Effectiveness Of Plyometric and Progressive Resisted Exercises in Improving Vertical Jump in College Going Sports Students: A Comparative Study

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Abstract
Background: Vertical jump performance is a crucial factor in many sports, as it directly influences athletic abilities such as sprinting, agility, and power. Plyometric training (PT) and progressive resisted exercises (PRE) are widely used methods to enhance lower limb strength and explosive power. However, there is limited comparative research on their relative effectiveness among college sports students.
Objective: This study aims to compare the effectiveness of plyometric exercises and progressive resisted exercises in improving vertical jump performance among college-going sports students.
Methods:
The study was conducted among the undergraduate students of physiotherapy college of both genders between the age group 18-25, who had a history of playing basketball, volleyball, cricket. Total 70 samples were collected and 35 was divided in each group by the random sampling technique. Pre intervention scores were being collected through depth vertical jump and intervention was given to each group for 2 weeks. Lastly post intervention scores were calculated and the study was concluded.
Results: Both groups showed significant improvements in vertical jump height post-intervention ($p < 0.05$). However, the plyometric training group demonstrated a greater percentage increase in jump performance compared to the progressive resisted exercise group.
Conclusion: While both training modalities are effective in enhancing vertical jump performance, plyometric exercises appear to be more beneficial for college sports students. These findings suggest that coaches and trainers should consider incorporating plyometric drills to maximize lower limb explosiveness in athletic training programs.

Keywords: Plyometric training, progressive resisted exercises, vertical jump, college athletes, sports performance

INTRODUCTION

Resistance training (RT) represents an efficient method to improve specific physical performance in team sports athletes. RT in team sports have shown improvements on strength and jump performance (Paz-Franco et al., 2017).It also seems to have beneficial effects on the muscular power and motor skill performance of adolescent athletes. Progressive resisted exercise (PRE) is a method of increasing the ability of muscles to generate force. It has also shown to improve the ability to generate force with moderate to large effect sizes that may carry over into an improved ability to perform daily activities that have remained virtually unchanged since they were described by Delorme and Watkins almost 60 years ago (Badillo et al., 2015)`.Isotonic resistance training typically uses alternating cycles of eccentric and concentric muscle actions to cause joint motion and move loads as a training stimulus (Ghosh & Biswas., 2005). Traditionally, PRE has been used by young adults who are healthy to improve athletic performance. However, recent reviews have emphasized the potential health benefits of including PRE as part of the promotion of physical activity in the community. The potential health benefits of incorporating PRE into an overall fitness program include helping to reduce risk factors associated with osteoporosis as well as diseases such as cardiovascular disease and diabetes (Badillo et al., 2015)`

Plyometric exercises are characterized by explosive power output, explosive reactivity and eccentric muscle contraction during dynamic movements. The potential benefit of plyometric training basically depends on its contraction mechanism that involves the Stretch Shortening Cycle (SSC). SSC consisted of three phases, phase-I i.e. eccentric phase that involves the preloading phase, phase II, which is the time between the eccentric and concentric muscle actions, it's also called amortization, and phase III is the concentric phase or de-loading phase (Taylor et al., 2005). Plyometrics training is one such training strategy that allows the

