International
Journal of Medical and Exercise Science
(Multidisciplinary, Peer Reviewed and Indexed Journal)

ORIGINAL ARTICLE

EFFICACY OF PLYOMETRIC TRAINING ON LOWER LIMB FLEXIBILITY, LEG EXPLOSIVENESS AND DYNAMIC BALANCE AMONG NON-PROFESSIONAL MALE FOOTBALL PLAYERS- A SINGLE BLINDED STUDY

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ABSTRACT

Background of the study: Football has developed into a very popular. Frequency of injury rate in amateur soccer player is higher, contact with another player is the most common one followed by distortion and turning/twisting, almost 30% of traumatic injuries were associated with foul play and comparing players from all levels (including top level) while low-level players had lower exposure to soccer, they were more prone to get injured. Objectives of the Study were to find the effectiveness of plyometric training on lower limb flexibility in non–professional male football players. Also was t**o** study the effectiveness of plyometric training on leg explosiveness in non –professional male football players and to study the effectiveness of plyometric training on dynamic balance in non –professional male football players. **Methodology:** Sixty subjects who fulfill the inclusion criteria is selected. Then the subjects have been divided into 2groups. Group A and Group B of 30 subjects each where Group A is control group and Group B is the experimental group, subjects were blinded in the study. Prior consent form will be obtained. On the first day pre test was conducted using sit and reach test to measure lower limb flexibility, standing broad jump test for leg explosiveness and star excursion balance test to determine dynamic balance for each group. Then post test score is obtained after 3months from each group. **Results:** There was a significant difference inflexibility (t=2.904), leg explosiveness (t=2.406) and SEBT right leg stance for anterior (t=4.098), anterior–lateral (t=2.981),anterior–medial (t=3.358), medial (t=2.634), posterior(t=2.741), posterior – lateral (t=2.452), posterior – lateral (t=2.952) and lateral (t=4.978),SEBT left leg stance for anterior(t=4.828), anterior – lateral(t=4.040),anterior –medial (t=2.827), medial (t=4.487), posterior(t=2.924), posterior –lateral(t=2.157), posterior –medial (t=2.093) and lateral(t=3.327) between control and experimental group with levelof significance p≤0.05. Conclusion: The study concluded that plyometric training helps in improving lower limb flexibility, leg explosiveness and dynamic balance in non-professional male football players. **Conclusion:** After analyzing the study it can be concluded that plyometric training helps in improving lower limb flexibility, leg explosiveness and dynamic balance in non -professional football players.

Keywords: Plyometric Training, Lower limb flexibility, Leg explosiveness, Dynamic balance.

Received on 07th February 2025; Revised on 18th February 2025; Accepted on 28th February 2025
DOI:10.36678/IJMAES.2025.V11I01.013

INTRODUCTION

Football has become a hugely popular sport among people of allages.[1]and is a team sport that involves brief sprints, sharp accelerations, decelerations, rapid changes of direction, hops, and tackles, among many other movements[2,3]. In terms of the game's duration, football is a sport that necessitates high-quality technical skills. Toplayin90 minutes of regular time, a player must be able to demonstrate his or her technicalabilityin2 x45 minutes. Players must always move whether they have the ball or not, such as dribbling to pass an opponent and kicking into an opponent's goal to score. The focus of football is on team games, in which eleven players compete against each other[4].

Football is a game of physical contact with a high risk of injury. In a study conducted among young football players of different levels, nearly40% of them had non-mechanical injures to their lower limbs[5], most of which were due to muscle strains and sprains, and injuries to tendons and ligaments in the knees[6]. The estimated injury rate is 9.11 injuries/1000 h of football related activities. Compared to training (6.84/1000h) the incidence of injury during match play (24.29/1000h) is higher. The thigh is the most common injury site (31.7%) and musclestrainsaccountsfor41.2%of all injuries. Moderate injuries (8-28 days) are common (44.2%) [7]. In professionals less severe injuries are occurred, where as moderate and severe injuries are prevalent in amateurs, the overall injury incidence for competitive amateur soccer players ranges from 5.2 to 9.6per 1000hoursofplay, player to player contact is a frequent injury mechanism. In amateur soccer games, more than half of all injuries may occur[5].

Plyometric training (PT) consists of dynamic and rapid stretching of muscles (eccentric action) immediately followed by a concentric of shortening action of the same muscles and connective tissues. Exercises are of high-intensity, explosive muscular contractions combining strength and speed for acquisitions of benefits in power[7-9].

The stretch-shortening cycle (SSC) is used in plyometric training, which involves a lengthening movement (eccentric) followed by a shortening action (concentric). The eccentric pre-stretch phase of plyometric activity stretches the muscle spindle and non-contractile tissue within the muscle (series elastic components [SEC] and parallel elastic components [PEC]). This eccentric pre-stretch will enhance the resultant concentric muscle contraction in between eccentric and concentric phase there is one phase called as amortization phase, if the amortization phase is delayed, the stored energy is wasted as heat, the stretch reflex is not activated and the resultant positive work of the concentric contraction is not as effective. One of the primary goals of plyometric training is to decrease the time of amortization phase[23]. Concentric shortening phases are final phase of the plyometric movement results from many interactions including the biomechanical response that utilizes the elastic properties of the pre-stretched muscles [10-12].

The contractile component of act in and myosin cross bridges with the sarcomere, which plays a crucial role in motor control and force production during plyometrics, is the physiological basis of plyometric training. The pre-stretch of the muscle-tendon unit and the physiological length-tension curve are used in the plyometric movement to improve the

ability of the muscle fibers to generate additional tension and, as a result, force output occurs. The format of plyometric training belongs to eccentric muscle contractions create the most force, followed by isometric contractions and then concentric contractions[13].

