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Is Plyometric Exercise Effective than Squat Training in Improving Flexibility and Vertical Jump Height in Untrained Female College Students?

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ABSTRACT

Background of the study: Appropriate amount of flexibility and power of lower extremities are essential to prevention of injury in untrained individuals. While various methods are used to improve flexibility and power, plyometric exercises are considered to improve both flexibility and power. The present study aimed to determine and compare the effects of 4 weeks of plyometric exercise and squat exercise on flexibility and explosive power in untrained female college students.
Methods: This double blinded randomized controlled study included 39 female participants randomly assigned to three groups: Plyometric exercise, squat exercise and control group (n=13 each).1RM measured prior to the experimental session was used to determine the training intensity of the squat exercise for each week. A structured and progressive protocol for both plyometric and squat exercise were administered for 4 weeks, 2 sessions in a week with a total of eight sessions. Flexibility and explosive power were measured using sit and reach test and vertical jump test respectively, before and after the experiment sessions.
Results: One way ANOVA showed significant differences between groups for flexibility (p=0.009) and explosive power (p=0.016). Post hoc analysis with Bonferroni correction revealed plyometric exercise improved flexibility and power better than the other two groups.
Conclusion: *From the results of this present study, it can be concluded that* a 4 week structured, progressive, low intensity plyometric exercise program *can be effective* in improving lower extremity flexibility and power in untrained female college students.

Keywords: Plyometric exercise, squat training, Flexibility, Sit and reach test, Explosive power, Vertical Jump Test

INTRODUCTION

Plyometric training is defined as quick powerful movement involving an eccentric contraction followed immediately by explosive concentric contraction. [1-4] Plyometric works on the principles of Stretch-Shortening Cycle (SSC). It is considered as an effective mode of training because it enhances dynamic joint stabilization, eccentric strength, rate of force production and neuromuscular efficiency which in turn promotes an increase in muscle power. Muscles are trained under tension that is greater than normal maximal tension. Stretch load tolerance is improved as there is an increased threshold of Golgi tendon organ (GTO) activation, when plyometric exercises are used in training. [5-9] Long term development of power requires enhanced strength which is achieved through plyometric exercises. [10]

The ability of contractile tissue to produce tension and a resultant force based on the demand placed on the muscle is termed as strength. Squat training is effective in the development of strength and power of lower extremity musculatures. Squat also has a positive influence on overall neuromuscular efficiency. While performing vertical jump, muscles involved in squat undergo a combined eccentric and concentric contraction and hence produce a greater force. [11]

Since more of female students are engaged in sitting activity in their regular class in 90-90 position, they are compromising on flexibility of knee flexors which in turn will lead to tightness predisposing them to knee injuries. Whenever they aim for any additional activity which involves jumping or change in direction, adequate levels of flexibility and skeletal muscle strength are necessary for execution of efficient movements which in turn provides optimal performance in competitive sports. [12-14] Females who are not high level athletes and engage themselves in recreational activity could be at greater risk for knee injuries. Therefore basic training is necessary in female population to prevent injuries at the knee.

The present study was conducted to determine and compare the effects of four week targeted strength training protocol by means of squat training and a plyometric exercise training protocol on flexibility and lower extremity explosive power in untrained female students.

METHODS

This study included female participants selected from two different colleges through convenient sampling method. Criteria for inclusion were: age in the range 18 to 25 years and females who are not physically active. Participants with a previous history of any lower limb injury or surgery, those who were refrained to participate in physical activity and pregnant females were excluded. From a total sample frame of 351 participants, 39 were included in the study as per the inclusion and exclusion criteria. They were randomly allocated (n=13 in each group) into one of the three groups: Strength training (StG), Plyometric (PG) and control group (CG) by sealed opaque envelope method. All researchers involved in the study and the participants were blinded to the allocation. All pre and post measurements were taken by a single, blinded Physiotherapist who was not a part of this study. Written informed consent was obtained from the participants before the commencement of the study by explaining the details of the study in accordance with the institutional ethical standards of the ethics committee on human experimentation and the Helsinki declaration of 1975.

Before the commencement of the study, one Repetition maximum (1RM) was measured for squats, using barbells in the strength training group, to determine the training intensity of the back squats for each week. On the day of experiment, participants from both experimental groups were informed to refrain from heavy meals and caffeine at least 2 hours before the session. They were informed to empty their bladder prior to the session. Both the groups performed static jogging as warm-up for 5minutes following which 1minute rest was given.

