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Effect of plyometric training on speed, power and agility in adolescents playing basketball

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ABSTRACT

Background and Aims

This study was done to see the effect of plyometric training on adolescents playing basketball on their power, speed and agility after them performing their normal routine. In adolescents power, speed and agility is usually not as good as the elite players, exactly why it leads to various injuries. Plyometric Training has been shown to improve Speed, Power and Agility in Elite players.

Methods

30 Participants were included for this experimental study in the age group 15-17 years, males and females and were randomly divided into 2 groups (n=15); Experimental and Control, the control group performed their normal routine and the experimental group performed their normal routine followed by a set plyometric exercises for 6 weeks, thrice a week. The Pre and Post outcome measures used were Lane Agility Drill Test, 3/4th Court Sprint Test and Standing Vertical Jump Test.

Results

There was an improvement in the Lane Agility Drill Test timing with a p-value of 2.68848E-05, also in the 3/4th Court Sprint Test with a p-value of 0.00389 but not much improvement in the Vertical Jump Test with a p-value of 0.614 in the Experimental Group for all the 3 tests.

Keywords: Plyometric training, Agility, Speed, Power, Amortization, Stretch Shortening Cycle

INTRODUCTION

Basketball is an aerobic-based anaerobic sport which needs high intensity drills which includes jumping, hopping, for taking shots and rebounds, turns, sprints and also low intensity drills are necessary like jogging and walking. [1] In basketball, the ability to generate maximal strength levels in the shortest period of time (muscular power) has been considered as essential to obtain high sport performance levels. The National Federation of State High School Association states that around 1 million students take part in basketball in high school annually. Approximately

23% of these players get injured and more than 65% of these injuries happen to occur in the lower extremity. Many risk factors have been identified in basketball players from which traumatic and overuse lower limb injuries is the most common, previous injuries, being female, biomechanical alignment and anatomical factors, reduced muscle flexibility, reduced vertical jump height, use of tape or braces, reduced reflex response time, and poor balance. Of these factors, not all are directly modifiable. The most modifiable risk factor in prevention of injuries has been identified to be neuromuscular control according to a lot of reports. [2]

Plyometric training is defined as a system of high-velocity resistance training characterized by a rapid, resisted, eccentric contraction during which the muscle elongates, immediately followed by a rapid reversal of movement with a resisted concentric contraction of the same muscle. [3]

There is a rapid elongation followed by an immediate shortening utilizing the elastic energy stored during the stretching phase that occurs in the muscles during these exercises. The stretch cycle is the rapid eccentric loading phase, and the shortening cycle is the concentric phase. The time between the shortening cycle and the stretch is called as the Amortization phase and it is necessary to keep this phase as brief as possible by a rapid reversal of movements to capitalize on the increased tension in the muscle. [4]

Plyometric training has been applied in various studies and there is a general agreement that it improves sports specific skills such as vertical jump and muscle power production and agility. [5]

Agility has been defined as a rapid whole body movement with change of velocity or direction in response to stimulus. [6]

Change of direction refers to a movement where no immediate reaction to a stimulus is required, thus the direction is pre-planned and is affected by strength, power and speed. [6]

Power is defined as the ability to exert maximal force in as short time as possible as in accelerating, jumping and throwing implements. [4]

Speed is defined as the ability to move across the ground or move limbs rapidly to grab or throw. [4]

Sports physical therapists take great efforts to avoid injuries, rehabilitate the injuries in such a way that the athletes returns to performing his activities, improves the strength and conditioning of the athletes and also make the specificity of sports performance easy. Because of this, there is an increasing demand to improve performance as faster as possible. [7]

Plyometrics may be included as an integral part of the exercise program that can produce all the aforementioned outcomes. As great forces are being imposed on the extremities during sports and athletics, it is necessary to have increased force production so therefore there is a huge demand to develop power in the performance phase of rehabilitation. [7]

The prevalence of a basketball player getting injured in a game is very high and therefore to avoid such injuries it is important to train the particular players in a way such that their speed, power and agility improves and injuries are reduced.