Objectives of the study were to find the effectiveness of plyometric training on lower limb flexibility in non- professional male football players. Also to study the effectiveness of plyometric training on leg explosiveness in non- professional male football players. To study the effectiveness of plyometric training on dynamic balance in non Professional male football players.

METHODOLOGY

Study design: Single blinded study design, pre-test, post-test with control group. This Study conducted at School of Medical Education, Kottayam. Sample size: 60samplesof population who satisfied the inclusion and exclusion criteria were selected Study duration: The study was conducted over a period of three months.

Inclusion criteria: Non-professional male Football players, Age group 18–23 years, Playerswhoplayfootballatleast4daysper week.

Study procedure. Total of 60 subjects were recruited using purposive sampling. Subjects were initially examined for the inclusion and exclusion criteria. All the eligible participants were verbally instructed as to the intent and protocol of the study. Procedure of the training programmed was explained well and informed consent was collected. All outcome measures were assessed at baseline and after 6 weeks. Participants were instructed to report any symptoms or feelings of falling during the exercise sessions. 60 patients were divided into two groups.

Group A (N=30) Control group, Group A participants were subjected to conventional treatment alone for 20 minutes, 2 days per week for 6 weeks. Group B (N=30)-Experimental group, Group B participants were subjected to plyometric training along with conventional therapy for 40 minutes, 2 days per week for 6 weeks. Pre test assessment score was done using Sit and reach test, Star excursion balance test and Standing board jump test to check the lower limb flexibility, dynamic balance and leg explosiveness in both groups.

Group A (Control group)

In conventional treatment, participants were trained with FIFA 11+ warm up training programme for 20 minutes which includes, Part-1 Running exercises for 8minutes includes, running straight ahead

Place 5 pairs of cones parallel, approximately five to six meters apart. Subjects start from the first cone subjects Jog up to the last cone. On the way back, progressively increase the speed.

A. Running hip out: Subjects may Walk or jog comfortably, stopping at each cone and lift your knee and rotate your hip outward. Alternate between left and right legs.

B. Running hip in: Subjects may Walk or jog comfortably, stopping at each cone and lift your knee and rotate your hip inward. Alternate between left and right legs

C. Running circling partner: Subjects run forward in pairs to the first set of cones. Shuffle

sideways to 90 degrees to meet in the middle. Shuffle an entire circle around one another and then return to the cones. Repeat for each pair of cones. Remember to stay on your toes and keep your center of gravity low by bending your hips and knees.

D. Running shoulder contact: Subjects run forward in pairs to the first pair of cones. Shuffle sideways by90 degrees to meet in the middle then jump sideways toward each other for making shoulder-to-shoulder contact. At the time of landing maintain both feet, hips and knees are bent. Avoid knees buckling inward.

E. Running quick forwards and backwards: Subjects run forward in pairs to the second set of cones then run backward quickly to the first pair of cones, keeping the hips and knees slightly bent. Continuing the drill, running two cones forward and one cone backward. Each exercises for 2 sets.

Part-2 Exercises for10 minutes,

A. Static bench: Subjects in prone lying position .Lift the body up and supported by forearms then Pull the stomach in and hold the position for 20-30 seconds for three sets. The body should maintain a straight line position.

B. Static sideways bench: Subjects lie on one side with the knee of lower most leg bent to 90 degree. Support the upper body by for earm and knees. Lift the upper most leg and hips up to subjects shoulder, hip and knee should being straight line. Hold the position for 20- 30sec and three sets for both sides.

C. Hamstrings: Subjects Kneel on the ground ,one of the other subject hold down the ankles of performing subject, body should completely straight from shoulder to knee throughout the exercise. Subject lean forward as far and controlling the movement with the hamstrings and gluteal muscles. When subjects can no longer to hold the position, gently put weight on hands, and falling into push-up position. Repeat it for 3-5 repetitions /1 set.

D. Single-leg stance-hold the ball: Subjects in single stance, holding the ball with both hands. Keep the body weight on the ball of foot avoid knees buckling inward. Hold it for 30 sec. Change legs and repeat. For 2two sets.

E. Squats-With Toe Raise: Subject Stand with feet hip-width apart with hands on hips. Perform squats by bending the hips and knees about 90 degrees. Avoid knees buckle inward. Subjects descend slowly then straighten up more quickly. When the legs are completely straight, stand on toes then slowly lower down again. Repeat the exercise for 30 sec for two sets.

F. Jumping-Vertical jumps: Subject was Stand with feet hip-width apart. With hands on hips. Perform squats by bending the hips and knees about 90 degrees hold it for 2sec. Avoid knees buckle inward. From the squat position, jump up as high, Land softly on the balls of feet with bending of hip and knees. Repeat the exercise for 30 sec for two sets.

Part-3 includes running exercises for 2minutes,

A. Running across the pitch: Subjects were run across the pitch, from one side to the other, at 75-80% maximum pace. For two sets.

B. Running Bounding: Subjects run with high bounding steps with a high knee lift, landing gently on the ball of foot for two sets.

C. Running plant and cut: Subjects were Jog 4-5 steps then plant on the outside leg and cut to change direction for two sets.

Group B (Experimental group)

Group B participants were subjected to Plyometric training along with FIFA 11+ warm up training for 40 minutes and 6 weeks.

Week-1

A. Side to side ankle hops: Subject stand straight with by sides and feet hip-width apart, Jump with both feet to the right and then to the left, in a quick, repetitive manner.

B. Standing jump reach: Subject stand straight jump in to air, keep feet together and explode your arms forward and throw them up in the air reaching overhead.

C. Front cone hops: Subject stand in upright position, slightly bend the knees forward, place one cone in front of the subjects and jump forward over the cones.

D. Double leg lateral hop: Subject stand in upright position, slightly bend the knees forward, and rapidly explode upward and to the side also to swing arms forcefully upwards. For2 sets and15 repetitions with low intensity, with1-2minutes rest in between the sets.

