Comparative Analysis of Plyometric Training Program and Dynamic Stretching on Vertical Jump and Agility in Male Collegiate Basketball Player

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Abstract: The purpose of the study was to compare, analyze the individual and combined effect of plyometric training program and dynamic stretching on vertical jump and agility. The subjects included 45, healthy male collegiate basketball players between the ages of 18-25. All subjects were tested in the vertical jump and agility using the Sergeant Jump test and T-test respectively prior to starting the dynamic stretching and plyometric training program. The subjects then completed a four week plyometric training program and were retested. Univariate ANOVA was conducted to analyze the change scores (post – pre) in the independent variables by group (plyometric, dynamic stretching and combined) with pre scores as covariates. The Univariate ANOVA revealed a significant group effect for Sergeant Jump test F = 12.95, P = 0.000 for Dynamic stretching group, F = 12.55, P = 0.000 for Plyometric training group and F = 15.11, P = 0.000 for combined group. The combined group reveled, maximum increase in the height when compared with the pretest scores. For the T-Test agility scores a significant group effect was found F = 2.00, P = 0.043 for Plyometric training group, F = 9.14, P = 0.000 for combined group while dynamic stretching group F = 2.11, P = 0.088 reveled non significant results. The findings suggested that two days of plyometric training a week in combination with dynamic stretching for four weeks is sufficient enough to show improvements in vertical jump height and agility. The results also suggest that two days of plyometric training and dynamic stretching are equally effective in improving vertical jump height. In contrast dynamic stretching two days a week for four weeks was not sufficient enough to show improvements in agility while plyometric training was sufficient.

Keywords: Plyometric, Dynamic Stretching, Agility, Sergeant Jump, Basketball

Introduction

Basketball is one of the most popular team sport extensively played and viewed all over the world. Through time, basketball has developed to involve common techniques of shooting, passing, dribbling, including player's positioning as well as offensive and defensive structures. While competitive basketball is carefully regulated, numerous variations of basketball have developed for casual play. While competitive basketball is primarily an indoor sport, played on a basketball court, less regulated variations have become exceedingly popular as an outdoor sport among both inner city and rural groups. What does a basketball player needs? Apparently, it is the ability to rapidly switch between forward, backward, lateral and vertical movement. Now, the question arises to our minds "How we can enhance the above movements?" Possibly through basic training or some enhanced training programs. It is understood that the key to success for any game is to become proficient with the more basic training versions and then advance to more difficult ones, In view of the above, we can say a basketball player needs good fitness, flexibility, power, strength, agility, endurance and vertical jumping ability to achieve sporting targets.

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This study is an attempt to address few above said components through plyometric exercises and dynamic stretching with the view to help basketball player achieving good performance during the game. Researches have suggested that plyometric exercises were initially utilized to enhance sport performance and are more recently being used in the rehabilitation of injured athletes to help in preparation for a return to sport participation [1]. Plyometric training can contribute to improvements in vertical jump performance, acceleration, leg strength muscle power, increased joint awareness and overall proprioception. Plyometric drills usually involve stopping, starting, and changing directions in an explosive manner. These movements are components that can assist in developing agility [2]. By enhancing balance and control of body positions during movement, agility theoretically should improve. It has been suggested that increases in power and efficiency due to plyometrics may increase agility training objectives and plyometric activities have been used in sports such as football, tennis, soccer or other sporting events that agility may be useful for their athletes [2]. Plyometric is a rapid pre stretching of a muscle during an eccentric action, followed immediately by a concentric action of same muscle and connective tissue. The sequence of events is known as "stretch shortening cycle" [2]. It is a form of exercise which links strength with speed of movement. There are basically two phases of muscle contraction during the running or jumping motion. Muscles go through a stretch phase, and then a contraction phase. These exercises are designed to shorten the cycle time between the two phases. A rapid cycle time allows maximum energy transfer between stretch and contraction phases the stored elastic energy within muscle is used to produce more force than can be provided by a concentric action alone [2]. Flexibility is often overlooked as a factor in leaping ability of a player; jumping high is based on the elasticity of muscles and tendons. Without extreme flexibility, one can never jump as high as he can with proper training. Flexibility can be attained by proper stretching, it is a technique to elongate the muscle. Static stretching involves holding a position while dynamic stretching involves moving parts of your body and gradually increasing reach, speed of movement or both. With this dynamic nature of stretching, literature is suggestive of affecting agility along with flexibility. Basic hamstring and quadriceps stretches can be done in just a few minutes either standing or seated on the floor. But some professionals believe that stretching does not help to increase vertical performance, while other believe stretching has no bearing on vertical jump performance and is just a result of proper form of execution of jump[3]. It has also been widely acknowledged that insufficient research has been conducted to determine the effects of stretching on sporting activities. Dynamic stretching as well as plyometric exercises is commonly used to enhance vertical jump and agility. Various studies have been done to see the effect of dynamic stretching and plyometrics on vertical jump and agility in different sports and age groups. Majority of research literature prove it to be effective and accepted globally, but very few have talked about their comparative and combined effect on these variables. This study was taken up to see the comparative as well as combined effect of dynamic stretching and plyometric training program on vertical jump and agility in male collegiate basketball players.

