Resistance Training, Plyometric Training and Complex Training on Strength Output

[a]Ashokan. K, [b]George Abraham

[a]Ph.D Scholar, Department of Physical Education and Sports Sciences, Annamalai University, Tamil Nadu, India

[b]Assistant Professor, Department of Physical Education and Sports Sciences, Annamalai University, Tamil Nadu, India

Abstract

The present investigation was made to determine the effect of resistance training, plyometric training and combined both trainings on strength. Sixty physically active and interested volunteers (n = 60) aged between 17-20 years were randomly selected as the subject of the current study. The selected subjects were randomly assigned into four equal groups with fifteen subjects each (n = 15). The group I was involved with resistance training (RT), group II was given plyometric training (PT), group III underwent combined resistance and plyometric training (RPT) and group IV acted as a control (CG). The experimental groups underwent their respective experimental treatment for eight weeks, 3 days a week and a session on each day. The control group was not exposed to any specific training apart from their regular activities. Leg strength was taken as variable for this investigation. The pre and post test were conducted one day before and after the experimental treatment. The collected data were analysed using analysis of covariance (ANCOVA) and Scheffe's test was applied as a post hoc test to determine which of the paired mean difference significantly. The result of the study revealed that all the three trainings such as resistance training (RT), plyometric training (PT) and combined resistance and plyometric (RPT) training produced significant improvement on leg strength ($p \lesssim 0.05$) as compared to control group (CG)

KEYWORDS: Resistance training, plyometric training, complex training, leg strength

Introduction

Physical fitness is one of the most important factors that determine the performance level of an individual. Resistance training is defined as a specialized method of conditioning that involves the progressive use of a wide range of resistive loads and a variety of training modalities (eg, free weights [barbells and dumbbells], weight machines, elastic cords, medicine balls [weighted balls filled with sand or cloth], and body weight) designed to enhance health, fitness, and sports performance. Resistance training is an anaerobic form of exercises (Teng *et al*., 2008). It is caused to enhance the ability of the body to perform at very high force or power outputs for a very short period of time (Baechle, 1994). Progressive resistance training is a muscle training programme in which the amount of resistance is systematically increased as the muscles gain in strength. The adaptational changes and health implications of resistance exercise are very dynamic and variable for each individual. In strength training load refers to the mass or amount of weights utilized for specific exercises. It will help to improve the strength, power and size of muscle (Bloomfield, 1994). The percentage of one repetition maximum (1RM) method was used in this training programme. It is the maximum load that can be lifted successfully one time through the full range of movement (Fielding *et al.*, 2002). Marked evidence indicates that regular participation in a resistance training program or a plyometric training program can improve measures of strength and power in adults (Chu, 1998; Fleck and Kraemer, 1997). Thus, both resistance training and plyometric training are typically recommended for adults when gains in motor performance are desired.

Plyometric training has been established as a training method that improves the muscle-tendon unit's ability to tolerate stretch loads and the efficiency of the stretch-shorten cycle (SSC) (Allerheiligen, 1994 & Chu, 1998). It is a type of exercise training designed to produce fast, powerful movements and improve the functions of the nervous system, generally for the purpose of improving performance in sports – plyometric movements, in which a muscle is loaded and then contracted in rapid sequence, use the strength, elasticity and innervations of muscles and surrounding tissue to jump higher and run faster, depending on the desired training goal (Brooks, 1996). This training involves and uses, practicing plyometric movements to toughen tissues and train nerve cells to stimulate a specific pattern of muscle contraction, so the muscles generate as strong a contraction as possible in the shortest amount of time (Chu, 1998). A plyometric contraction involves first a rapid muscle lengthening movement (eccentric phase), followed by a short resting phase (amortization phase), then an explosive muscle shortening movement (concentric phase), which enables the muscles to work together in doing the particular motion (Andrew, 2010).

Strength, or the ability to express force, is a basic physical characteristic that determines the performance efficiency in sports .So muscular strength is the basic ability for athletes to control the more skills. Furthermore, how to improve the muscular strength is the problem which athletes and coaches often concerned about. Leg strength is very essential for sports persons, especially athletes. The strength of a muscle related to its sectional area or girth. The larger the muscle, the stronger it is (Taafee *et al.*, 1996). In this study the leg dynamometer is the instrument used to measure the leg strength. The capacity of the lower limb to extent muscular force, the leg strength is measured by the limits of lifting resistance in lowering to and arising from sitting position (Johnson & Nelson, 1982).

Therefore, the purpose of the present investigation was to analyse the impact of resistance training, plyometric training and combined both trainings on strength output. Even though initial gains in strength and power due to training are mediated by neural factors, we used a eight week training program since previous investigations reported favorable changes in performance in youth (Martel et al, 2005; Myer et al, 2006) and adults (Adams et al., 1992 & Vossen et al, 2000) following eight weeks of resistance and plyometric training. We hypothesized that the combinatorial effects of plyometric and resistance training would result in significantly greater improvements in strength output.