Week-2

A. Diagonal Jump: Subjects stand straight with feet together and arm at sides, jump with maximum effort either to the side or in diagonal manner.

B. Cone hops with180degree rotation: Subjects jump over the conein180 degree rotation manner.

C. Hexagon drill: Subjects jump over the cone in Hexagonal manner.

D. Lateral Jump in Single leg: Subjects in single limb position and make jump in sideward direction.

E. Standing long jump with lateral sprint: Subjects stand with both feet together, jump forward with forward running For2 sets and 15 repetitions with low/medium intensity, with 1-2minutes rest in between the sets.

Week-3

A. Squat jump: Subjects make a squat position, with arms swinging forward and backward jumps to a maximum distance.

B. Lateral squat jump: Subjects make a squat position, with arms swinging forward and backward jumps to a maximum distance in sideward direction.

C. 90 degree squat jump: Subjects make a squat position, jump with 90 degree rotation in mid-air and land.

D. 180-degree squat jump split squat jump: Subjects make a squat position, jump with 180-degree rotation in mid-air and land For 2 sets and 10 repetitions with medium intensity, 2-3minutesrestin between the sets

Week-4

A. Single leg vertical jump: Subject stand in single leg and rapidly explode up ward with arms swing forcefully upward and reach as high as possible.

B.

C. Single leg zig-zag hops: Subject stand in single leg and jump over the cones in zig- zag manner.

D. Double leg zig-zag hops: Subject stand in both leg jumps over the cones in zig- zag manner.

E. Lateral barrier hops; Placing an obstacle keeps the leg together and jumps from side to side over the obstacle

For 2 sets& 10 repetitions with medium intensity with 2-3 minutes rest in between the sets.

Week–5

A. Linear hops: Place cone in front of the subjects and in single leg position with knee and hip slightly bent hop forward and land on the same foot the player hopped with and also for other leg.

B. Lateral hops: Subjects standing straight keep the feet together jump in a side to side with both feet.

C. Kangaroo jumps: Subjects stand in upright position with slightly bent the knees, quickly drop the body by bending the knees and rapidly explode upward to the front. At the highest point of jump, cycle the feet under their own buttocks as in cycling or running motion, by keeping the feet together.

D. 90-degreerotation jump

Double leg jump, and rotate 90 degree in mid air and land.

E. 180°rotationjump: Double leg jump, rotate 180 degree in mid air, hold landing for 2 sec and then repeat in reverse direction

For 2 sets and 10 repetitions with high intensity with 3-4 minutes rest in between the sets.

Week-6

A. Single leg push off: Aboxwith15-40 cm height, players stand in front of the box, place right leg on the box and push off the right leg and jump up in the air, on landing right leg back on the box and left leg on the floor.

B. Lateral push off: Aboxwith15-40 cm height, players stand in front of the box, place right leg on the box and push off the right leg and jump across the box and land to lateral side of the box with right foot and maintain left foot on the box, jump back and pushing off the feet.

C. Box jump: Aboxwith15-40cmheight is selected, the subjects stands with feet distanced at the shoulder width facing the box. The subjects make as light squat and jumps on to the box from ground by swinging both arms. For2 sets and 10 repetitions in high intensity with3-4minutes rest in between the sets.

Exercises were given for 2days per 6 weeks.

Posttest assessment was done using Sit and reach test, Star excursion balance test and Standing board jump test to check the lower limb flexibility, dynamic balance and leg explosiveness in both groups to assess changes in the lower limb flexibility, dynamic balance and leg explosiveness after the exercise training program. Pre test and posttest data were analyzed using paired t test and two sample t test as statistical tool.

Outcome measure

1. Sit and reach test
2. Standing Broad Jump test
3. Star excursion balance test
4. Sit and reach test

Subjects performed a short warm-up prior to the test. They were instructed to sit without shoes and soles of the feet flat against the sit and reach box at the 26 cm mark. Inner edge of the soles placed within 2 cm of the measuring scale. With fingertips overlapped, subjects were asked to slowly reach forward with both hands as far as possible keeping

knees extended and held this position for approximately2 seconds. Best of two trials were recorded.

- **Standing Broad Jump test**

The performer was standing with the feet parallel to each other and behind the standing mark. The performer bended the knees and swing the arms and jumped as for forward as possible. Best of three trials were recorded as the score. The subjects were advised to have sufficient warm-up before going through the tests.

- **Star excursion balance test**

Small amount of setup is required before the application of technique. Four strips of athletic tape will need to be cut to a lengthof6-8 feet each. Two pieces will be used to forma ‗+', with the other two being placed over top to for Manx'so that a star shape is formed. It is important that all lines are separated from each other by a 45° angle. The person performing the test must maintain their balance on one leg, while using the other leg to reach as far as possible in 8 different directions. The person (standing on his/her left leg for example) must reach in8 different positions, once in each of the following directions: anterior, antero medial, medial, postero medial, posterior, postero lateral, lateral and antero lateral. Person has performed 3 successful reaches with each foot in all directions, record the reach distance of each successful attempt, with a pencil, in order to calculate the athlete's SEBT score after the test.

Average distance in each direction (cm)=Reach1+Reach2 +Reach3 /3, Relative distance in each direction (%) =Average distance in each direction/ leg length * 100, These calculations should be performed for both the right and left leg in each direction, providing you with a total of 16 scores per athlete.

Materials: Stopwatch, Cones (20cm), Measuring, tape, Pen and Document sheet, Whistle, Consent Form, Marking tape

Plan of analysis: Paired t test: To compare the pre and posttest values of experimental and control group.

Two sample t test: To compare the post test values of experimental group to the control groups.