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Materials and Methods

Subjects: 45 subjects who met the inclusion criteria were assigned to three groups. Group-A included 15 subjects who performed the Dynamic Stretching. Group-B included 15 subjects who performed the Plyometric Training Program. Group-C included 15 subjects who performed both the training. Subjects were selected from Giri Centre of Sports Authority of India at Haryana Agricultural University campus, Hisar (Haryana), Mahavir Stadium Hisar (Haryana. All the subjects were assessed for inclusion and exclusion criteria of the study. Healthy males within the age group 18 – 25 years playing basketball at collage level were included for the study. Individuals who had good flexibility, satisfactory balance and functional strength, full ROM, good muscle power were included in the study. Individuals with any musculoskeletal and neurological impairment, any pathological condition of spine, hip, knee and pelvis, any traumatic condition in past 6 months were excluded from the study.

Procedure:

Preliminary measurements, taken prior to beginning the study, included the measurement of vertical jump height and agility score Sergeant Jump Test: The athlete stands side on to a wall and reaches up with the hand closest to the wall. Keeping the feet flat on the ground, the point of the fingertips is marked or recorded. The athlete then stands away from the wall, and jumps vertically as high as possible using both arms and legs to assist in projecting the body upwards. Attempt to touch the wall at the highest point of the jump. The difference in distance between the reach height and the jump height is the score. The best of three attempts is recorded (Figure 1, 2)

Figure 1: Reach position for Sergeant Jump test

Figure 2: Subject performing Sergeant Jump test

T-Test Agility: The four cones were set as illustrated in the diagram below. The subject starts at cone A. On the command of the timer, the subject sprints to cone B and touches the base of the cone with their right hand. They then turn left and shuffle sideways to cone C, and also touch its base, this time with their left hand. Then shuffling sideways to the right to cone D and touching the base with the right hand, then shuffle back to cone B touching with the left hand, and run backwards to cone A. The stopwatch is stopped as they pass cone A. (Figure 3, 4)

Figure 3: Starting Position for T- Test

Figure 4: Subject performing T-Test

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The measurement was performed in an identical manner in all the three groups before starting the training after 1st, 2nd, 3rd, 4th weeks of the training. Dynamic Stretching procedures: Subjects Performed dynamic stretching for the following muscle groups i.e. hamstrings quadriceps, glutei, hip flexors and calf (Table-1). Plyometric training procedure: The subjects performed different types of plyometric drills initiated with low intensity and winded up with high intensity (Table-2).