Materials and method

To achieve this, sixty (n = 60) physically active and interested students of Annamalai University, India, were randomly selected as subjects and their age ranged between 17 to 20 years. The selected subjects were randomly assigned into four equal groups with fifteen subjects each (n = 15). The group I was involved with resistance training (RT), group II was given plyometric training (PT), group III underwent weight training and plyometric training for alternate days (RPT) and group IV acted as a control (CG). The exercise groups trained thrice per week on nonconsecutive days (Monday, Wednesday and Friday) for eight weeks and a session on each day under carefully monitored and controlled conditions. The control group was not exposed to any specific training apart from their regular activities. Leg strength was taken as variable for this investigation. The leg strength was measured by using leg dynamometer. Before the commencement of the experimentation, the investigator recorded 1RM for all the two groups taking each subject separately. The following resistance exercises were used to resistance training group and performed with progressive method, squat, bench press, push press, overhead press, standing calf raise, biceps curl, front squat, incline press, upright row, standing calf raise, and triceps extension exercises. The intensity ranged from 60% to 90% of 1RM. The components of this program included preparatory movement training and plyometric training. The following plyometric exercises were used, box jump (depth or drop jump), tuck jump, split jump, bounding, steps, single leg hop (alternate leg), hurdle jump, medicine ball exercise. These exercises were performed for 90 minutes in a day. The pre and post test data were collected one day before and after the experimental treatment. Group III performed combined weight and plyometric training for alternate days. Following every resistance training session, subjects in both groups performed two sets of 12 to 25 repetitions of abdominal (e.g., abdominal curl), lower back (e.g., kneeling trunk extension) and rotator cuff (e.g., external rotation) strengthening exercises. Subjects were taught how to record their data on workout logs and did so throughout the training period. The instructors reviewed the workout logs daily and made appropriate adjustments in training weight and repetitions throughout the study period.

Table I
Percentage of Intensity, Repetition and Sets of Resistance Training

Groups	**Components**	**Weeks**							
		I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**
Resistance Training	Intensity	60	60	70	70	80	80	90	90
	Repetitions	8 to 10	8 to 10	6 to 8	6 to 8	4 to 6	4to 6	2 to 4	2 to 4
	Sets	2	2	2	2	3	3	3	3

Table II
Percentage of Intensity, Repetition and Sets of Plyometric Training

Groups	**Components**	**Weeks**							
		I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**
Plyometric	Intensity	60	60	70	70	80	80	90	90

Training	Repetitions	10 to 12	10 to 12	8 to 10	8 to 10	6 to 8	6 to 8	4 to 6	4 to 6
	Sets	2	2	2	2	3	3	3	3

Data Analysis

Mean and standard deviation were calculated for leg strength of each training group. And the data were analyzed by using analysis of covariance (ANCOVA). If the '*F*' value was found to be significant for adjusted post-test mean, Scheffe's test was used as a post hoc test to determine the significant difference between the paired mean. All analysis was carried out using SPSS version (Field, 2000) and statistical significance was set at $p < 0.05$.

Results

Table III. Analysis of covariance for leg strength of experimental groups and control group

Test	RT	PT	RPT	CG	SOV	SS	df	MS	*F*
Pre-test									
Mean	73.87	74.13	73.60	73.20	B	7.13	3	2.38	0.07
S.D (±)	5.68	5.21	6.06	6.54	W	1943.47	56	34.71	
Post-test									
Mean	82.27	80.40	85.60	74.40	B	993.60	3	331.20	14.45*
S.D (±)	4.71	4.08	4.15	5.96	W	1283.73	56	22.92	
Adjusted Post-test									
Mean	82.19	80.21	85.64	74.62	B	957.57	3	319.19	19.25*
					W	911.86	55	16.58	

*Significant F = (df 3, 56) (0.05) = 2.776; ($P \leq 0.05$) F = (df 3, 55) (0.05) = 2.78; ($P \leq 0.05$).

Table III indicates that pre and post test mean and standard deviation of experimental and control groups on leg strength. The obtained '*F*' value for pre test mean on leg strength was 0.07, which was lesser than table value of 2.776 for degree of freedom 3 and 56 at 0.05 level of confidence; hence there was no significant difference in pre test data of experimental and control groups. The analysis of the post and adjusted post test mean data reveals that obtained '*F'* value of 14.45 and 19.25 respectively, which were higher than table 'F', hence there exists a significant difference in leg strength among the experimental and control groups. Since, four groups were compared, whenever obtained 'F' value for adjusted post test was found to be significant, Scheffe's test was used to find out the paired mean difference and it was presented in Table IV.