Funding: Own funding,

RESULTS

Directions	Test	Mean	S.D	MeanDifference Score	Paired„t"test & p-value
Anterior	Pretest	88.27	2.35	2.14	t=19.515 p = 0.0001 S***
	PostTest	90.41	2.29		
Anterior–Lateral	Pretest	80.42	2.82	2.44	t=17.444 p = 0.0001 S***
	PostTest	82.86	2.90		

Anterior–Medial	Pretest	90.65	2.06	1.39	t= 3.218 p= 0.003 S**
	PostTest	92.04	3.11		
Medial	Pretest	92.79	1.97	2.42	t=17.855 p = 0.0001 S***
	PostTest	95.21	1.99		
Posterior	Pretest	96.50	2.62	1.93	t=11.732 p = 0.0001 S***
	PostTest	98.43	2.29		
Posterior–Lateral	Pretest	92.90	2.28	2.95	t= 9.692 p = 0.0001 S***
	PostTest	95.85	2.19		
Posterior–Medial	Pretest	96.06	2.48	2.17	t=11.661 p = 0.0001 S***
	PostTest	98.23	2.92		
Lateral	Pretest	79.33	1.15	1.71	t= 7.517 p = 0.0001 S***
	PostTest	81.04	1.82		

***p<0.001,**p<0.01,S–Significant

Table 1: Comparison of pretest and posttest SEBT (right leg stance) in Control group

The above table shows the comparison of pretest and posttest SEBT (right leg stance) in Control group. Paired t' test was computed to compare the pretest and post test SEBT scores. It was found that the calculated t' test value for anterior (t=19.515), anterior–lateral (t=17.444), anterior–medial (t=3.218), Medial (t=17.855), posterior (t=11.732), posterior–lateral (t=9.692), posterior–medial (t=11.661) and lateral (t=7.517) was found to be statistically significant p<0.001 and P<0.01 level respectively. This clearly infers that there was significant improvement in the SEBT (right leg stance) scores among the samples in the control group.

Directions	**Test**	**Mean**	**S.D**	**Mean Difference Score**	**Paired t" test & p-value**
Anterior	Pretest	87.99	2.52	2.08	t=11.010 p = 0.0001 S***
	Post Test	90.07	2.27		
Anterior–Lateral	Pretest	78.10	2.76	2.65	t=16.920 p = 0.0001
	Post Test	80.85	2.60		

					S***
Anterior–Medial	Pretest	91.18	3.10	2.46	t=20.180
	Post Test	93.74	3.11		p = 0.0001 S**
Medial	Pretest	94.64	2.01	2.28	t=14.013
	Post Test	96.92	2.19		p = 0.0001 S***
Posterior	Pretest	96.62	2.25	2.18	t= 9.204
	Post Test	98.80	2.64		p = 0.0001 S***
Posterior–Lateral	Pretest	92.75	4.26	1.72	t= 3.708
	Post Test	94.47	3.74		p= 0.001 S***
Posterior–Medial	Pretest	94.98	3.40	2.50	t= 7.716
	Post Test	97.48	4.07		p = 0.0001 S***
Lateral	Pretest	77.57	2.74	2.40	t=12.086
	Post Test	79.97	2.99		p = 0.0001 S***

***p≤0.001, S–Significant

Table 2. Comparison of pretest and posttest SEBT (left leg stance) in Control group

The above table shows the comparison of pretest and post test SEBT (left leg stance) in Control group. Paired t' test was computed to compare the pretest and post test SEBT scores. It was found that the calculated t' test value for anterior (t=11.010, anterior–lateral (t=16.920), anterior–medial (t=20.180), medial (t=14.013), posterior (t=9.204), posterior–lateral (t=3.708), posterior–medial (t=7.716) and lateral (t=12.086) was found to be statistically significant p≤0.001 level. This clearly infers that there was significant improvement was observed in the SEBT (left leg stance) scores among the samples in the control group.

Directions	**Test**	**Mean**	**S.D**	**Mean Difference Score**	**Paired t", test & p-value**
Anterior	Pretest	88.14	2.86	4.87	t=14.680
	PostTest	93.01	2.62		p = 0.0001 S***
Anterior– Lateral	Pretest	80.32	2.59		t=15.966

	PostTest	84.89	2.35	4.57	p = 0.0001 S***
Anterior– Medial	Pretest	90.79	2.33	3.58	t=24.196 p = 0.0001 S***
	PostTest	94.37	2.19		
Medial	Pretest	92.96	2.08	3.69	t=17.312 p = 0.0001 S***
	PostTest	96.65	2.24		
Posterior	Pretest	96.48	2.73	3.74	t=19.528 p = 0.0001 S***
	PostTest	100.22	2.74		
Posterior– Lateral	Pretest	92.72	2.31	4.64	t=16.347 p = 0.0001 S***
	PostTest	97.36	2.57		
Posterior– Medial	Pretest	95.96	3.00	4.62	t=19.356 p = 0.0001 S***
	PostTest	100.58	3.24		
Lateral	Pretest	79.50	1.25	3.86	t=17.213 p = 0.0001 S***
	PostTest	83.36	179		

***p<0.001,S–Significant

Table 3: Comparison of pre test and post test SEBT (right leg stance) in Experimental group

The above table shows the comparison of pretest and posttest SEBT (right leg stance) in Experimental group. Paired ‗t' test was computed to compare the pretest and post test SEBT scores. It was found that the calculated ‗t' test value for anterior (t=14.680, anterior – lateral (t=15.966), anterior – medial (t=24.196), medial (t=17.312), posterior (t=19.528), posterior – lateral (t=16.347), posterior – medial (t=19.356) and lateral (t=17.213) was found to be statistically significant p≤0.001 level. This clearly infers that after the intervention, there was significant Improvement was observed in the SEBT (right leg stance) scores among the samples in the experimental group