Table-1: Dynamic Stretching Procedure

S. No	Muscle group	Stretch	Preparation	Execution
1	Quadriceps	Split lunge	Stand with feet far apart; one foot forward and other foot behind	Squat down by flexing knee and hip of front leg until knee of rear leg is almost in contact with floor i.e. bouncing the heel to the glutei. Return to original standing position by extending the hip and knee of the forward leg. Repeat. Continue with opposite leg
2	Gluteus	Seated side lunge	Stand with the feet shoulder width apart	Lunge to one side with first leg. Land on heel then forefoot. Lower body by flexing knee and hip of lead leg, keeping knee pointed the same direction of foot, bouncing on the front leg. Return to original standing position by forcibly extending the hip and knee of the lead leg. Repeat by alternating lunge with opposite leg
3	Hamstrings	Sitting leg 'fence' rhythm stretch	Be in a sitting position, Straighten the right leg and keep the foot upright with the fence, bend the left leg and place the sole of the left foot against the inside of the opposite thigh or knee	Bend gently forward from the hips and reach for your ankle. Do not try to force your head to your knee. Keep the toes of the straight leg pointing upward and the leg relaxed. Keep repeating this on the alternating legs
4	Hip flexors	Split lunge bounce	Stand with feet far apart; one foot forward and other foot behind	Squat down by flexing knee and hip of front leg until knee of rear leg is almost in contact with floor. Return to original standing position by extending the hip and knee of the forward leg. Continue with opposite leg
5	Calf	Single leg wall bounce	Lean against a wall and extend your right leg back, keeping your heel on the ground, and bend your left leg	Lean towards the wall, keeping your body in a straight line. Gradually step back with the right leg as far as you can go, keeping your heel on the ground.

Warm up/ Cool down Procedure: All the subjects underwent 11 minutes of warm up protocol including 5 minutes of static stretching and 6 minutes of jogging prior to training and ended up with cool down session of 7-8 minutes of jogging. Time duration: All the training programs were carried out for 2 days per week for four weeks. Post-stretch measurements after 1st, 2nd, 3rd, 4th weeks post intervention measurements for the vertical jump height and T- test agility score were taken the same manner as the pre intervention measurements .All the measurements were taken by the same examiner.

Table-2: Plyometric drills

S.No	Drill	Equipment	Start	Action
1	Side to side ankle hops		Stand with feet shoulder width apart and the body in vertical position.	Using both feet jump side to side, covering a span of two to three feet; produce the motion from the ankles. Keep the feet shoulder width apart and land on both feet at the same time
2	Standing jump and reach	Wall with a target marked	Stand with feet shoulder width apart	Squat slightly and explode upward, reaching for a target. Do not step before jumping
3	Front cone hops	A row of 6 to 10 cones set at 3 feet apart	Stand with feet shoulder width apart at the end of line of barriers.	Keeping feet shoulder-width apart, jump over each barrier, landing on both the feet at the same time. Use a double arm swing and work to decrease the time spent on the ground between each barrier
4	Split squat jump		Spread the feet far apart, front to back, and bend the front leg 90^0 at the hip and knee	Jump up, using arms to help lift, and hold the split squat position. Land in the same position and immediately repeat the jump
5	Standing long jump	Soft landing surface	Stand in semi squat with feet shoulder width apart	Using a big arm swing and a counter – movement (flexing) of the legs, jump forward as far as possible
6	Lateral jump over barrier	One cone or hurdle	Stand alongside the object to be cleared	Jumping vertically but pushing sideways off the ground, bring the knees up to jump sideways over the barrier
7.	Double leg hops		Stand with feet shoulder width apart	Squat down and jump as far forward as possible. Immediately upon touching down, jump forward again. Use quick double arm swings and keep landings short.

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8.	Lateral cone hops	3 to 5 cones lined up 3 feet apart	Stand with feet shoulder width apart at the end of line of cones	Jump sideways down the row of cones, landing on both feet. In clearing the last cone, land on the outside foot and push off to change direction, then jump two footed back down the row of cones sideways. At the last cone, push off again on the outside foot and change directions
9.	Tuck jumps with knees up		Stand with feet shoulder width apart and the body in vertical position, do not bend the waist	Jump up, bringing the knees up to the chest and grasping the knees with the hands before the feet return to the floor. Land in a standing vertical position. Repeat the jump immediately
10.	Single leg bounding		Stand on one foot	Bound from one foot as far forward as possible, using the other leg and arms to cycle in the air for balance and to increase forward momentum.
11	Lateral jump single leg		Stand with shoulder width apart	Jump up but push sideways to the left off the ground and land on your left foot. Immediately push off sideways to the right, landing on the left foot again. Continue pushing off from and landing on your left foot for the prescribed repetitions. Repeat this exercise using other leg.