muscle to reach exponential increase in the maximum strength and speed of movement. Several physiological adaptations were reported following Plyometrics training. The adaptations include muscle hypertrophy (increase in the cross-sectional area of muscle fibers and number of muscle fibers) resulting in increased muscle strength; increase in synchronous motor neuronal pool firing due to enhanced stretch reflex mechanisms resulting in increased muscle power; increase in ventilation and stroke volume resulting in endurance and increase in bone mass due to raiding the shortest duration mechanical loading (Ghosh & Biswas , 2005). Plyometric drills usually involves topping, starting and changing directions in an explosive manner. These movements are components that can assist in developing fitness. 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 these athletes. Plyometric training has been proposed for the development of explosive-power performance and specifically for the improvement of Vertical Jump(VJ) ability (Ramachandran & Pradhan,2014). Luebbers showed that a short-term plyometric training protocol resulted in significant enhancements in VJ performance in physically active college-aged men. Recently, the Luebbers protocol was reported to positively affect VJ performance in well-trained soccer players Plyometric training can enhance explosive contractions in both pre pubertal and pubertal populations. Such a regimen is a natural preparation for many sports, with its emphasis on jumping, throwing, hopping, and skipping, and it is particularly appropriate in runners, where there is a need to develop explosive movements, such as sprint departure, sprint acceleration,and maximal running velocity[(Elsayed & El , 2012). Nature is such that if polymetric exercises are performed with maximum effort, the muscle can increase the opinion of many exercise physiologists, neural adaptations - the explosive power that affects muscles in 2 to 4 weeks. Plyometric and weight training 3 times a week will run only when sufficient recovery time between training sessions exist . Plyometric exercises such as jumping; hopping, skipping, and bounding are executed with the goal of increasing dynamic muscular performance. Therefore, Plyometrics has been widely used for increasing dynamic athletic performance such as vertical jump, agility speed, agility and muscle activation of lower extremities (Chelly et al., 2015) .Long term development of power requires enhanced strength which is achieved through plyometric exercises and stretch load tolerance is improved as there is an increased threshold of Golgi tendon organ (GTO) activation, when plyometric exercises are used in training (Morsal et al., 2014).Plyometric training has been reported to increase maximal vertical jump height effectively. This effect of PT is generally believed to be caused by neural adjustments in motor unit recruitment or neural firing frequency, enhanced reflex potentiation, and/or changes in muscle and connective tissue elastic properties Reports on the effect of PT on muscle morphology are much scarcer. Plyometric training has been described as exercises or drills that combine speed and strength to produce an explosive movement and an increase in power. It has been promoted as being specific to almost every sport due to the combination of force and velocity developments. Plyometrics are also categorized by their amazing ability to increase reactive strength and jumping skill and coordination (Murugan et al., 2020)

Many investigations have clearly established that strength and plyometric training can improve concentric phase peak force, velocity, and power in jumping. Vertical jump height has been shown to increase an average of 4.7–15% depending on the exact nature and length of training. Other variables have been reported as well including rate of force development (RFD), rate of power development (RPD), impulse, and work. Some investigations have reported values for both the eccentric phase and concentric phase(Mateescu 2013).

However, despite the increasing popularity of plyometric training with young athletes, there is very little empirical evidence regarding the efficacy of plyometric training with adolescents. Furthermore, the bulk of research investigating plyometric training efficacy has looked at high-impact plyometric exercises such as depth jumps, which may be contraindicated for youth as a result of the high risk of injury to the growth plates possibly resulting in leg-length discrepancy (Kijowksi 2015). This exercise aimed to improve the muscle for achieving maximum strength within the shortest possible time. Plyometric exercise was mainly used by martial artist, sprinters and high jumpers to improve performances has gain the popularity and used by the athletes in all types of sport. The depth jump technique that uses explosive movement to develop explosive power to increase muscle strength and speed up attack ability. (Rubley 2011).The training volume of lower body Plyometrics is typically quantified as the number of foot contacts per exercise session. Plyometric exercises are used to improve explosive power and prevent injury. While these exercises have been shown to be effective, the details of program design are not well established. Research has quantified important program design variables such as plyometric intensity and the time course of post training recovery (Sari 2020). Plyometric-based exercises involve a rapid transition from an eccentric to concentric contraction. This movement inducing neuromuscular changes that facilitate and enhance the power and speed of congruent movement structures. Therefore, plyometric tasks via countermovement, which deeply rely on the ability to achieve high levels of force via application of the stretch-shortening cycle (SSC), will play an important role