Directions	**Test**	**Mean**	**S.D**	**Mean Difference Score**	**Paired t" test & p-value**
Anterior	Pretest	88.89	2.84	4.14	t=22.769 p = 0.0001 S***
	PostTest	93.03	2.47		
Anterior–	Pretest	79.07	2.78		t=22.988

Lateral	PostTest	83.56	2.78	4.49	p = 0.0001 S***
Anterior–Medial	Pretest	92.17	3.34	3.85	t=22.907 p = 0.0001 S***
	PostTest	96.02	3.42		
Medial	Pretest	95.27	1.74	3.79	t=21.093 p = 0.0001 S***
	PostTest	99.06	1.44		
Posterior	Pretest	97.22	1.87	3.61	t=11.703 p = 0.0001 S***
	PostTest	100.83	2.75		
Posterior–Lateral	Pretest	92.54	3.49	4.01	t=15.801 p= 0.001 S***
	PostTest	96.55	3.75		
Posterior–Medial	Pretest	95.39	3.51	4.24	t=22.506 p = 0.0001 S***
	PostTest	99.63	3.90		
Lateral	Pretest	78.13	3.01	4.37	t=23.758 p = 0.0001 S***
	PostTest	82.50	2.91		

***p≤0.001,S–Significant

Table 4: Comparison of pre test and posttest SEBT (left leg stance)in Experimental group

The above table shows the comparison of pretest and post test SEBT (left leg stance) in Experimental group. Paired t'test was computed to compare the pretest and post test SEBT scores. It was found that the calculated t'test value for anterior (t=22.769, anterior–lateral(t=22.988),anterior–medial(t=22.907),medial(t=21.093), posterior (t=11.703), posterior–lateral (t=15.801), posterior–medial (t=22.506) and lateral(t=23.758) was found to be statistically significant p≤0.001 level. This clearly infers that after the intervention, there was significant improvement wasobserved in the SEBT (left leg stance) scores among the samples in the experimental group.

Directions	**Test**	**Control Group**		**Experimental Group**		**Mean Difference Score**	**Student Independent" test & p-value**
		Mean	**S.D**				
	Pretest	88.28	2.35	88.14	2.86	0.14	t= 0.202 p=0.841 N.S

Anterior	PostTest	90.41	2.29	93.01	2.62	2.60	t= 4.098 p=0.0001 S***
Anterior–Lateral	Pretest	80.42	2.82	80.32	2.59	0.10	t= 0.134 p=0.894 N.S
	PostTest	82.86	2.90	84.89	2.35	2.03	t= 2.981 p=0.004 S**
Anterior–Medial	Pretest	90.65	2.06	90.79	2.33	0.14	t= 0.246 p=0.806 N.S
	PostTest	92.04	3.11	94.37	2.19	2.33	t= 3.358 p=0.001 S***
Medial	Pretest	92.79	1.97	92.96	2.08	0.17	t= 0.324 p=0.747 N.S
	PostTest	95.21	1.99	96.65	2.24	1.44	t= 2.634 p=0.011 S*
Posterior	Pretest	96.50	2.62	96.48	2.73	0.02	t= 0.034 p=0.973 N.S
	PostTest	98.43	2.29	100.22	2.74	1.79	t= 2.741 p=0.008 S**
Posterior–Lateral	Pretest	92.90	2.28	92.72	2.31	0.18	t= 0.309 p=0.758 N.S
	PostTest	95.85	2.19	97.36	2.57	1.51	t= 2.452 p=0.017 S*
Posterior–Medial	Pretest	96.06	2.48	95.96	3.00	0.10	t= 0.136 p=0.892 N.S
	PostTest	98.23	2.92	100.58	3.24	2.35	t= 2.952 p=0.005 S*

Lateral	Pretest	79.33	1.15	79.50	1.25	0.17	t= 0.536 p=0.594 N.S
	PostTest	81.04	1.82	83.36	1.79	2.32	t= 4.978 p=0.0001 S***

***p≤0.001,**p<0.01,*p<0.05,S–Significant,N.S–NotSignificant

Table5: Comparison of pretest and posttest SEBT (right leg stance) between the Control and Experimental group.

The above table shows that the comparison of pretest and posttest SEBT(right leg stance) between the Control and Experimental group. The comparison of pretest level of SEBT (right leg stance) score among the samples showed no significant difference between the groups which was evident from the calculated student independent ‗t' test values. The comparison of post test level of SEBT (right leg stance) score among the samples showed significant difference between the groups which was evident from the calculated student independent ‗t' test values for anterior (t=4.098), anterior – lateral (t=2.981), anterior – medial (t=3.358), medial (t=2.634), posterior (t=2.741), posterior – lateral (t=2.452), posterior – lateral (t=2.952)and lateral (t=4.978).

Directions	**Test**	**Control Group**		**Experimental Group**		**Mean Difference Score**	**Student Independent„t" test & p-value**
		Mean	**S.D**	**Mean**	**S.D**		
Anterior	Pretest	87.99	2.52	88.89	2.84	0.90	t =1.303 p=0.198 N.S
	Post Test	90.07	2.27	93.03	2.47	2.94	t =4.828 p=0.0001 S***
Anterior Lateral	Pretest	78.10	2.76	79.07	2.78	0.97	t =1.352 p=0.182 N.S
	Post Test	80.75	2.60	83.56	2.78	2.81	t =4.040 p=0.0001 S***
Anterior Medial	Pretest	91.18	3.10	92.17	3.34	0.99	t =1.190 p=0.239 N.S
	Post Test	93.64	3.11	96.02	3.42	2.38	t =2.827 p=0.006 S**
Medial	Pretest	94.64	2.01	95.27	1.74	0.63	t =1.284 p=0.204 N.S
	Post Test	96.92	2.19	99.06	1.44	2.14	t =4.487 p=0.0001 S***
	Pretest	96.62	2.25	97.22	1.87	0.6	t =1.120 p=0.268 N.S