METHODOLOGY

Participants were selected on the following criteria: (1) Participants who play basketball on an inter-collegiate level (2) age group 15-17. (3) Males and females. Participants with history of pain in the lower limbs, pathology or trauma or surgery done in the lower limbs, individuals who are already doing high-intensity training, respiratory disorder, neurological disorder, were excluded from the study.

Thirty participants met this criteria and an informed consent was taken from them in written format. The procedure was explained to the participants by the therapist.

Formation of Groups

Thirty Participants were randomly divided into two groups, Group A: Control and Group B: Experimental Group. Group A performed their normal routine practice. Group B performed their normal routine practice and then immediately performed a set of plyometric exercises.

Outcome Measures

Lane Agility Drill Test [8] - Set up the cones as illustrated in the diagram. The test is based on the pro-sized foul lane (16’ wide x 19’ deep). Lane width is only 12 feet. The markers are set outside the lane markings. The subject will start with one foot behind the start line. Hand timing starts from

the first movement from the set position. Run towards the baseline i.e. forward, then once you reach the cone, start a side shuffle and move to the right across the baseline. Once you reach the next cone, start a back pedal till the foul line and then again start a side shuffle towards the left i.e. at the starting cone. Here the subject touches the floor and again performs the same drill in the reverse direction to complete another revolution. During the entire testing, the subject should always be facing the baseline. 3 trails are allowed. [8]

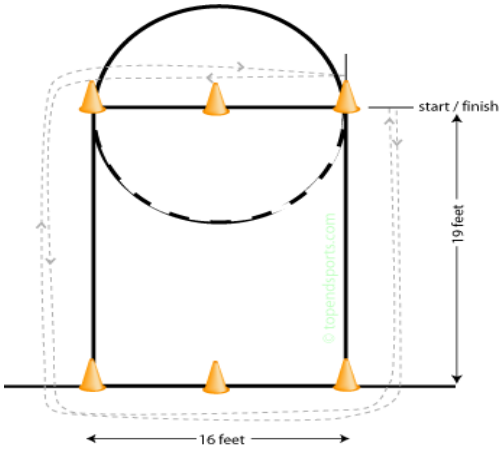


Fig. 1: Lane Agility Drill Test

3/4th Court Sprint Test [9].- In this test, the subject is asked to run at a maximum sprint over ¾ of a basketball court. 2 cones are placed at the elbows of free-throw lane lines and baselines, and 2 cones on the opposite free- throw lines. A proper warm-up should be done. The subject should start from the behind the court baseline, with 1 foot up to the line. The tester should ask the subject to continue running hard past the finish markers and also encourage to maximize speed. 3 trails are allowed and best time is recorded to the nearest 2 decimal place. [9, 10]

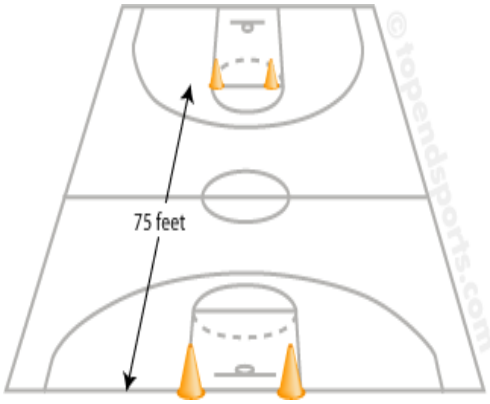


Fig. 2: 3/4th Court Sprint Test

Standing Vertical Jump Test. [11] The athlete stands next to wall with his hand reaching closest to the wall. The feet should be kept flat on the ground and this point of fingertips is marked. This is called Standing Reach Height. The athlete then moves a little Away from the wall and jumps vertically as high as possible using both arms and legs to assist the body to move upwards. The athlete then attempts to touch the wall at the highest point of the jump. The difference between jump height and the standing reach height is the score. 3 trials are allowed. [11]

