriceps and hamstring muscle strength for both right and left sides, vertical jump height and speed were greater than the table value at 5% level of significance ($p<0.05$) indicating significant improvement on dependent variables.

Table 3: Analysis of pre and post test data for Quadriceps muscle static strength, Hamstring muscle static strength, Explosive strength and speed within experimental group

Parameter		Mean	SD	Mean difference	t	Significance level (p-value)
Quadriceps right	Pre	14.20	1.85			
	Post	14.36	1.79	0.16	6.28	p<0.05
Quadriceps left	Pre	13.43	1.57			
	Post	13.79	1.37	0.36	3.58	p<0.05
Hamstrings right	Pre	13.48	2.15			
	Post	13.70	2.12	0.22	8.40	p<0.05
Hamstrings left	Pre	13.56	2.45			
	Post	13.79	2.39	0.23	10.99	p<0.05
	Pre	30.66	4.48			
Vertical jump height	Post	36.86	2.69	6.20	8.18	p<0.05
	Pre	7.99	0.45			
Speed	Post	7.26	0.45	0.73	72.08	p<0.05

Analysis of pre and post test data in experimental group revealed that, t value for quadriceps and hamstring muscle strength for both right and left sides, vertical jump height and speed were greater than the table value at 5% level of significance ($p<0.05$) indicating significant improvement on dependent variables.

Table 4: Analysis of Quadriceps muscle strength between experimental and control group for right and left sides

Group	Side	Mean	S.D	Difference between means	t	Significance level (p-value)
Experimental group	Right	14.36	1.79			
Control group		10.60	1.16	3.76	6.79	p<0.05
Experimental group	Left	13.79	1.37			
Control group		11.58	0.99	2.20	5.03	p<0.05

Table 5: Comparison of Hamstrings muscle strength between experimental and control group for right and left sides

Group	Side	Mean	S.D	Difference between means	t	Significance level (p-value)
Experimental group	Right	13.70	1.02			
Control group		10.34	2.12	3.35	5.50	p<0.05
Experimental group	Left	13.79	2.39			
Control group		10.80	1.30	2.99	4.25	$p < 0.05$

Table 6: Comparison of Explosive strength between experimental and control group

Group	Mean	S.D	Difference between means	t	Significance level (p-value)
Experimental group	36.86	2.69			
Control group	32.40	5.92	4.46	2.65	$p < 0.05$

Table 7: Comparison of Speed between experimental and control group

Group	Mean	S.D	Difference between means	t	Significance level (p-value)
Experimental group	7.26	0.45			
Control group	7.93	0.42	0.67	4.18	$p < 0.05$

Statistical analysis between experimental and control groups revealed that, t value for quadriceps and hamstring muscle strength for both right and left sides, vertical jump height and speed were greater than the table value at 5% level of significance ($p<0.05$). The result supports significant role of plyometric exercise training for improvement of static and explosive strength and speed among long jump athletes.

DISCUSSION

Statistical analysis of this study demonstrated improvement in static strength, dynamic strength and speed among both the groups but experimental group reported significant improvement compared to control group.

Paired t test of both control and experimental group revealed significant improvement in quadriceps and hamstring muscle strength on both right and left sides. Improvement in Quadriceps and Hamstrings muscle strength during standing long jump was reported in a study conducted by Wen-Lan Wu et al. (2003). According to this study, the biomechanical analysis of standing long jump reported peak force generation during the push off phase in both vertical and horizontal directions. The study also reported a significant difference in the knee angulation during the preparatory phase of jump to the push off phase of long jump, starting the jump at 90^0 knee angle provide a greater force on the leg muscles. There was increase in vertical and horizontal ground reaction force leading to significant improvement in the muscular strength. [10]

The vertical jump height test showed significant difference in paired t test indicating significant difference in the explosive strength. It can be justified by literature of Eduardo J. A. M et al. (2008) that reported several contributing factors such as, better synchronization of body segments, increased coordination levels and greater muscular strength/force for increase in the jump height. The study also describes the fact that increase in vertical jump can be due to the activation of both muscular fibers and nervous system, so that slow twitch fiber behave like fast twitch fibers. Plyometric exercise increases motor neuron excitability and reflex potentiation which could lead to significant improvement in explosive strength. [11]

Analysis revealed significant improvement in speed within both groups. According to the study conducted by Gunnar Elling Mathisen et al. (2015), while training there is increase in maximal firing frequency and action potential in the muscle which in turn helps in the improvement of motor unit recruitment, central nervous activation and improved technical skill. This might be the reason for significant improvement in speed. [12]

Unpaired t-test revealed significant improvement in quadriceps and hamstring muscle strength on both right and left extremities among experimental group that underwent plyometric training in addition to conventional exercises compared to control group. This finding is supported by the study conducted by Robert U. Newton et al (1994). When there is dynamic explosive movements, type 2 muscle fibers are recruited and as the velocity of contraction increases, the muscles ability to generate strength will be increased. It is possible that the gain in strength must be due to the increased neural activities like increased motor neuron recruitment, increase in the rate and synchronization of firing, and motor learning. The connective tissues around the muscle fibers thicken, giving more support to the muscle. The changes are caused by decrease in inhibitory function of central nervous system and Golgi tendon organ. It is said that non-contractile soft tissues of the muscle may develop strength more rapidly with eccentric training. This explains the reason for significant improvement in Hamstring and Quadriceps strength among the experimental group compared to control group. [13,14]

Another study conducted by Kristian Vissing et al. (2008) also reported that during plyometric training, there is exploitation of the stretch shortening cycle (SSC), in which a rapid eccentric muscle contraction facilitates an increased force and power output as the movements are done rapidly. In addition, there is increase in the type I and type II muscle fibers in response to plyometric training. This might be the reason for significant improvement in the strength among experimental group. [15] Another point is that there is increase in the peak torque and maximal shortening velocity in type I, type IIa and hybrid IIa/IIx fibers with peak increase in power with a moderate hypertrophy of both type I and type II muscle fibers as described by Goran Markovic. [16]

Experimental group reported significant improvement in explosive strength as assessed by vertical jump height test, compared to control group. This finding can be justified by the literature of Ioannis G. Fatouros, who reported that plyometric exercise causes a rapid deceleration of body followed by rapid acceleration, which in turn evoke the elastic properties of the muscle fiber and connective tissue. This mechanism helps the muscle to store energy during deceleration and release the energy during acceleration. [17] Another literature by Jennifer L. Hunnicutts described that plyometric exercise improves the elastic component of muscle tendon complex and single fiber contractile performance. It also improved the muscle strategy and landing mechanism. [18,19] Peak increase in the muscular power can provide optimal increase in the jumping activity in long jump sport.

Statistical analysis with unpaired t-test revealed significant improvement in speed among experimental group that underwent plyometric training, which could be due to improvement in muscle strength and elastic component of the muscle tendon complex and greater recruitment of type IIa muscle fibers. Robert G. Lockie et al. (2011) reported that power and strength qualities affect the production of force during acceleration which in turn reduces the ground contact time as the acceleration increases. This might be the reason for significant improvement in speed among the experimental group. [20]

CONCLUSION

Present study revealed that plyometric training of 6 weeks tendered significant improvement in lower extremity static and explosive strength and speed as measured by hand-held dynamometry, vertical jump height and 50 meter sprint test respectively.

Therefore, plyometric training is recommended for improvement in lower extremity strength and speed among long jump athletes which can enhance performance in the sport event.

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