Posterior	Post Test	98.80	2.64	100.83	2.75	2.03	t =2.924 p=0.005 S**
Posterior Lateral	Pretest	92.75	4.26	92.54	3.49	0.21	t =0.212 p=0.833 N.S
	Post Test	94.47	3.74	96.55	3.75	2.08	t =2.157 p= 0.035 S*
Posterior Medial	Pretest	94.98	3.40	95.39	3.51	0.41	t =0.467 p=0.642 N.S
	Post Test	97.48	4.07	99.63	3.90	2.15	t =2.093 p=0.041 S*
Lateral	Pretest	77.57	2.74	78.13	3.01	0.54	t =0.750 p=0.457 N.S
	Post Test	79.97	2.99	82.50	2.91	2.53	t =3.327 p=0.002 S**

***p≤0.001,**p<0.01,*p<0.05,S–Significant,N.S–NotSignificant

Table 6: Comparison of pretest and posttest SEBT (left leg stance) between the Control and Experimental group

The above table shows that the comparison of pretest and posttest SEBT (left leg stance) between the Control and Experimental group. The comparison of pretest level of SEBT (left leg stance) score among the samples showed no significant difference between the groups which was evident from the calculated student independent ‗t' test values. The comparison of post test level of SEBT (left leg stance) score among the samples showed significant difference between the groups which was evident from the calculated student independent ‗t' test values for anterior (t=4.828), anterior – lateral (t=4.040), anterior – medial (t=2.827), medial (t=4.487), posterior (t=2.924), posterior – lateral (t=2.157), posterior – medial (t=2.093) and lateral (t=3.327).

Test	**Pretest**		**Posttest**		**Mean Difference Score**	**Paired t"test & p-value**
	Mean	**S.D**	**Mean**	**S.D**		
Control Group	208.07	8.22	210.77	8.22	2.70	t=10.807 p = 0.0001 S***
Experimental Group	208.97	9.29	216.20	9.24	7.23	t=10.369 p = 0.0001 S***
Mean Difference score	0.90		5.43		***p<0.001, *p<0.05,	

Student Independent's" test & p-value	t=0.397 p=0.693 N.S	t= 2.406 p= 0.019 S*	S– Significant N.S–Not Significant

Table7: Comparison of pre test and post test standing board jump within and between the Control and Experimental group

The above table shows the comparison of pretest and post test standing board jump within the control group and t =10.369for experimental group was found to be statistically significant at p<0.001 level. This clearly shows that there was significant improvement in standing board jump among the samples in the control and experimental group.

The above table also shows the comparison of pretest and post test standing board jump between the Control and Experimental group. It shows that the calculated student independent t' test value of t = 0.397 in the pretest was not found to be statistically significant. This clearly shows that there was no significant difference in standing board jump among the samples between the control and experimental group at the pretest level.

The above table further shows that the calculated student independent t' test valueoft=2.406intheposttestwasfoundtobestatisticallysignificant.Thisclearly shows that there was a significant improvement in standing board jump among the samples between the control and experimental group at the posttest level in which the experimental group had better improvement than the samples in the control group.

Test	**Pretest**		**Posttest**		**Mean Difference Score**	**Paired t" test & p-value**
	Mean	**S.D**	**Mean**	**S.D**		
Control Group	26.07	3.90	28.17	3.94	2.10	t=28.571 p = 0.0001 S***
Experimental Group	26.03	3.97	30.90	3.33	4.87	t=13.133 p = 0.0001 S***
Mean Differencescore	0.04		2.73		*****p<0.001,**p<0.01 S –**	

Student Independent t" test & p-value	t=0.033 p=0.974 N.S	**t= 2.904 p= 0.005 S****	**Significant N.S–Not Significant**

Table 8: Comparison of pretest and post test sit and reach for flexibility within and between the Control and Experimental group

The above table shows the comparison of pretest and posttests it and reach for flexibility within the Control and Experimental group. It shows that the calculated paired t' test value of t=28.571 for control group and t=13.133 for the experimental group was found to be statistically significant at p<0.001 level. This clearly shows that there was significant improvement in sit and reaches for flexibility among the samples in the control and experimental group.

The above table also shows the comparison of pretest and post test sit and reach for flexibility between the Control and Experimental group. It shows that the calculated student independent t'test value of t =0.033inthepretest was not found to be statistically significant. These clearly show that there was no significant difference in sit and reach for flexibility among the samples between the control and experimental groups at the pretest level.

The above table further shows that the calculated student independent t' test value oft = 2.904 in the post test was found to be statistically significant at p<0.01 level. This clearly shows that there was significant difference in sit and reaches for flexibility among the samples between the control and experimental group at the posttest level in which the experimental group had better improvement than the samples in the control group.

Post SEBT	direction	Number	mean	S.D	Valueoft statistic	d.f	significance
Group A	anterior	30	90.41	2.29	4.098	58	0.0001
	Anterior lateral		82.86	2.90	2.981		0.004
	Anterior medial		92.04	3.11	3.358		0.001
	medial		95.21	1.99	2.634		0.011
	posterior		98.43	2.29	2.741		0.008
	Posterior lateral		95.85	2.19	2.452		0.017
	Posterior medial		98.23	2.92	2.952		0.005
	lateral		81.04	1.82	4.978		0.0001
	anterior		93.01	2.62	4.098		0.0001
	Anterior lateral		84.89	2.35	2.981		0.004
	Anterior medial		94.37	2.19	3.358		0.001

Group B	medial	30	96.65	2.24	2.634	58	0.011
	posterior		100.22	2.74	2.741		0.008
	Posterior lateral		97.36	2.57	2.452		0.017
	Posterior medial		100.58	3.24	2.952		0.005
	lateral		83.36	1.79	4.978		0.0001

Table: 9 Comparison of the Post SEBT (right) Values of the two groups

Table 9 shows the comparison of post test level of SEBT (right leg stance) score among the samples showed significant difference between the groups which was evident from the calculated student independent t' test values for anterior(t=4.098), anterior – lateral (t=2.981), anterior – medial (t=3.358), medial (t=2.634), posterior (t=2.741), posterior – lateral (t=2.452), posterior – lateral (t=2.952) and lateral (t=4.978).

