IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Effects Of Unilateral And Bilateral Plyometric Training In Combination With Resisted Sprinting On Selected Sprint Kinematics Of Adolescent Sprinters

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Abstract

This study aims to compare the effect of unilateral and bilateral plyometric training in combination with resisted sprinting on sprint kinematics of adolescent boys' sprinters' speed, flight time and ground contact time. Forty-five moderately trained subjects, aged 13 to 15 years studying in different schools from Idukki and Kottayam districts, of Kerala state, India were selected as subjects. The selected subjects divided into three groups, namely, Unilateral Plyometric training in Combination with Resisted Sprinting (UPTCRS) Group I (n = 15), Bilateral Plyometric Training in Combination with Resisted Sprinting (BPTCRS) Group II (n = 15) and (CG) Control Group III (n=15). Both the groups performed maximal effort of plyometric leg exercises and resisted sprinting for 3 days a week for 12 weeks. Group I performed all the exercises with full repetition of each limb subsequently change to other side of the limb, left limb followed by right limb. Group II performed all the exercises with both limbs simultaneously. The data were analysed by using SPSS version 20, paired 't' test for each group, and ANCOVA were used to find out the effect between the groups. The paired mean differences were determined using Scheff's post hoc test whenever the adjusted post-test 'F' ratio values were found to be significant. Results of the study show that unilateral and bilateral plyometric training in combination with resisted sprinting were significantly improved speed, flight time and ground contact time.

Results of the study shows unilateral and bilateral plyometric training in combination with resisted sprinting were significantly improved on speed. Speed 't' ratio of UPTCRS, BPTCRS and CG were 3.09,3.59 and 0.140 (4.49%, 4.52% and 0.01%) . Flight time 't' ratio of UPTCRS,UPTCRS and CG were 9.13,7.93 and 1.87 and (11.81%,8.67% and 0.16%. Ground contact timeT 't' ratio of UPTCRS,BPTCRS and CG were 12.13,10.66 and 1.46 (18.04%,14.39% and 1.51%). (P< 0.01).The conclusion of the study stated that the speed ,flight time and ground contact time of the unilateral and bilateral plyometric training in combination with resisted sprint training group subjects were significantly increased when compared with the control group. However, when comparing the experimental groups, bilateral plyometric training in combination with resisted sprinting group was better than unilateral plyometric training in combination with resisted sprinting group.

Key word : Unilateral Plyometric Training, Bilateral Plyometric Training ,Resisted Sprinting, Speed, Flight time and Ground contact time.

INTRODUCTION

Sprinting, one of the most exhilarating athletic endeavors is a discipline that requires athletes to cover a set distance in the shortest possible time through an explosive burst of energy. This activity demands coordinated movement of the arms, legs, and torso to achieve optimal efficiency. To reach peak performance, sprinters must not only develop exceptional speed but also maintain proper body alignment to maximize their potential. sprint performance is a fundamental aspect of many sports, requiring optimal kinematic and neuromuscular adaptations for maximal acceleration, speed, and efficiency. Key sprint kinematics, including flight time, speed, and ground contact time (GCT**)**, play a crucial role in determining overall sprinting success. Improving these variables through targeted training interventions can significantly enhance athletic performance, particularly in adolescent sprinters who are still developing their neuromuscular capabilities. Plyometric training, a widely used method for improving explosive strength and power, has been shown to enhance sprint kinematics by stimulating the stretch-shortening cycle (SSC) and increasing neuromuscular efficiency **(Markovic & Mikulic, 2010**). Two primary types of plyometric training unilateral and bilateral offer distinct benefits. Unilateral plyometric training, which emphasizes single-leg force production and coordination, closely mimics the biomechanics of sprinting. In contrast, bilateral plyometric training, which involves both legs working simultaneously, allows for greater force generation due to increased load capacity **(Sole et al., 2013).** Another effective method for improving sprint performance is resisted sprint training, a specialized approach to sports conditioning, has garnered significant attention for its potential to enhance an athlete's speed and power. Running against any kind of resistance, usually in the form of a weighted item or a parachute that the runner tows behind them, is known as resisted sprinting. There have been conjectures by teachers that these training techniques will cause an athlete's sprinting ability to change. Furthermore, it has been demonstrated that resisted sprinting, such weighted sprints or sled towing, enhances force output and acceleration by boosting sprint-specific strength and ground response forces. **(Petrakos et al., 2016).**