Results:

The descriptive data for age, height and mass for all the 3 groups was matched and no statistical difference was found.

Data analysis was done using the software package SPSS. The mean and standard deviation of all the variables were analyzed. The general linear model, repeated measure procedure provides analysis of variance (ANOVA) when same measurement is made several times on each subject. This test was thus taken up for the study to analyze the results obtained over a period 4 weeks after pre-test value recording.

Vertical Jump: As per the graph 1, vertical jump increases significantly in Group **C >** A, but there was a slight decrease in the vertical jump height in Group A for the 1st week which can be seen through the mean ± S.D values that show initial values as Group A- 46.86a ± 2.604, Group B - 46.26a ± 2.792, Group C - 47.ooa ± 2.097 and

1st week values as Group A- 49.66b ± 2.526, Group B - 45.66c ± 3.062, Group C - 53.40a ± 3.680. In the 2nd week there was a more significant improvement in Group B - 48.93b ± 3.261 but Group A - 51.00ab ± 3.116 and C - 52.60a ± 3.960 showed almost similar results. Group C - 55.40a ± 4.747 showed most significant improvements in the 3rd week but Group A - 52.06b ± 2.016 and B - 50.40b ± 2.720 showed almost similar results. There was a slight decrease in the mean value of vertical jump during the 4th week of study but Group C - 54.60a ± 4.656 showed the best significant results while Group A - 51.66b ± 2.439 and B - 49.93b ± 2.840 showed almost similar statistically significant results when compared with the initial values. (Table-3)

Table-3: Mean and standard deviation for vertical jump height at different intervals (Pre training, Post 1st, 2nd, 3rd, 4th weeks) of exercises for Group A, Group B and Group C
Note: Means with the same superscript are not significantly different.

Mean ± S.D.					
Gr	Pre training	Post 1st wk	Post 2nd wk	Post 3rd wk	Post 4th wk
A	46.86^{a} ± 2.604	49.66^{b} ± 2.526	51.00^{ab} ± 3.116	52.06^{b} ± 2.016	51.66^{b} ± 2.439
B	46.26^{a} ± 2.792	45.66^{c} ± 3.062	48.93^{b} ± 3.261	50.40^{b} ± 2.720	49.93^{b} ± 2.840
C	$47.oo^{a}$ ± 2.097	53.40^{a} ± 3.680	52.60^{a} ± 3.960	55.40^{a} ± 4.747	54.60^{a} ± 4.656
C.D.	2.403	2.303	2.554	2.481	2.542

Table 4 : ANOVA for vertical jump height at different intervals (Pre training, Post 1st, 2nd, 3rd, 4th weeks) of training within Group A, Group B and Group C
$P \leq 0.05$ – Significant $P \geq 0.05$ – Not significant * - Significance T-test

Group	F value	P value
A	12.95	0.000**
B	12.55	0.000**
C	15.11	0.000**

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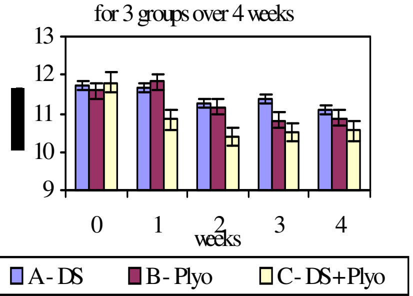
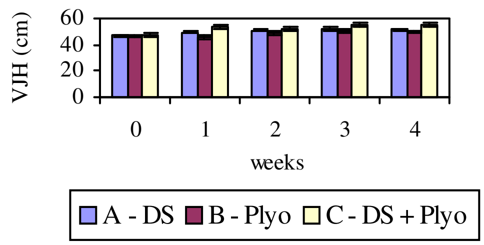
Graph 1 Mean comparison of agility score for 3 groups over 4 weeks



Graph 2. Mean comparison of VJ for the 3 groups



Graph-1 clearly demonstrates a decrease in agility score during the 4 weeks. As per the graph Group C show most significant decrease in agility score while Group A had shown a slight significant decrease but Group B demonstrated some increase in the agility score which can be compared through the mean ± SD values, initial values for Group A - 11.70a ± 1.595, Group B - 11.60ab ± 1.959, Group C - 11.80b ± 0.284 and 1st wk values for group A - 11.64a ± 1.150, group B - 11.83a ± 1.404, Group C -10.85b ± 0.158.