Table IV. Scheffe's post hoc test for the difference between paired mean on leg strength

Adjusted Post Test Mean				MD	*CI*
RT	PT	RPT	CG		
82.19	80.21	-	-	1.98	4.29
82.19	-	85.64	-	3.45	
82.19	-	-	74.62	7.57*	
-	80.21	85.64	-	5.43*	
-	80.21	-	74.62	5.59*	
-	-	85.64	74.62	11.02*	

* Significant, ($p \leq 0.05$)

Table IV showed that the adjusted post test mean difference in leg strength between resistance training group and control group, plyometric training group and control group, combined resistance and plyometric training group and control group and plyometric training group and combined groups are 7.57, 5.59, 11.02 and 5.43 respectively. These values are higher than the required confidence interval value of 4.29, which shows significant difference at the 0.05 level of confidence. It also showed that there was no significant difference between two other experimental groups. The pre, post and adjust post test mean values of experimental groups and control group on leg strength were graphically represented in the figure 1.

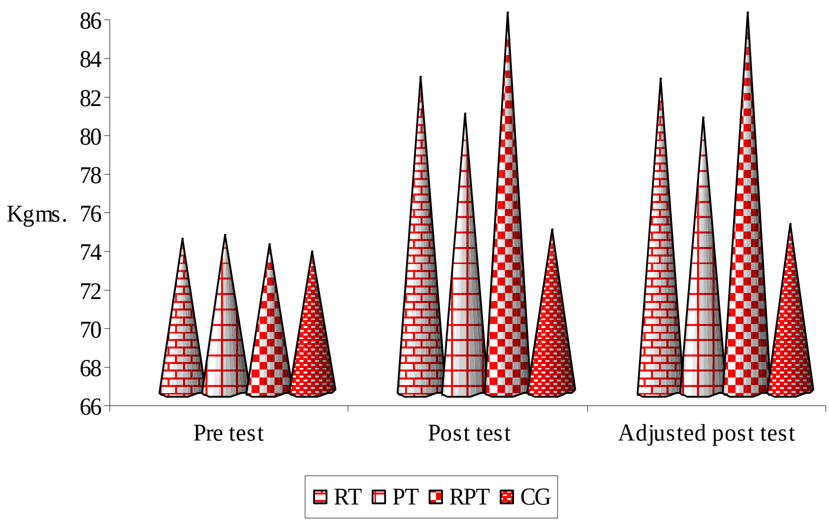

Figure 1: The pre, post and adjusted post test mean values of experimental groups and control group on leg strength

Discussion

The main findings from this study were a significant improve in leg strength ($p \leq 0.05$) following an 8 – week resistance training, plyometric training and combined resistance and plyometric training. Resistance training and plyometric training alone, as evidenced by this study have a significant effect on increasing leg strength. Strength and power variables are considered as the main determinants of athletic performance. Many research studies suggest that resistance training may be valuable for determining the physical variables such as leg strength (Lesnegard *et al*., 2010; Badillo *et al*., 2006 and Sankaranayanan & George, 2011). Teixeira *et al*. (2001) pointed out that resistance training three times per week is an effective as five times per week. The development of leg strength as a result is supported by the findings of Robert *et al.* (2002), Hunder *et al*. (2001) and George & Thomas (2011). The various training components (E.g. sets, repetitions, rest, intervals) could be manipulated the training loads used for the most important factor that determine the training stimuli and the consequent training adaptations(Myer *et al*., 2006 & Jones *et al*.,2001). Results from several investigations involving adults suggest that combining plyometric training with resistance training may be useful for enhancing muscular performance (Adams et al., 1992; Fatouros et al., 2000). Similar findings were recently reported by Myer and colleagues (2005) who observed that a six week, multi-component training program which included resistance training and plyometric training significantly enhanced strength, jumping ability in female adolescent athletes as compared to a non-exercising control group. Thus the effects of plyometric training and resistance training may actually be synergistic, with their combined effects being greater than each program performed alone. Studies also suggest that changes in motor performance skills resulting from the performance of combined resistance training and plyometric training are greater than with either type of training alone (Adams et al., 1992 and Fatouros et al., 2000). From the results of the present study and literature, it is concluded that the dependent variable such as leg strength was significantly improved due to the influence of resistance training, plyometric training and combined both.

Conclusion

It is evident from a number of the adaptations that occur with resistance training and plyometric training that there are several physical fitness related benefits. Any practical application requires careful implementation and individual experimentation. The results of the study showed that there was a significant improvement in leg strength between resistance training group and control group, plyometric training group and control group and combined resistance and plyometric training group and control group. The results also revealed that there was a significant difference in leg strength in between two training groups such as plyometric training group and combined resistance and plyometric training group. Moreover, we have demonstrated that the combined resistance and plyometric training programme were more effective than resistance training and plyometric training alone in improving leg strength of college male students.

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