METHODOLOGY

Subjects and Variables

This study aimed to examined how the speed, flight time and ground contact time of sprinters were affected unilateral and bilateral plyometric training in combination with resisted sprinting. The participants were 45 adolescents boys' sprinters from different schools in Idukki and Kottayam districts, Kerala state, India. The subjects were divided into three groups of fifteen each . In Group I, UPTCRS, Group II, BPTCRS and Group III, CG. The speed, flight time and ground contact time was measured by 50 meter run test.

Training protocol

This 12-week training program includes unilateral and bilateral plyometric training in combination with resisted sprinting to increase the speed, flight time and ground contact time of adolescent boys' sprinters. The program gradually increases in complexity and intensity using a progressive overload technique. Training was carried out for three days a week, with an emphasis on developing lower extremity power. Group I UPTCRS, Group II BPTCRS, and Group III acted as CG. The unilateral plyometric training exercises included in this training program were single-leg depth jump, single-leg box jump, and single leg bounding. The bilateral plyometric training exercises included in this training program were double-leg depth jumps, double-leg box jumps, and double leg bounding. Group, I completed all the exercises by fully repeating each limb subsequently change to the left limb and then to the right limb, respectively. Group II executed every exercise simultaneously using both limbs. Group III do not participate in any special training. The resisted sprint training program includes weighted vest and harness running. The training distance comprised 30-50 meters, and the initial intensity was fixed at 70% and increased once every two weeks by 5%. Both the training groups had the same volume, intensity, and frequency of training. Whereas, the rest intervals between repetition and set are 45-60 sec and 2 minutes respectively.

Experimental Design and Statistical Technique

The study was formulated as a random group design consisting of pre and post test conducted for all the subjects on selected criterion variables. Post test was conducted after the experimental treatment of 12 weeks and the scores were recorded. Data were analysed by paired 't' test. Additionally, the improvement in percentage (%) was also calculated to find out the impact of the experiment. The normality of the data was found through mean, standard deviation, and 'F' ratio. The analysis of covariance (ANCOVA) was applied to

find out the significant difference in each criterion variable among the groups. Whenever, the obtained 'F' ratio value for adjusted post-test means was found to be significant at 0.05 level, Scheffe's post hoc test was done.

Analysis of Speed

Table I

Descriptive Analysis on Speed of UPTCRS, BPTCRS and CG

Group	Test	Mean	Standard Deviation	Mean Difference	't' ratio	Percentage of Changes
UPTCRS	Pre	5.06	0.088	0.278	3.09*	5.49%
	Post	4.79	0.323			
BPTCRS	Pre	5.08	0.094	0.230	3.59*	4.52%
	Post	4.84	0.270			
CG	Pre	5.07	0.104	0.001	0.140	0.01%
	Post	5.07	0.099			

*Significant at 0.05 level of confidence (df 2 and 14 and 2.15)

The pre and post test mean (M), standard deviation (SD) and mean differences (MD) values on speed of the UPTCRS, BPTCRS and CG are given in table I. The calculated 't' values of UPTCRS (3.09) and BPTCRS (3.59) and CG (0.140) groups are greater than the necessary table value (df 14=2.15) for significance at 0.05 level. It exposed those considerable differences be present between the pre and post test means of UPTCRS and BPTCR groups on speed .The result produced 5.49% percentage of changes in speed due to UPTCRS 4.52% of changes due to BPTCRS and 0.01% of changes in CG. The data (pre & post) collected from the UPTCRS,BPTCRS and CG on speed was analyzed by using analysis of covariance and the resultant outcomes are clearly detailed in table number II.