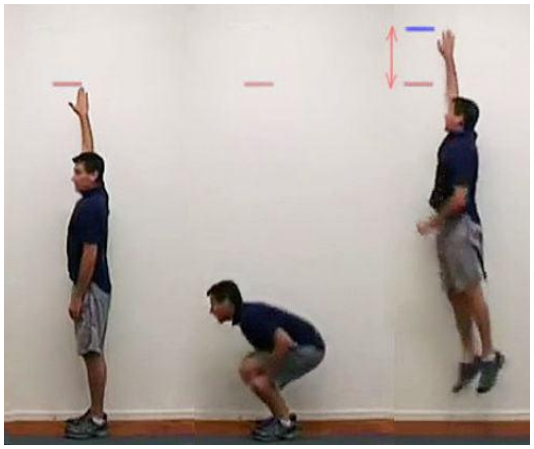


Fig. 3: Standing Vertical Jump Test

Tests were conducted, Pre and Post; prior to the training a total testing session was done for each participant. Warm-up; 10 minute rest between each tests. 3 minute rest between reps. Before testing, subjects were given practice trials to become familiar with the testing procedures. All tests were counterbalanced pre and post testing to ensure that testing effects are minimized. Subjects performed each test 3 times and the results were averaged. Anthropometric data of the participants were also taken which consisted of Height and Weight.

Intervention

Group A (Control group)

The participants in the control group were first tested for all the three tests prior the training session could be started. They performed their normal basketball routine which consisted of warm up in which they were made to do neck rotations, wrist rotations, Elbow movements, shoulder rotations, hip rotations, cross toe touches, Front middle back toe touches, spot marching, ankle rotations, hops, skipping, court sprints, double leg hops. Minimum ten repetitions of each exercise were performed. After which they performed a set a basketball specific exercises which consisted of Layups, Passing Practice, Layups with passing, Rebound practice, Sprints and each exercise was repeated at least 25 times. They did not perform the plyometric exercises. At the end of six weeks, the participants were tested for all the 3 tests again.

Group B (Experimental Group)

The participants in the experimental group were also first tested for all the three tests prior the training session was started. They also performed their normal basketball routine same like the Control Group. After performing the basketball specific Exercises, they performed a set of Plyometric Drills which were taken by the therapist.

6 Week training protocol [12]

TRAINING WEEK	PLYOMETRIC DRILL	SETS X REPS	TRAINING INTESITY
WEEK 1	Side to side ankle hops	2 X 15	Low
	Standing jump and reach	2 X 15	Low
	Front cone Hops	2 X 6	Low
WEEK 2	Side to side ankle hops	2 X 15	Low
	Standing Long Jump	2 X 6	Low
	Lateral jump over barrier	2 X 15	Med
	Double leg hops	5 X 6	Med
WEEK 3	Side to side ankle hops	2 X12	Low
	Standing Long Jump	4 X 6	Low

	Lateral Jump over barrier	22 X 12	Med
	Double Leg Hops	3 X 8	Med
	Lateral Cone Hops	2 X 12	Med
WEEK 4	Diagonal cone hops	4 X 8	Low
	Standing long jump with lateral sprint	4 X 8	Med
	Lateral cone hops	2 X 12	Med
WEEK 5	Diagonal cone hops	2 X 7	Low
	Standing long jump with lateral sprint	4 X 7	Med
	Lateral cone hops	4 X 7	Med
	Cone hops with 180 deg turn	4 X 7	
WEEK 6	Diagonal cone hops	2 X 12	Low
	Hexagon drills	2 X 12	Low
	Cone hops with change of direction sprint	4 X 6	Med
	Double leg hops	3 X 8	Med

The sessions were performed thrice a week for 6 weeks and the intensity of the exercises increased every week. [12] Post six weeks, the participants were again tested for all the 3 tests.