During the 2nd week all the 3 groups has shown significant decrease in the agility score but Group C was the most significant as shown by the values for mean ± SD for Group A -11.24a ± 1.006 , Group B -11.17a ± 0.906, Group C - 10.39b ± 0.109. There was a slight increase in the agility score for Group A -11.35a ± 0.86 and Group C -10.51b ± 0.478 during the 3rd week , while Group B - 10.81b ± 0.635 has shown significant decrease in the 3rd week also. 4th week landed up with some increase in the agility score for Group B - 10.88ab ± 0.605 and C - 10.54b ± 0.378 while Group A - 11.10a ± 0.712 has shown slight decrease when compared to the scores of the 3rd week. Group C has shown most significant decrease in the agility score, group A has shown least significant difference while Group B had shown almost similar results to both the groups when compared with the initial values. (Table 5)

Table 5: Mean and standard deviation for agility score at different intervals (Pre training, Post 1st, 2nd, 3rd, 4th weeks) of exercises for Group A, Group B and Group C
Note: Means with the same superscript are not significantly different.

Mean ± S.D.					
Groups	0 wk	1st wk	2nd wk	3rd wk	4th wk
A	11.70^{a} ± 1.595	11.64^{a} ± 1.150	11.24^{a} ± 1.006	11.35^{a} ± 0.86	11.10^{a} ± 0.712
B	11.60^{ab} ± 1.959	11.83^{a} ± 1.404	11.17^{a} ± 0.906	10.81^{b} ± 0.635	10.88^{ab} ± 0.605
C	11.80^{b} ± 0.284	10.85^{b} ± 0.158	10.39^{b} ± 0.109	10.51^{b} ± 0.478	10.54^{b} ± 0.378
C.D.	1.081	0.775	0.578	0.499	0.429

Table 6: ANOVA for agility score at different intervals (Pre training, Post 1st, 2nd, 3rd, 4th weeks) of training within Group A, Group B and Group C
$P \leq 0.05$ – Significant $P \geq 0.05$ – Not significant * - Significance

Group	F value	P value
A	2.11	0.088
B	2.00	0.043*
C	9.14	0.000**

Discussion

This study is an attempt to investigate that whether dynamic stretching is a useful addition to plyometrics for the athletes who require repetitive jumping activity and agility. The subjects selected in the study were male collegiate basketball players, between 18-25 years (mean 21.5 yrs). The subjects had attained the maturity level, as this has also been suggested as a prerequisite to be considered prior to the administration of the plyometrics, that the participant has reached a basic maturation level [3], adequate static, dynamic strength, with proper balance and functional strength [4]. Since the procedures involved were dynamic in nature, the subjects were excluded from the study who had muscular pain, orthopaedic or neurological impairment, met with any kind of surgery or having any pathological or systemic disease. Such was in consistence with the study by Terese L.Chmielewski et al who also mentioned that there is loading of the joints, and the tissues has to tolerate high forces for the same reason, the athletes having any kind of acute inflammation or pain, immediate postoperative status, and joint instability were excluded from the study[1]. The result demonstrates that the vertical jump height readings for the Sergeant jump test was improved by 4.8 cm (10.2%) in the Group-A which underwent dynamic stretching and 3.6 cm (7.9%) in the Group-B which underwent plyometrics while the Group-C which received both i.e. dynamic stretching and plyometrics showed most significant improvement in vertical jump height by 7.6 cm (16.1%) which was statistically significant proved the research hypothesis. The increase in height following dynamic stretching i.e. for Group-A is 4.8 cm (10.2%) which may be due to explosive force produced enhancement of the neuromuscular function. The Sergeant Jump test showed significant improvement statistically as well as practically in the 1st week of study. During the 2nd week, the improvement seen was also statistically as well as practically significant. The 3rd week also revealed improvements in vertical jump height practically but not statistically. These findings are in accordance with the study conducted by Michael J. Duncan et al who observed the acute effects of warm up protocol on flexibility and vertical jump in children and concluded that vertical jump height was significantly varied by 9.1% following dynamic warm up when compared to static warm up [5]. The improvements achieved were the result of enhanced neuromuscular function. The occurrence of 'post activation potentiation' is believed to increase the rate of force development, thereby increasing speed and power production as per Sale D et al.[6]