Exercise protocol:

Strength Training group: Participants in this group performed squats with barbell [15] and every week, a specified percentage of 1RM was used with its reference to the training intensity in terms of resistance (Table 1). A resistance training exercise in which a barbell is loaded with appropriate weight plates as measured by 1RM for each subject was used and is held by the subject overhead with extended elbows. Standing with one leg forward the subject flexes at the hip and the knee until the posterior thigh of the forward leg is parallel to the ground with foot in full contact with the ground.

Table 1: Progression of 1RM (in percentage), repetitions and sets of squats with barbell in Strength training group

	Intensity	Repetitions	Sets	Rest between sets (in secs)
Week 1	50% of 1 RM	15	3	30
Week 2	60% of 1 RM	12	3	30
Week 3	70 % of 1 RM	10	3	30
Week 4	80% of 1 RM	8	3	30

Plyometric group: Participants performed three low intensity Plyometric exercises in the form of front jump, lateral jump and depth jump. [16] Each jump was performed for 5 repetitions x 3 sets for the first and second weeks, with a rest period of 30 seconds between sets. For the third and fourth weeks, they performed all three jumps for 10 repetitions x 3 sets, with a rest period of 30 seconds between sets.

In both the groups the training was conducted on two alternate days in a week with a total of eight sessions.

Participants in the control group performed their routine activities and their outcome measures were measured on day 1 and at the end of 4th week same as the other two groups.

Outcome measures:

Flexibility of the lower extremity was measured using Sit and Reach Test [17-18] and explosive power of lower extremity using Vertical jump height. [19] All measurements were taken before the administration of exercise protocol in both the groups and at the end of 4th week.

Collected data were analyzed using SPSS version 20. Descriptive statistics of mean, standard deviation were used to describe the demographic characteristics and outcome measures of participants. One way Analysis of Variance (ANOVA) was used to compare the differences in mean of sit and reach distance and vertical jump height measures pre and post experiments. Post-Hoc analysis with Bonferroni correction was used if ANOVA showed statistical significance. Significance level was set at $p \leq 0.05$.

RESULTS

Table 2. Demographic characteristics of participants in all three groups

Variable	StG (n=13)	PG (n=13)	CG (n=13)	F	p value*
Mean (SD)					
Age (in years)	19.08 (0.95)	19.23 (0.92)	19.46 (1.12)	0.481	0.622
Height (in cms)	155.15 (6.1)	154.54 (4.99)	152.31 (5.4)	0.956	0.394
Weight (in Kgs)	50.66 (9.07)	47.63 (6.42)	48.28 (8.88)	0.493	0.615
BMI (kg/m^2)	20.99 (3.42)	19.9 (2.11)	20.94 (4.61)	0.393	0.678

*Significant at p<0.05

StG: Strength training Group, PG: Plyometric Group and CG: Control Group, SD: Standard Deviation, BMI: Body Mass index

Table 3. Mean comparison of baseline values of outcome measures used in the study

Variable	StG (n=13)	PG (n=13)	CG (n=13)	F	p value*
Mean (SD)					
SRT distance (in cms)	17.78 (5.25)	17.46 (4.8)	19.15 (5.73)	0.374	0.690
VJH (in cms)	19.21 (5.64)	19.03 (5.41)	21.24 (4.87)	0.695	0.506

Significant at p<0.05

StG: Strength training Group, PG: Plyometric Group and CG: Control Group, SD: Standard Deviation, SRT: Sit and Reach Test, VJH: Vertical Jump Height

Table 4. Comparison of mean differences+ of outcome measures at the end of 4 weeks of training (8 sessions)

Variable	StG (n=13)	PG (n=13)	CG (n=13)	F	p value*
Mean (SD)					
SRT distance (in cms)	2.61 (3.1)	6.18 (3.64)	2.38 (3.08)	5.458	0.009
VJH (in cms)	.68 (4.02)	5.17 (4.96)	0.04 (4.92)	4.665	0.016

*Significant at p<0.05

+*Mean difference was computed by subtracting the mean of pre-test values from the mean of post-test values. One way ANOVA was used to compare the mean of mean differences between groups.*

StG: Strength training Group, PG: Plyometric Group and CG: Control Group, SD: Standard Deviation, SRT: Sit and Reach Test, VJH: Vertical Jump Height

DISCUSSION

The purpose of the study was to find out the effect of the plyometric training and strength training on vertical jump height and flexibility on untrained collegiate females. This 4 week program improved the vertical

jump height by 5.17cm in plyometric, 0.68 cm in the strength training and 0.04 cm in control groups respectively. Flexibility as measured using sit and reach test improved by 6.18 cm in the plyometric group, 2.61 cm in strength training group and 2.38 cm in control group.