as modality responsible for power development (Ebben , 2014). During the plyometric workout, the muscle is quickly stretched before being quickly contracted. The nervous system is getting ready to react to the cycle of stretching and shortening more swiftly. That type of training can improve an athlete's speed, explosive power production, and strengthening of bone. The main purpose of Plyometrics is to improve jumping ability and jumping capability has been assumed by means of essential for effective execution in several sports. Plyometrics can take the form of vertical or horizontal exercises, or a combination of both. The SSC contributes less to horizontal than to vertical jumping performance, because a vertical loading of the Musculo-tendinous unit accumulates greater elastic energy during movement in the eccentric phase (Maćkała et al., 2021). It has been also suggested that Plyometrics prevents knee ligament injuries because of the improved hamstring to quadricepsratio,a parameter often used for quantifying active knee joint stability (Jlid et al., 2019) .It has been found that plyometric training results in a wide range of distinct physiological and biomechanical adaptations (e.g. increased motor unit recruitment and rate of force developmental) Several meta-analyses have been published demonstrating the effectiveness of Plyometrics at improving distinct power-related attributes in athletes from different disciplines, including soccer, handball, and volleyball. Likewise, there is a growing body of experimental evidence examining the effects of plyometric training on physical fitness attributes in basketball players, specifically(Meszler & Váczi , 2019)

Vertical Jump Test: To test the jump height, 2 different types of VJs were performed: the Squat jump(SJ) and the Counter Movement Jump(CMJ). The SJ—only the concentric phase of the movement was used. The jump was started from a static position at 90 degree of knee flexion. The subjects were instructed to keep their hands on their hips and were encouraged to jump as high as possible. (Campillo et al., 2022).The CMJ —uses the eccentric phase of movement to achieve the jump. The jump was initiated from an eccentric action of the knee and hip extensors. The Subject was instructed to keep their hands on the waist and jump as high as possible[19]. (Thompson et al., 2015).Vertical jumping is a fundamental component of many sports and also may be predictive of performance in other sports in which it is not the primary component. The effects of PLY on vertical jump performance have been widely researched [20]. (Carvalho et al., 2012) .Vertical jumping (VJ) performance is determined by a complex interaction among several factors including maximal force capacity, rate of force development, muscle coordination, and stretch shortening cycle (SSC) use. Various training methods have been applied to improve VJ performance, such methods include plyometric (PL) training, resistance training, weight lifting (WL) training, and electrical stimulation[21,22]. .(Sozbir 2016) (Arabatzi et al., 2010)

Though there are studies on the effect of Plyometrics and PRE on established athletes , there is dearth in studies comparing there effect in college going budding athletes. The objective of the study was therefore to evaluate the effectiveness of Plyometrics and Progressive resisted exercises and to compare the effectiveness of PRE and plyometrics in improving muscle strength in the college going sports students.

Materials and Methodology

The study design is a comparative study done in the University for a duration of 6 months .After taking permission from the University, and after ethical clearance by the IRB, we have recruited participants based on the inclusion and exclusion criteria. The inclusion criteria was students playing basketball, volleyball, cricket between age 18-25 years. Gender included were both males and females. Exclusion Criterian were any students with known history of cardiac problems, Respiratory disease, Any major injury, history of surgery in the lower extremities .The total 70 subjects were divided into 2 groups, using random sampling method ,35 in each respective group. Group A denoted plyometrics exercises whereas group B denoted PRE. Permission and informed consent was taken from the athletes and assessment is done according to our outcome measure which is Depth Vertical Jump Scores . Recorded and adapted exercise program were given to the subjects based on the division of groups. 2 weeks protocol was been set for both the groups and post depth vertical jump scores were taken at the end of the intervention.

Outcome Measures:

Depth vertical jump performance–

Depth vertical jump height (DVJ) was measured to evaluate multi-joint power generating ability in the lower extremities. Participants were standing next to a wall extending one arm to touch the highest point possible while remaining flat-footed, to record standing reach height. After this procedure participants dropped from a 22 cm platform and performed a maximal effort double-leg vertical jump using arms wing. The test was performed using the chalk method (Twist and Eston, 2005) by rubbing chalk on the fingers of the dominant hand and reaching to leave a mark on the wall as high as possible (while remaining flat-footed), after which followed a proper form to jump and place a chalk mark as high as possible on the wall.

Both the Training programs were done for two weeks on the respective groups

Group-I (PTG) : Underwent Plyometric Training (PT). whereas Group-II (RTG) underwent Resistance

Training (RT). The training program was done for three days in a week and 60 min total session daily and continued for 2 weeks including the time of warm-up & cooling down .