Table II

Analysis of Covariance Result on Speed of UPTCRS, BPTCRS and CG

Adjusted means of groups			SoV	Sum of Squares (SS)	df	Mean Squares (MS)	'F' ratio
UPTCRS	BPTCRS	CG					
4.79	4.84	5.07	B	0.664	2	0.332	5.42*
			W	2.511	41	0.061	

*Significant at 0.05 level of confidence (df 2 and 41 and 3.23)

The adjusted means on speed of UPTCRS (4.79), BPTCRS (4.84), and CG (5.07) groups are resulted in the 'F' ratio of 5.42 which is greater than table value (df 2&41=3.23) for significance at 0.05 level. Consequently, it is decided that major deviation be present among the adjusted means of UPTCRS, BPTCRS and CG on speed.As, the attained 'F' ratio value in the adjusted means of UPTCRS, BPTCRS and CG is found significant, the post hoc (Scheffe's) test was applied to discover the paired mean difference, as given in table number-III.

Table III

Scheffe's Test Outcomes on Speed of UPTCRS, BPTCRS and CG

Adjusted means of groups				
UPTCRS	**BPTCRS**	**CG**	**Mean Difference**	**Confidence Interval**
4.79	4.84		0.05	0.22
4.79		5.07	0.28*	0.22
	4.84	5.07	0.23*	0.22

*Significant at 0.05 level of confidence

The Scheffe's test result established that considerable mean differences present between training in combination with resisted UPTCRS and BPTCRS (0.05), UPTCRS and CG (0.28), BPTCRS and CG (0.23) groups on speed, because, these mean differences (MD) values are more than the confident interval (CI) value (0.22) for significance at 0.05 level.

Figure-I

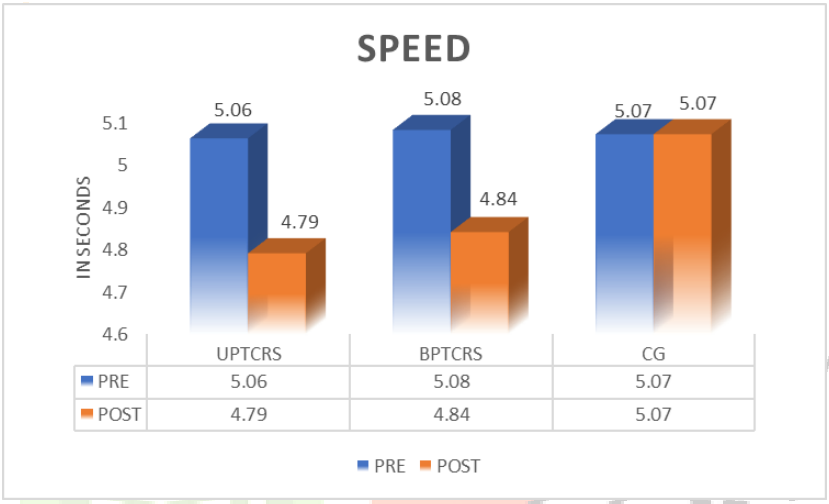

Figure Screening Displayed the Mean Values on Speed

Analysis of Flight Time

Table IV

Descriptive Analysis on Flight Time (FT) of UPTCRS, BPTCRS and CG

Group	Test	Mean	Standard Deviation	Mean Difference	't' ratio	Percentage of Changes
UPTCRS	Pre	0.121	0.0023	0.0143	9.13*	11.81%
	Post	0.107	0.0057			
BPTCRS	Pre	0.121	0.0027	0.0105	7.93*	8.67%
	Post	0.110	0.0059			
CG	Pre	0.120	0.002	0.0002	1.87	0.16%
	Post	0.120	0.002			