M Climstein [20] conducted a study in which subjects were trained in squat and plyometric for 6 weeks and the vertical jump height improved 3.3 cm in squat group whereas 3.81 cm in plyometric group. G L Moghe [21] conducted a study on swimmers in the improvement in vertical jump height after plyometric training and the increment in vertical jump height was the 4.5 cm. A study by Rajal B. Sukhiyaji [22] showed 6 weeks of plyometric exercise was effective to improve vertical jump height in basketball players. Results from the present study showed better improvements in vertical jump height after 4 weeks of training as compared to the improvements specified in the previous studies mentioned above where training was provided for 6 weeks.

According to results from studies in the past [5,23] it was observed that plyometric training improved the hip and thigh muscle power which is usually measured by vertical jump test. Komi [24] suggested that better neuromuscular adaptation is considered to be one of the physiological mechanisms responsible for the improvement in power in the muscle which is obviously observed after plyometric training.

The increase in vertical jump height observed in this study after plyometric training can be attributed to the fact that there is an increase in the use of elastic and neural benefit of stretch shortening cycle as was explained by Goranmarkovic. [25] Also it can be understood that plyometric training increases the power which is gained by the muscle strength and speed and this power is considered an important factor for improving vertical jump height. [26] This was also observed and concluded by Baker [27] who suggested that the vertical jump height increases when the contractile unit of muscle and stretch shortening cycle is facilitated by training. The present study results also support the observations of Laurent *Malisoux* [23] *who suggested that SSC exercises training increases the fiber force, contraction velocity and so power.*

Bosco [5] concluded that plyometric training can increase the threshold level of GTO activation which increases the tolerance of stretch load in muscles fibers which in turn facilitates the strong stretch reflex. Barbosa [28] conducted a study which showed that weight training can improve sit and reach score in elderly women. Resistive training program increases the motor neuron excitability and activate the stretch reflex. However, results of the present study shows no significant difference between the strength training group and control group suggesting less improvements in flexibility after 4 weeks of strength training.

Limitations

This study had its own limitations that need to be addressed. First, sample size of this study was small. Secondly, results of this study is limited only to female gender, hence further studies can involve both genders. Third, as per our objectives and interest, untrained college students were included in our study. Further studies can include athletes and sport person to determine the effect of plyometric exercise protocol used in this study.

CONCLUSION

Based on the observations it can be concluded that a 4 weeks structured, progressive plyometric exercise program is beneficial in improving the flexibility and explosive power of lower extremity in untrained female college students.

REFERENCES

1. Chimera NJ, Swanik KA, Swanik CB, Straub SJ. Effects of Plyometric Training on Muscle-Activation Strategies and Performance in Female Athletes. Journal of athletic training. 2004;39(1):24-31.
2. Hewett TE, Lindenfeld TN, Riccobene JV, Noyes FR. The effect of neuromuscular