Post SEBT	**direction**	**Number**	**mean**	**S.D**	**Valueof tstatistic**	**d.f**	**Significance**
Group A	anterior		90.07	2.27	4.828	58	0.0001
	Anterior-lateral		80.75	2.60	4.040		0.0001
	Anterior-medial		93.64	3.11	2.827		0.006
	Medial		96.92	2.19	4.487		0.0001
	posterior		98.80	2.64	2.924		0.005
	Posteriorlateral		94.47	3.74	2.157		0.035
	Posterior-medial		97.48	4.07	2.093		0.041
	Lateral		79.97	2.99	3.327		0.002
Group B	anterior		93.03	2.47	4.828	58	0.0001
	Anterior-lateral		83.56	2.78	4.040		0.0001
	Anterior-medial		96.02	3.42	2.827		0.006
	Medial		99.06	1.44	4.487		0.0001
	posterior		100.83	2.75	2.924		0.005
	Posterior lateral		96.55	3.75	2.157		0.035
	Posterior-medial		99.63	3.90	2.093		0.041
	Lateral		82.50	2.91	3.327		0.002

Table: 10 Comparison of the Post SEBT (left) Values of the two groups

The above table shows the comparison of post test level of SEBT (left leg stance) score among the samples showed significant difference between the groups which was evident from the calculated student independent t' test values for anterior (t=4.828), anterior – lateral (t=4.040), anterior–medial (t=2.827), medial (t=4.487), posterior (t=2.924), posterior– lateral (t=2.157), posterior–medial (t=2.093) and lateral (t=3.327).

Post standing broad jump test	Number	Mean	S.D	Value of t statistic	d.f	Significance
Group A **Group B**	30 30	210.77 216.20	8.22 9.24	2.406	58	0.019 **Significant**

Table: 11 Comparison of the Post standing broad jump test of the two groups

The above table further shows that the calculated student independent t' test value of t = 2.406 in the post test was found to be statistically significant. This clearly shows that there was a significant improvement in standing board jump among the samples between the control and experimental group at the posttest level in which the experimental group had better improvement than the samples in the control group.

Post sit and reach test	Number	Mean	S.D	Valueof tstatistic	d.f	Significance
GroupA **GroupB**	30 30	28.17 30.90	3.94 3.33	2.904	58	0.005 **Significant**

Table: 12 Comparison of the Post sit and reach test of the two groups

The above table further shows that the calculated student independent t' test value of t=2.904 in the posttest was found to be statistically significant at p<0.01 level. This

clearly shows that there was significant difference in sit and reaches for flexibility among the samples between the control and experimental group at the post test level in which the experimental group had better improvement than the samples in the control group.

Demographic Variables Distribution between Groups

Group	Age		Height		Weight	
	Mean	S.D	Mean	S.D	Mean	S.D
Control Group	19.70	1.78	170.20	4.79	63.80	6.09
Experimental Group	20.13	1.50	171.23	6.89	62.30	8.15

Table 13: Comparison of mean and standard deviation of demographic variables of samples in Control group and Experimental group

The above table shows that the mean age of samples in the Control Group A was19.70±1.78 and in the Experimental Group the means age of the samples was 20.13±1.50.

The mean height of samples in the Control Group was 170.20±4.79 and in the Experimental Group the means height of the samples was 171.23±6.89.

The mean weight of samples in the Control Group was 63.80±6.09 and in the Experimental Group the means height of the samples was 62.30±8.15.

Gender wised Distribution of Subjects between Groups

Group	Sex	
	Frequency	Percentage
Control Group	30	100.0
Experimental Group	30	100.0

Table 14: Frequency and percentage distribution of gender of samples in Control and Experimental group

The above table shows that the all 30(100%) were male both in the control and experimental group.

DISCUSSION

The study aimed to find out the effects of Plyometric training on lower limb flexibility, leg explosiveness and dynamic balance among non- professional male football players. 60 subjects those satisfied the inclusion criteria was selected and randomly divided into 2groups;GroupA(control) and Group B(experimental), 30 in each, subjects they do not know which group they belongs, to avoid bias in the study. A brief explanation about the procedure of interventions was given and a consent form was obtained from each subject.

The control group received FIFA11+ warm up training program and subjects in experimental group received plyometric training along with conventional programme for a period of 6 weeks. The pretest and posttest data was collected using Sit and reach test, standing broad jump test and star excursion balance test as outcome measures. Pretest and posttest were analyzed using paired t test and two sample t test as statistical tool.

The result shows that there is a significant improvement in post-test experimental group, mean value of sit and reach test were 30.90 shows high significance with the t value of 13.133 and p value 0.0001.While the comparison of posttest level of SEBT(right leg stance) score among the samples showed significant difference between the groups which was evident from the calculated student independent t' test values for anterior (t=4.098), anterior–lateral (t=2.981),anterior – medial (t=3.358), medial (t=2.634), posterior (t=2.741),posterior–lateral(t=2.452), posterior – lateral (t=2.952)and lateral (t=4.978) and The comparison of post test level of SEBT (left leg stance) score among the samples showed significant difference between the groups which was evident from the calculated student independent ‗t' test values for anterior (t=4.828), anterior – lateral (t=4.040), anterior – medial (t=2.827), medial (t=4.487), posterior (t=2.924), posterior – lateral (t=2.157), posterior–medial (t=2.093) and lateral (t=3.327); While mean value of standing broad jump test were 216.20 shows high significance with the t value of 2.046 and p value 0.019.