*Significant at 0.05 level of confidence (df 2 and 14 and 2.15)

The pre and post test mean (M), standard deviation (SD) and mean differences (MD) values on flight time of the UPTCRS, BPTCR and CG are given in table IV. The 't' values of UPTCRS (9.13) and BPTCRS (7.93) and CG (1.87) groups are greater to table value (df 14=2.15) for significance at 0.05 level. It exposed those considerable differences be present between the pre and post test means of UPTCRS, BPTCRS and CG on flight time. The result produced 11.81% percentage of changes in flight time due to UPTCR 8.67% of

changes due to BPTCRS and 0.16% of changes in CG. The data (pre & post) collected from the UPTCRS, BPTCRS and CG on flight time was analyzed by using analysis of covariance and the resultant outcomes are clearly detailed in table number V.

Table V

Analysis of Covariance Result on Flight Time of UPTCRS, BPTCRS and CG

Adjusted means of groups			S o V	Sum of Squares	Df	Mean Squares	'F' ratio
UPTCRS	BPTCRS	CG					
0.107	0.111	0.121	B	0.002	2	0.001	35.33*
			W	0.001	41	2.143	

*Significant at 0.05 level of confidence (df 2 and 41 and 3.23)

The adjusted flight time (FT) means of UPTCRS (0.107), BPTCRS (0.111) and CG (0.121) groups resulted in 'F' ratio value 35.33 which is greater to table value df 2&41=3.23 for significance at 0.05 level. Therefore, it is decided that, major variation be present between the adjusted means of UPTCRS, BPTCR and CG on flight time.As, the attained 'F' ratio value in the adjusted means of UPTCRS, BPTCRS and CG was found significant, the post hoc (Scheffe's) test was applied to discover the paired mean difference, as given in table number VI.

Table VI

Scheffe's Test Outcomes on Flight Time of UPTCRS, BPTCRS and CG

Adjusted means of groups			Mean Difference	Confidence Interval
UPTCRS	BPTCRS	CG		
0.107	0.111		0.004	0.02
0.107		0.121	0.014*	0.02
	0.111	0.121	0.010*	0.02

*Significant at 0.05 level of confidence

The mean differences between UPTCRS and BPTCRS (0.004), UPTCRS and CG (0.014), BPTCRS and CG (0.010) groups on flight time, is significant because, these mean differences (MD) are more than the confident interval (CI) value (0.02) for significance at 0.05 level. It confirmed that, due to UPTCRS, BPTCRS and CG impact the flight time of the adolescent boys' sprinters was considerably enhanced whereas UPTCRS group is significantly better than in BPTCRS developing flight time of the adolescents boys' sprinters. The flight time mean (pre, post & adjusted) values UPTCRS, BPTCRS and CG factions are indicated in figure no-II.

Figure-II

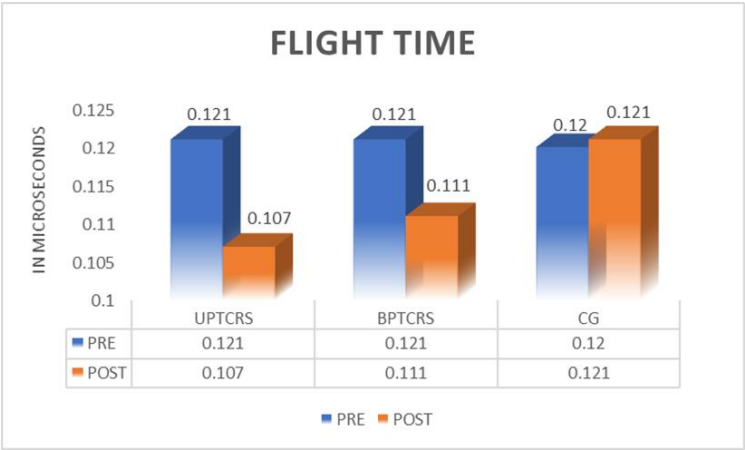

Figure Screening Displayed the Mean Values on Flight Time (FT)