RESULTS

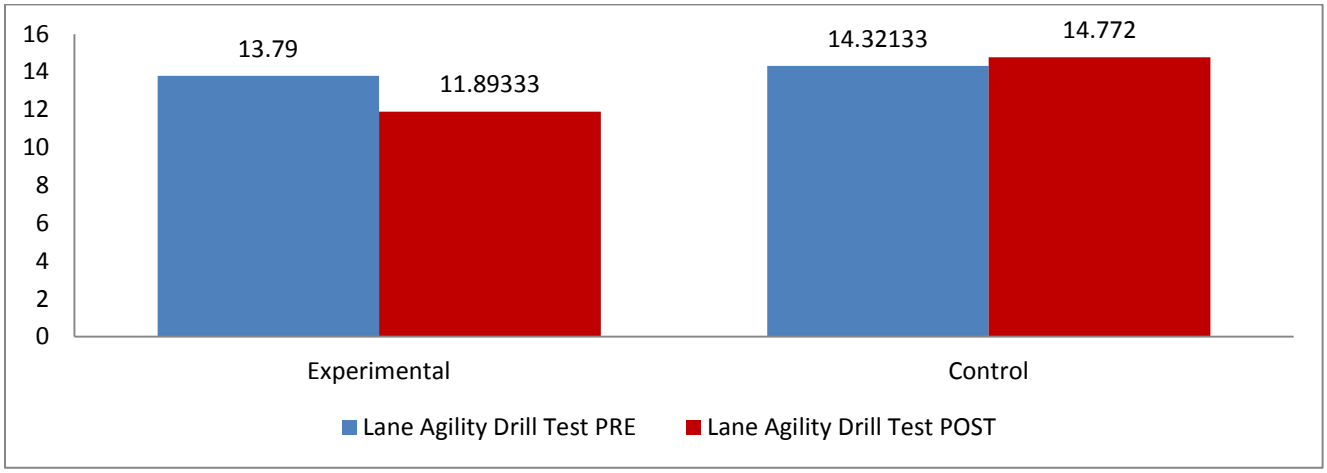
The study included 30 subjects in the age group of 15-17 years, 12 Girls and 18 Boys. 't' test was applied in the study, Paired 't' test was used within the groups(pre and post) and Unpaired 't' test was used between the groups(Experimental and Control). [13]

Table 1. Comparison between Experimental and Control Groups within the groups.(Paired 't' test)

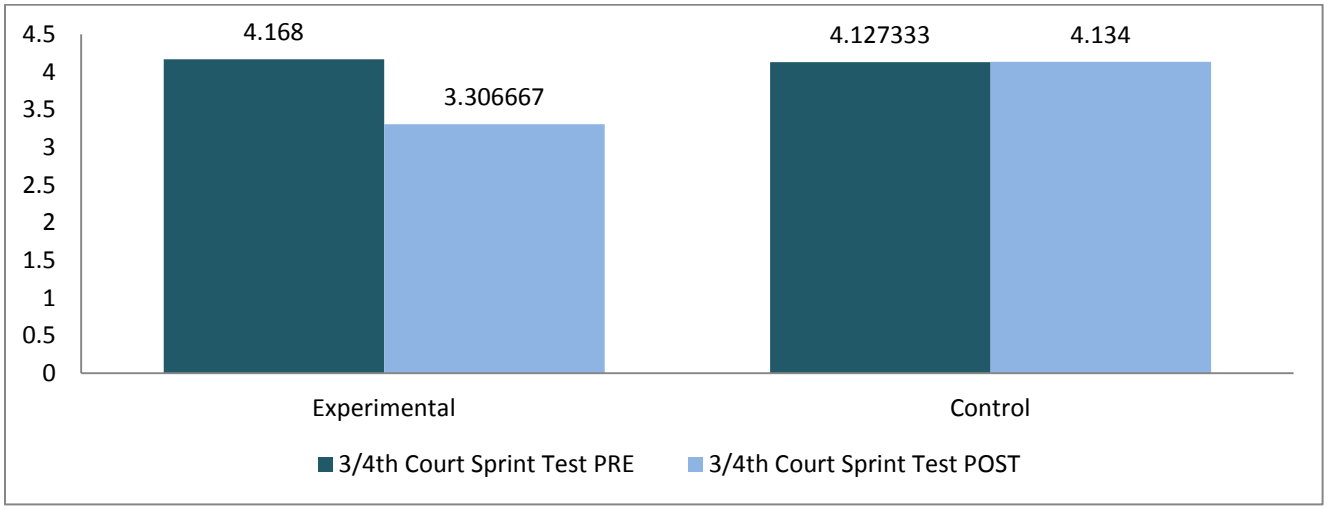
	CONTROL			**EXPERIMENTAL**			**SIGNIFICANCE**
TEST	Average		'P' Value	Average		'P' Value	
	PRE	POST		PRE	POST		
Lane Agility Drill test	14.32	14.77	0.01755	13.79	11.89	9.82307E-11	Extremely Significant
3/4th Court Sprint Test	4.13	4.13	0.43868	4.16	3.30	1.61802E-06	Extremely Significant
Vertical Jump Test	0.40	0.40	0.10189	0.34	0.46	6.72946E-10	Extremely Significant