training on the incidence of knee injury in female athletes. A prospective study. The American journal of sports medicine. 1999; 27(6):699-706.
3. Myer GD, Ford KR, Brent JL, Hewett TE. The effects of plyometric vs. dynamic stabilization and balance training on power, balance, and landing force in female athletes. Journal of strength and conditioning research. 2006;20(2):345-53.
4. Myer GD, Ford KR, McLean SG, Hewett TE. The effects of plyometric versus dynamic stabilization and balance training on lower extremity biomechanics. The American journal of sports medicine. 2006;34(3):445-55.
5. Bosco C, Ito A, Komi PV, Luhtanen P, Rahkila P, Rusko H, et al. Neuromuscular function and mechanical efficiency of human leg extensor muscles during jumping exercises. Acta physiologica Scandinavica. 1982;114(4):543-50.
6. Viitasalo JT, Bosco C. Electromechanical behaviour of human muscles in vertical jumps. Eur J Appl Physiol Occup Physiol. 1982;48(2):253-61.
7. Bosco C, Viitasalo JT, Komi PV, Luhtanen P. Combined effect of elastic energy and myoelectrical potentiation during stretch-shortening cycle exercise. Acta Physiol Scand. 1982;114(4):557-65.
8. Bosco C, Tarkka I, Komi PV. Effect of elastic energy and myoelectrical potentiation of triceps surae during stretch-shortening cycle exercise. Int J Sports Med. 1982;3(3):137-40.
9. Bosco C, Viitasalo JT. Potentiation of myoelectrical activity of human muscles in vertical jumps. Electromyogr Clin Neurophysiol. 1982;22(7):549-62.
10. Cormie P, McGuigan MR, Newton RU. Developing maximal neuromuscular power: Part 1--biological basis of maximal power production. Sports Med. 2011;41(1):17-38.
11. MonsefCherif MS, Sana Chaatani, Olfa Nejlaoui, DaghbajiGomri, AouidetAbdallah. The Effect of a Combined High-Intensity Plyometric and Speed Training. Asian Journal of Sports Medicine. 2012;3(1):21-8.
12. Medicine ACoS. ACSM position stand: The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in healthy adults. Med Sci Sports Exerc. 1998;30:975-91.
13. Lee EJ, Etnyre BR, Poindexter HB, Sokol DL, Toon TJ. Flexibility characteristics of elite female and male volleyball players. J Sports Med Phys Fitness. 1989;29(1):49-51.
14. Watson AW. Sports injuries related to flexibility, posture, acceleration, clinical defects, and previous injury, in high-level players of body contact sports. Int J Sports Med. 2001;22(3):222-5.
15. Thomas R. Baechle RWE. Essentials of Strength Training and Conditioning. 3rd ed: Human Kinetics; 2008.
16. Potach DH, & Chu, D.A. Plyometric Training. In: Beachle TR, & Earle, R.W, , editor. Essentials of Strength Training and Conditioning. 3rd ed: Human Kinetics; 2008. p. 413-27.
17. Baltaci G, Un N, Tunay V, Besler A, Gerceker S. Comparison of three different sit and reach tests for measurement of hamstring flexibility in female university students. British journal of sports medicine. 2003;37(1):59-61.
18. Mayorga-Vega D, Merino-Marban R, Viciana J. Criterion-Related Validity of Sit-and-Reach Tests for Estimating Hamstring and Lumbar Extensibility: a Meta-Analysis. Journal of sports science & medicine. 2014;13(1):1-14.
19. Harman EA, Rosenstein MT, Frykman PN, Rosenstein RM. The effects of arms and countermovement on vertical jumping. Medicine and science in sports and exercise. 1990;22(6):825-33.
20. Kent Adams JPOS, Katie L. O'Shea, Mike Climstein. The Effect of Six Weeks of Squat, Plyometric and Squat-Plyometric Training on Power Production. Journal of Applied Science Research. 1992;6(1):36-41.
21. G.L. Moghe PND. The effect of plyometric training on the competitive swimming block start. Asian Journal of Physical Education and Computer Science in Sports. 2011;5(1):4-5.
22. Sukhiyaji RB SM. Effects of Six Weeks Plyometric Training in Comparison to Bent Leg Raise (BLR) plus Strength Training on Vertical Jump Height and Agility in Young Basketball Players. Int J Health Sci Res. 2019;9(8):205-17.
23. Malisoux L, Francaux M, Nielens H, Theisen D. Stretch-shortening cycle exercises: an effective training paradigm to enhance power output of human single

muscle fibers. Journal of applied physiology. 2006;100(3):771-9.
24. Komi PV. Physiological and biomechanical correlates of muscle function: effects of muscle structure and stretch-shortening cycle on force and speed. Exerc Sport Sci Rev. 1984;12:81-121.
25. Markovic G. Does plyometric training improve vertical jump height? A meta-analytical review. Br J Sports Med. 2007; 41(6):349-55.
26. Anderst WJ, Eksten, F., & Koceja, D.M. Effects of plyometric and explosive resistance training on lower body power. Med Sci Sports Exerc. 1994;26(S31).
27. Baker D. Improving Vertical Jump Performance Through General, Special, and Specific Strength Training: A Brief Review. Journal of Strength & Conditioning Research. 1996;10(2).
28. Barbosa AR, Santarem JM, Filho WJ, Marucci Mde F. Effects of resistance training on the sit-and-reach test in elderly women. J Strength Cond Res. 2002;16(1): 14-8.

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