TECHNIQUE:

Name of the Exercise	Week-1	Week-2
Jump & Squat	2x8	2x8
Single leg hop((both)	2x6	2x7
Double leg bounding	2x8	2x8
Split jump	2x6	2x6
Tuck jump	2x6	2x6
Box jump	1x8	1x8
Depth jump	1x8	1x8

Table 1: Plyometric Training Protocol for 2 Weeks for Group 1

NameoftheExercise	Week-1(30%1RM)	Week-2(30%1RM)
Squat	2x10	2x10
Leg praise	2x10	2x10
Heelpraise	2x10	2x10
Lunge	2x10	2x10
Legcurl	2x10	2x10

Table 2: Resistance Training Protocol for 2 Weeks for Group 2

RESULT

Variables		Minimum	Maximum	Median(IQR)	Mean±SD
Group A (Plyometrics)	Age	18	24	21(19-23)	20.89±2.00
	Pre-Ex DVJ	15	27	20(17-24)	20.57±3.87
	Post-Ex DVJ	16	30	22(19-26)	22.6±4.20
Group B (Progressive Resisted Exercise)	Age	18	25	21(20-22.5)	21.2±1.66
	Pre-Ex DVJ	17	25	21(18.5-22.5)	20.8±2.39
	Post-Ex DVJ	18	25	22(20-23)	21.37±1.85

Table 3: Descriptive statistics of age, pre & post exercise scores of DVJ of both groups of subjects

Table 3 describes for Group A Plyometrics .The minimum age taken was 18 and maximum was 24 with median 21(19-23) and mean 20.89±2.00.The pre –Ex DVJ minimum was 15 and maximum was 27 with median value 20(17-24) and mean 20.57±3.87and the post-Ex DVJ minimum was16 and maximum was 30 with mean value 22(19-26) and median 22.6 ± 4.20. Whereas for Group B the minimum age was 18 and maximum was 25 with median value 21(20-22.5) and mean 21.2±1.66 and Pre-Ex DVJ score minimum was 17 and maximum was 25 with median value 21(18.5-22.5) and mean 20.8±2.39 and post-Ex DVJ score minimum was 18 and maximum was 25 with median value 22(20-23) and mean 21.37±1.85

Variables	Pre-ExDVJ	Post-Ex DVJ	Paired t-test	P Value	Significanc e
Group A (Plyometrics)	20.57 ± 3.87	22.6 ± 4.20	-10.933	0.00001	Both are significant
Group-B (Progressive Resisted Exercise)	20.8 ± 2.39	21.37 ± 1.85	-2.889	0.00669	

Table 4: Comparing the effective of group A(Plyometrics) and group B (Progressive Resisted Exercise) by using paired t-test

Table 4 explains about the effectiveness of both the groups, group A and group B. Using paired t-test, for group A the pre-Ex DVJ is 20.57±3.87 and post –Ex DVJ is 22.6±4.20 with paired t-test value -10.933 and P -value 0.00001.Whereas for group B pre-Ex DVJ is 20.8±2.39 and post-Ex- DVJ is 21.37±1.87 with paired t-test value -2.889 and P-value 0.00669.Since the P-value of both the groups are less than 0.005 therefore the

effectiveness of both the group is significant , but Plyometrics is slightly more effective than PRE in improving vertical jump