Table 2: Comparison between Experimental and Control groups between the groups.(Paired 't' test)

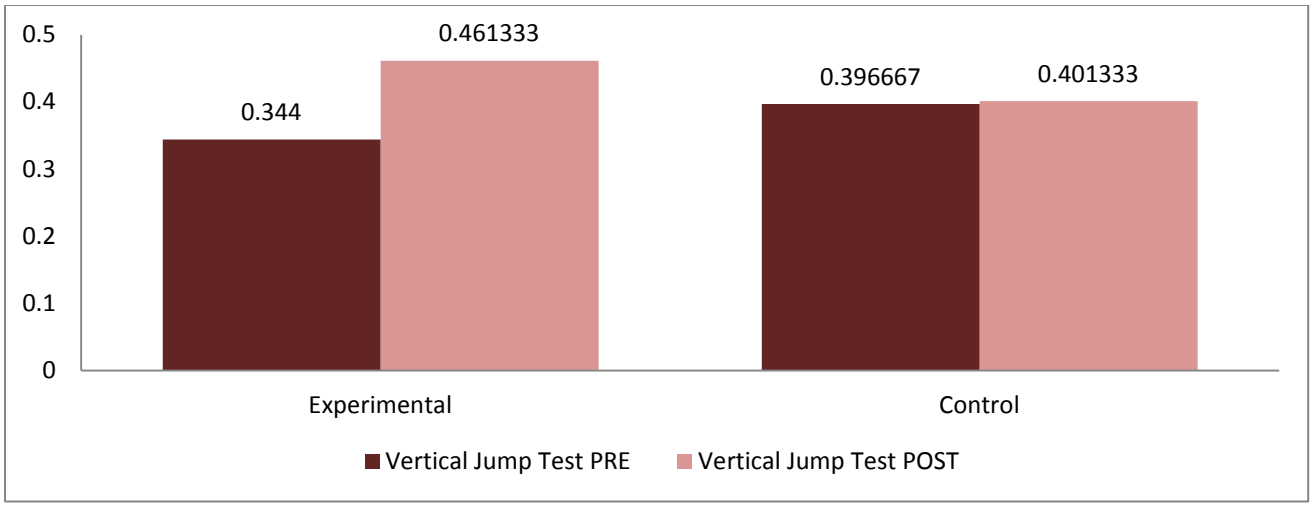
Tests	**Average**		**'P' Value**	**Significance**
	Experimental	**Control**		
Lane Agility Drill Test	12.005	14.772	2.68848E-05	Extremely Significant
3/4th Court Sprint Test	3.306	4.134	0.00389	Significant
Vertical Jump Test	0.46	0.40	0.614929	Not Significant