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It has also been postulated by Faigenbaum et al, that vertical jump height enhanced due to excitability of fast twitch motor units. However, no test was conducted for the detection of neuromuscular functions. Secondly, the increase in vertical jump height following dynamic stretching might be due to decrease in muscle stiffness. It has also been demonstrated that cyclic / dynamic stretching, or passive continuous motion, is effective for decreasing passive muscle stiffness [7].Dynamic stretching may decrease muscle stiffness by breaking the stable bonds between actin and myosin filaments [8] or by increasing muscle temperature [9]. Movement without holding at end range of motion, may not reduce neuromuscular sensitivity, but help to enhance coordination and proprioceptive sensation. The improvement in VJH following plyometrics in Group–B is 3.6 cm (7.9%) which is slightly less than 4.8 cm, but statistically there is no significant difference between the two values. Our findings are consistent with Goran Markovic et al [10] who postulated that plyometric training is more effective in improving vertical jump performance in the Stretch Shortening Cycle jumps, as it enhances the ability of subjects to use the elastic and neural benefits of the stretch shortening cycle. The T-test agility score time was improved by 5.12% in the Group-A which underwent dynamic stretching, 6.20% in the Group - B which received plyometric training program and by 10.67% in the Group-C which received dynamic stretching as well as plyometrics. Statistically, the Group-B which underwent only plyometrics has shown almost similar significant results as of Group-A & C. Group-A which underwent dynamic stretching, showed decrease in mean value over the period of 4 weeks but statistically, there was no significant decrease in the agility score compared to the baseline values. The findings of our study for the Group-A, dynamic stretching are not in agreement with the study conducted by McMillian et al [8] where the effect of static stretching versus dynamic stretching on power and agility were found to be significant in T-test agility scores following dynamic stretching. There was overall improvement in agility score by 6.20% in the Group-B which received plyometric training program is consistent with the result of a study of 6 weeks of plyometric training on agility by Michael G. Miller et al. The results improved for the T-test by 4.86% and is because of better motor recruitment or neural adaptations [2].

Limitations of the study: All the athletes were also going through their normal training routines, so the results achieved may not be 100% purely due to the effect of the considered variables, No specialized test for estimation of neuromuscular changes like EMG was done.

Future Research: The effect of dynamic stretching and plyometric training program was seen only for 4 weeks. Previous researches have proved the individual effect of dynamic stretching and plyometric training program for different durations. So, in future researches can be conducted for analyzing the combined effect over different durations. The present study only included male subjects and a particular basketball game. Likewise future researches can be conducted to analyze the combined effect of plyometric training program in female subjects and in different games.

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Conclusion

The study demonstrated that dynamic stretching and plyometrics when used in conjunction with one another provides both statistically significant and practically relevant improvement in vertical jump height and agility over a period of 4 weeks in male collegiate basketball players. Therefore, dynamic stretching is recommended to be incorporated prior to plyometrics when the vision is to enhance jumping ability and agility. The dynamic stretching and plyometric training program when studied individually has improved the vertical jump performance, however, both are almost equally effective in doing the same. The plyometrics has a role in improving agility, while dynamic stretching when studied individually do not have much significant effect for the same. The dynamic stretching protocol did not show any improvement in agility but, when combined with the plyometric training program, it showed significant effect in enhancing agility.

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