Analysis of Ground Contact Time

Table VII

Descriptive Analysis of Data on Ground Contact Time of UPTCRS, BPTCRS and CG

Group	Test	Mean	Standard Deviation	Mean Difference	't' ratio	Percentage of Changes
UPTCRS	Pre	0.133	0.0019	0.024	12.13*	18.04%
	Post	0.109	0.0065			
BPTCRS	Pre	0.132	0.0019	0.019	10.66*	14.39%
	Post	0.113	0.0059			
CG	Pre	0.132	0.0019	0.002	1.46	1.51%
	Post	0.113	0.0064			

*Significant 0.05 level of confidence (df 14 and 2.15)

The pre and post test mean (M), standard deviation (SD) and mean differences (MD) values on ground contact time of the UPTCRS BPTCRS and CG are given in table VII. The 't' values of UPTCRS (12.13) BPTCRS (10.66) and CG (1.46) groups are greater to table value (df 2&14=2.15) for significance at 0.05 level. It exposed those considerable differences be present between the pre and post test means of UPTCRS and BPTCRS groups on ground contact time. The result produced 18.04% percentage of changes in ground contact time due to UPTCRS ,14.39% of changes due to BPTCRS and 1.51% of changes in CG. The data (pre & post) collected from the UPTCRS, BPTCRS and CG on ground contact time was analyzed by using analysis of covariance and the resultant outcomes are clearly detailed in table number VIII.

Table VIII

Analysis of Covariance Result on Ground Contact Time of UPTCRS, BPTCRS and CG

Adjusted means of groups			SOV	Sum of Squares	Df	Mean Squares	'F' ratio
UPTCRS	BPTCRS	CG					
0.110	0.113	0.130	B	0.003	2	0.002	44.44*
			W	0.002	41	0.005	

*Significant at 0.05 level of confidence (df 2 and 41 and 3.23)

The ground contact time (GCT) adjusted means of UPTCRS (0.110), BPTCRS (0.113) and CG (0.130) groups are resulted in 'F' ratio of 44.44 which is larger than the table value df 2&41=3.23 for significance (0.05 level). Therefore, it is decided that, major variation is present between the adjusted means of UPTCRS, BPTCRS and CG on ground contact time. As, the attained 'F' ratio value in the adjusted means of UPTCRS, BPTCRS and CG was found significant, the post hoc (Scheffe'S) test was applied to discover the paired mean difference, as given in table number IX

Table IX

Scheffe's Test Outcomes on Ground Contact Time of UPTCRS, BPTCRS and CG

Adjusted means of groups			Mean Difference	Confidence Interval
UPTCRS	BPTCRS	CG		
0.110	0.113		0.003	0.06
0.110		0.130	0.020*	0.06
	0.113	0.130	0.017*	0.06

*Significant at 0.05 level of confidence.

The mean differences between UPTCRS and BPTCRS (0.003), UPTCRS and CG (0.020), BPTCRS and CG (0.017) on ground contact time (GCT), groups is significance because, these differences (MD) are more than the confident interval (CI) value (0.06) for significance at 0.05 level.It confirmed that**,** due to UPTCRS and BPTCRS impact the ground contact time of the adolescent boys' sprinters was considerably enhanced whereas UPTCRS group is significantly better than BPTCRS group in developing ground contact time of the adolescent boys' sprinters. The ground contact time mean (pre, post & adjusted) values of three factions are illustrated in figure no III.