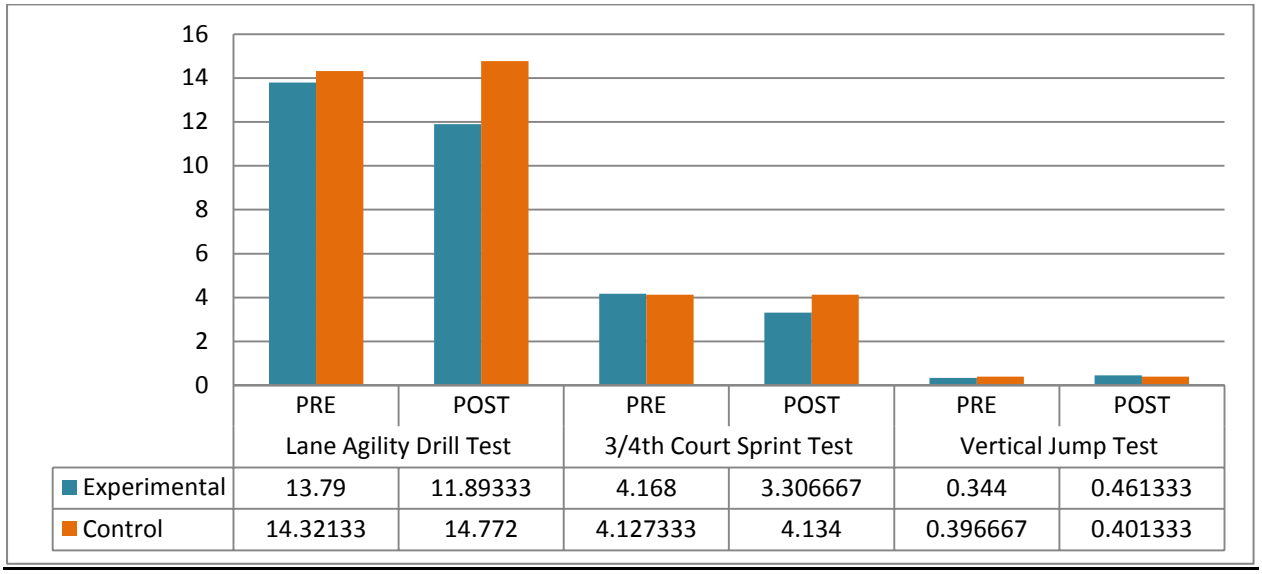
Graph 1: The comparison between the Experimental and Control group for Lane Agility Drill Test.



Graph 2: The comparison between the Experimental and Control group for 3/4th Court Sprint Test.



Graph 3: The comparison between the Experimental and Control group for Vertical Jump Test.



Graph 4: Comparison Between Experimental and Control Group

Within the group and between the groups analysis of Lane Agility Drill showed improvement post the Plyometric training in the Experimental Group and was statistically significant ($p < 0.0001$). Within the groups and between the groups analysis of 3/4th Court Sprint showed improvement post the Plyometric training in the Experimental Group and was also statistically significant ($p < 0.0001$).

Within the groups analysis for Standing Vertical Jump showed improvement post the Plyometric training in the Experimental Group ($p < 0.0001$) but between the groups the plyometric training did not show much improvement. ($p=0.614929$). The analysis shows that there was an improvement clinically between the experimental and control group but was not significant statistically.

DISCUSSION

The study was performed to assess the effect of Plyometric Training on Speed, Power and Agility in adolescents playing basketball. The study was performed on 30 subjects playing basketball on an inter-collegiate level. The subjects were then randomly divided into experimental and control group(n=15) respectively in which the experimental group performed a group of plyometric exercises right after their warm-up and the control group only performed their warm-up and routine practice. Each subject from the experimental group performed the sessions thrice a week for 6 weeks. The outcome measures were 3/4th Court Sprint Test to assess Speed, Lane Agility Drill Test to assess Agility and Standing Vertical Jump Test to assess Power. In this study, 30 students were included, 12 girls and 18 boys in the age group 15-17 years playing basketball. Out of this, 15 students were in the Experimental group that included 7 girls and 8 boys, and the same for the Control group.

The main result from this study was that Plyometric Training increased the Speed, Power and Agility in the subjects. The project study has shown an improvement in the speed taken pre and post the plyometric training. The 3/4th Court Sprint Test shows that there's a decrease in the time of the subjects.

The paired 't' test result for pre and post of 3/4th Court Sprint test was 1.61802E-06. The 'P' value is less than 0.0001, which is extremely significant. The unpaired 't' test result for post values between the experimental and control group was 0.00389 which is less than 0.0001, which is significant.(Table 1,2) (Graph 2)

Some plyometric drills which are specifically for speed have showed an improvement in increasing speed. The study has shown an improvement in the Agility taken pre and post the plyometric training. The Lane Agility Drill Test shows that there's a decrease in time of the subjects.