Discussion

The present study was performed to investigate the effectiveness of PT in comparison with RT on improving vertical jump in college going athletes. At the end of the 2-week experimentation it was found that both the training group i.e. RTG & PTG led to increases in improving vertical jump. Several studies suggested that the improvement of vertical jump is possible by both RT and PT. Study by Ghosh & Biswas, 2020 also found that both the RT and PT significantly improved the speed ability in comparison to Control Group of the athletes. Thus, speed ability can be developed through resistance training as well as through plyometric training. Study by Mateescu, A. (2013). established that explosive actions such as sprinting and jumping are essential fitness components for players. Current data indicate that RT once every second week in addition to specific training and matches may be a sufficient training stimulus that could help maintain jump, sprint, and Repeated Sprint Ability(RSA) performances in professional players. This study therefore suggests that 1 session of RT every second week in addition to normal training may be sufficient for maintaining fitness in players for approximately a 6-week period. Moran, J.et al ., 2023 examined the effects of Plyometric Jump training(PJT) on lower limb stiffness in healthy males and females. The main results indicate that PJT can induce small but statistically significant increases in lower limb stiffness. PJT can be used as an effective method that coaches can use to enhance direct and indirect stiffness in healthy males and females. However, based on the wider body of evidence, PJT may not be the best way to enhance stiffness and may be better utilized as a complementary method for enhancing it, alongside potentially more effective methods, such as traditional resistance training or eccentric resistance training. The time course of adaptation is also an important factor to consider; programmed lasting longer than 7 weeks are more effective. This could be directly related to the relative responsiveness of tendinous tissue compared to muscle tissue; the latter seems to adapting faster to neuromuscular training stimuli. Study by Chelly et al., 2015 indicates that 10 weeks of plyometric training enhanced the performance of early pubertal male runners relative to control subjects engaged in a standard conditioning program; the experimental group showed significant gains with respect to sprint velocities vertical jump height and power ,horizontal jump length . However, total leg and thigh muscle volumes, absolute and relative leg muscle power, maximal

pedaling velocity, and maximal force remained unchanged after the training period. Plyometric exercise involves stretching the muscle immediately before making a rapid concentric contraction. The combined action is commonly called a stretch-shortening cycle. Such contractions are often made during the different phases of running. Although gains of maximal strength are similar with traditional strength and plyometric training, the latter approach seems to induce greater gains in muscle power. Currently available findings regarding the impact of plyometrics on running performance are contradictory. Some studies have suggested that plyometric training can improve vertical jump height or power without any increase in sprint running performance. Study by Váczi1 M, et al., 2013 has

concluded that the training program significantly improved depth vertical jump performance, agility, and isometric knee extensor strength. Depth vertical jump performance, the greatest improvement in the experimental group was found in depth vertical jump performance. The majority of the studies demonstrate positive changes in counter movement jump tests, but less data is available on depth jump performance, a more specific measure of leg power in sports, where high impact forces are present during movements. It is reported 4% improvement in depth jump performance among athletes, while others found 7-9% improvement in non- athletes, after six weeks of PT. Study done by Malcolm T. Whitehead,2018 found that 8 weeks of separate plyometric and resistance training result in significant improvements in both low- and high-speed muscular strength as compared with a non training control group. The greatest improvement in high-speed muscular strength was observed in the plyometric group, although there was no significant difference in improvement in low-speed muscular strength regardless of training protocol. It has also seen that isotonic resistance training typically uses alternating cycles of eccentric and concentric muscle actions to cause joint motion and move loads as a training stimulus. Thus traditionally, PRE has been used by young adults who are healthy to improve athletic performance. Whereas Plyometric is based on Stretch Shortening Cycle (SSC). SSC consisted of three phases, phase-I i.e. eccentric phase that involves the preloading phase, phase II, which is the time between the eccentric and concentric muscle actions, it's also called amortization, and phase III is the concentric phase or de-loading phase. Plyometric training is one such training strategy that allows the muscle to reach exponential increase in the maximum strength and speed of movement. Several physiological adaptations were reported following Plyometrics training. The adaptations include muscle hypertrophy (increase in the cross-sectional area of muscle fibers and number of muscle fibers) resulting in increased muscle strength; increase in synchronous motor neuronal pool firing due to enhanced stretch reflex mechanisms resulting in increased muscle power. Thus, it is concluded that the use of plyometric training program is not only to break the monotony of training, but they can also improve the strength and vertical jump players. Hence, by going through all the mentioned above studies and the result of our study we found that both plyometric and progressive resisted exercise has effectiveness in improving vertical jump but plyometric is seemed to be more effective in improving vertical jump.

Limitation-The sample size of the study was less and the duration of training was only 2 weeks.

Conclusion

From the above result and discussions of the present study it can be concluded that both the RT and PT significantly improved the vertical jump in the university sports players. Thus, vertical jump can be developed through resistance training as well as through plyometric training. Also a,significant difference was found between RTG and PTG for improving vertical jump where PTG improved better than the RTG. It clearly states that PT had better effect for improving vertical jump than RT. So vertical jump can be developed better through plyometric training than resistance training.

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