Figure-III

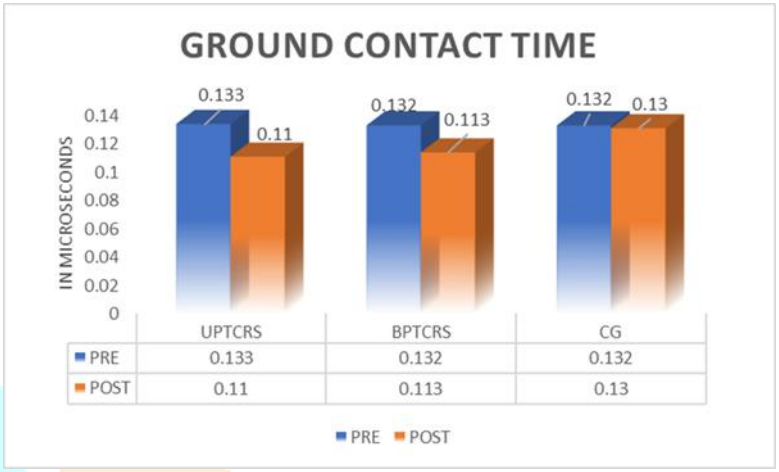

Figure Screening Displayed the Mean Values on Ground Contact Time (GCT) of UPTCRS, BPTCRS and CG

Discussion on Results

The results of the study stated that the unilateral and bilateral plyometric training in combination with resisted sprinting on speed, flight time and ground contact time of adolescent boys' sprinters has significantly improved. Among the experimental group unilateral plyometric training in combination with resisted sprinting had a high impact on to increase the speed, flight time and ground contact time of adolescent boys' sprinters.

The findings of this study align with previous research indicating that both unilateral and bilateral plyometric training, in combination with resisted sprint training, contribute to significant improvements in sprint speed. However, unilateral plyometric training was found to be more effective in enhancing acceleration speed compared to bilateral plyometric training in combination with resisted sprinting. This is likely due to its greater specificity to sprint mechanics, as sprinting relies on alternating single-leg propulsion. Unilateral plyometric exercises, such as single-leg bounds and hops, closely mimic sprinting movements and may improve inter-limb coordination, balance, and force application **(Spinks et al., 2007**). Unilateral plyometric training appears to be particularly effective in reducing GCT compared to bilateral training. Since sprinting involves alternating single-leg propulsion, unilateral exercises closely replicate sprint-specific movement patterns, leading to improved neuromuscular coordination and efficiency **(Gonzalez-Rave et al., 2014**). Additionally, unilateral training enhances stability and balance, which are essential for minimizing energy loss and maximizing force transfer during sprinting **(Cross et al., 2018**).Ground contact time (GCT) is a crucial factor in sprint performance, influencing both acceleration and maximum velocity phases. It refers to the duration a sprinter's foot remains in contact with the ground during each stride. Reducing GCT is essential for improving sprint speed, as shorter contact times allow for faster turnover rates and more efficient force application **(Nagahara et al., 2018**).Sprinting efficiency is largely determined by the ability to generate high levels of force in minimal time, which is directly linked to neuromuscular adaptations and explosive power **(Mero et al., 1992).** Resisted sprint training may have further contributed to these gains by enhancing the athletes' ability to generate both vertical and horizontal propulsive forces. Research suggests that resisted sprints help develop sprint-specific strength and power, allowing sprinters to maintain proper stride mechanics and achieve greater lift-off during the sprint cycle **(Petrakos et al., 2016)**. Overall, the significant improvements in flight time suggest that combining resisted sprint training with plyometric exercises is an effective strategy for enhancing sprint performance.

Conclusion

The conclusion of the study stated that the speed, flight time and ground contact time of the unilateral and bilateral plyometric training in combination with resisted sprint training group subjects has significantly increased when compared with the control group. However, when comparing the experimental groups, the unilateral plyometric training in combination (BPTCRS) with the resisted sprinting group has significant improved than the bilateral plyometric training in combination with resisted sprinting (UPTCRS) group. In this study it is observed that, unilateral and bilateral plyometric training in combination with resisted sprint training have significantly improved speed, flight time and ground contact time of adolescent boys' sprinters. This study indicates training modalities are strongly suggestable for the improvement of sprint kinematics of athletes.

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