The study result shows significant- difference in post-test group of experimental group and control group with 5% level of significance so the study rejects the null hypothesis and hence concluded as Plyometric training shows improvement in lower limb flexibility, leg explosiveness and dynamic balance in non-professional male football players.

The result of the study is consistent with observations of Vaismanet al (2017) football is a complex sporting activity, requires endurance and speed, includes short sprints, quick accelerations, and decelerations, rapid changes of direction, jumps and tackles among many other actions. The estimated injury rate is 9.11 injuries/1000 h of football related activities the dominant muscles in football sport include: upper leg muscles, back and upper back legs, lower legs and ankles, back upper shoulders and arms (Yuwon, Rachman, 2021). The thigh is the most common injury site (31.7%) and muscle strains accounts for 41.2% of all injuries, the substantial physiological demands and the body contact between players account for the higher injury incidence in this sport Shalaj et al (2016).

In this study, after the intervention, lower limb flexibility, leg explosiveness and dynamic balance outcomes improves in subjects of experimental group. Accord with the observations of Rubley et al (2009), it has been demonstrated that Plyometric training improves athletic ability and quality in soccer players.

The plyometric movement employs the pre-stretch of the muscle-tendon unit, and thus the physiological length-tension curve improves the ability of muscle fibers to generate more force. Eccentric muscle contractions generate the most force in plyometric training, followed by isometric contractions and then concentric contractions. The muscle spindle, the Golgi tendon organ (GTO), and the mechanoreceptors in joint capsules and ligaments are all proprioceptors in the body. Both agonist and antagonistic muscles can be facilitated, inhibited, or modulated when these receptors are stimulated.

There is an increase in afferent nerve firing when the muscle spindle is stretched. The strength of the signal transmitted to the spinal cord by the muscle spindle is proportional to the rate at which the stretch is applied. The faster the stretch, the stronger the neuro-logical signal delivered by the muscle spindle, and thus the higher the efferent muscle contraction (the plyometric movement's shortening cycle). Plyometric training aims to link speed and strength, resulting in explosive motions Accord with the observations of Lubis, (2004).

The term is frequently used to describe the process of repeatedly jumping or extending reflexes in order to achieve a more explosive reaction. Similar result was reported by Potach, (2004) in this plyometric method emphasizes the movement of stretching muscles quickly, in order to increase the ability of muscle response. The energy is stored in the elastic components of the muscle between contractions due to the fast conjunction of eccentric and concentric contractions this energy boosts muscle flexibility while also improving power (Saravanan Murugan et al, 2020). Improved flexibility can raise muscle tissue temperature, which improves blood circulation and promotes nutrient transport in the body (Gergley2009, Pearce, Zois &Carlson2009).

Improved circulation and increased nutrient transport to all lower back muscles thereby reduce the risk of injuries (Pacheco, Balius, Perrier ,Pavol, Hoffman,2011) it may reduce the stress in the lower back by relaxing hamstrings, hip flexors, quadriceps and other muscles attached to the pelvis (Marshall & Wallace 2009.Needham).If the lack of proper flexibility in hip flexor muscles may lead to anterior pelvic tilt (Moran, McGrath ,Marshall & Wallace 2009) which in turn increases the lumbar lordosis (Jaggers, Swank, Frost& Lee 2008) it can be resolved by rest, and by improving flexibility through training.

The training also aids in the improvement of lower-body stability. In this study, the experimental group showed Improvement in dynamic balance compared to control group. Accord with the study of Myer et al (2006) concluded that plyometric training regimens help to develop appropriate landing techniques and improve dynamic control in order to keep the center of mass stable. The sources of

visual, vestibular, and proprioceptive stimuli influence balance control. The mechanoreceptors send vital afferent information to the central nervous system about location (static) and movement (dynamic) by converting mechanical energy created by physical deformation of the joint and muscles into electrical energy in the form of nerve action potential for processing.

This system is essential for sustaining equilibrium. Visual cues are important for the creation of static balance, whereas proprioceptive input is required for dynamic balance, where plyometric training can enhance and stimulate proprioceptive activity. Granacher et al reported that the balance of young male soccer players increased significantly after the plyometric training. And it has been determined that different method of plyometric training (vertical, horizontal and combined) can increases the balance in soccer players as well as other motor elements.

Ramírez-Campillo R et al, showed that a significant improvement in all directions of dynamic balance (antero-posterior and medio-lateral balance) in soccer players by after six weeks of plyometric training. Improved dynamic balance has been reported to enhance functional adaptations, feed-forward adjustments that activate appropriate muscle activity before landing and also proprioceptive input, so that lower extremity injury risk may reduce. Might be due to these effects the plyometric training is effective in improving lower limb flexibility, dynamic balance and leg explosiveness in non- professional male football players along with conventional therapy.

This study includes some limitations; first, sample size was very small, further studies with large sample size are needed to confirm the findings. Second, it is not a double-blind study, it would be more accurate with blinded independent assessor to interventions for limiting the risk of bias. Third, the study duration was very short. Finally, Future study can do with other variables also. A Twelve-week program or an eight-week program can also be used in further studies. Only male participants were included in this study, further it can be done with both genders.

CONCLUSION

The study was to evaluate the effectiveness of plyometric training to improve lower limb flexibility, leg explosiveness and dynamic balance among non- professional football players. The result of the study shows that there is statistically significant difference between experiment group and control group. After analyzing the study it can be concluded that plyometric training helps in improving lower limb flexibility, leg explosiveness and dynamic balance in non -professional football players.

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