The paired 't' test for pre and post for Lane Agility Drill Test was 9.82307E-11. The 'P' value is less than 0.0001, which is extremely significant.

The unpaired 't' test for post values between the experimental and control group was 2.68848E-05, which is less than 0.0001, which is extremely significant.(Graph 1)

The study also showed an improvement in the jump height taken pre and post the plyometric training. The Vertical Jump Test shows that there's an increase in the vertical jump post the sessions done on the subjects. The paired 't' test for pre and post for Vertical Jump Test was 6.72946E-10 and the 'P' value is less than 0.0001 which is extremely significant. The unpaired 't'test for post values is 0.614929, which is not significant. (Graph 3) The analysis shows that there was an improvement clinically between the experimental and control group but was not significant statistically. This might be because of the short duration of the plyometric training being done on the subjects as it has been proven that Short term Plyometric Training does not have a very significant effect on vertical jump performance in players.(Table 1,2) [5, 15]

In Plyometrics, the physiology that takes place is such that the elastic energy in the tendons and muscles is increased with a rapid stretch and then briefly stored. This is the eccentric muscle action. If immediately following this a concentric muscle action occurs that is the stored energy is released, it all is equivalent to the force produced/generated. [14]

In a plyometric movement, the pre-stretch of the muscle-tendon unit physiological length-tension curve is what is being used to improve the ability of the muscle fibres to generate more tension and therefore more resultant force production. [8]

The skeletal muscle function is such that the Series Elastic Component (SEC), when stretched happens to store an elastic energy that increases the force produced. The Contractile Component (CC) that comprises of actin, myosin and cross-bridges is the main and primary source of muscle action during a concentric muscle action. The Parallel Elastic Component (PEC) that comprises of perimysium, epimysium, endomysium and sarcolemma, this all together exerts a passive force with unstimulated stretch. [14]

TABLE 16.1

Stretch-Shortening Cycle

Phase	Action	Physiological event
I—Eccentric	Stretch of the agonist muscle	▪ Elastic energy is stored in the series elastic component. ▪ Muscle spindles are stimulated.
II—Amortization	Pause between phases I and III	▪ Type Ia afferent nerves synapse with alpha motor neurons. ▪ Alpha motor neurons transmit signals to agonist muscle group.
III—Concentric	Shortening of agonist muscle fibers	▪ Elastic energy is released from the series elastic component. ▪ Alpha motor neurons stimulate the agonist muscle group.

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[14]

Whenever a muscle is stimulated, a stretch reflex is generated, i.e. an involuntary response of the muscle to an external stimuli which causes stretch in the muscle, so therefore it sends an input to the spinal cord via Type Ia nerve fibres. After synapsing with the alpha motor neurons in the spinal cord, a reflexive muscle action is caused is the impulses travel to the agonist extrafusal fibres. [14]

The stretch shortening cycle makes use of the stimulation of the stretch reflex and energy storage of the SEC to facilitate maximal increase in muscle recruitment over a small period of time. [14]

Plyometric training utilizes the *stretch-shortening cyc*le (SSC) by using a lengthening movement (eccentric) which is quickly followed by a shortening movement (concentric). [7]

The exercises used for training in the study were based on the Stretch Shortening Cycle (SSC) for power production and improvement in performance.

Hence the positive result of these tests namely Agility Drill Test, 3/4th Court Sprint Test and

Vertical Jump Test can be attributed to this mechanism of Stretch Shortening Cycle (SSC).

CONCLUSION

The Tests done were Lane Agility Drill Test which showed an improvement in the time taken by the subjects, the 3/4th Court Sprint Test also showed an improvement in the speed of the subjects tested. The Vertical Jump Test showed that there was an increase in the jump performance of the subjects.

Clinical Implication

As it is seen that plyometric training has a positive effect on the Vertical Jump performance, Agility performance and Speed performance, it can be routinely incorporated as a part of training protocol for the basketball players.

Further Scope

The study can be done for a longer duration i.e., for more than 6 weeks. [15]

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