



“Effect of Assisted and Resisted Training on Selected Kinematics Variables and Sprint Performance Among Male Sprinters”

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Abstract

The purpose of this study was to determine the effect of assisted and resisted sprint training on left foot to right foot step length, right foot to left foot step length and sprint kinematics among male sprinters. Thirty male sprinters aged 18–20 years were randomly selected and assigned to three groups of ten each: Assisted Sprint Training, Resisted Sprint Training, and Control. The experimental groups underwent their respective training programmes, while the control group followed its regular routine. The data were analyzed using Analysis of Covariance (ANCOVA), and Scheffé's post hoc test was employed to identify paired mean differences whenever significant F ratios were obtained. The level of significance was set at 0.05. The results revealed significant improvements in Right Foot to Left Foot Step Length ($F = 8.95$, $p < 0.05$) and Left Foot to Right Foot Step Length ($F = 12.31$, $p < 0.05$). Both assisted and resisted sprint training groups showed significantly greater improvements than the control group, whereas no significant difference was observed between the two experimental groups. It was concluded that both assisted and resisted sprint training are effective methods for improving selected sprint kinematic variables among male sprinters.

Keywords: Assisted and Resisted Exercises, Speed, Acceleration,

Introduction

Speed of movement in the proper sequence over time is the ultimate objective of optimum performance. As strength levels increase and all other biomotor areas have been developed, speed becomes a resultant of the training that has been applied. As the systems are trained, all principles must be adhered to in order for efficient and economical speed development to occur. If the athlete cannot maintain proper neuromuscular coordination due to physiological energy system fatigue, then the effectiveness of speed is reduced. Development of the biomotor abilities of work capacity, flexibility, co-ordination and strength are necessary in order to ensure that the sportsmen or athlete will be able to maintain speed in all of the sports events. One way to increase stride length and stride frequency is to increase overall functional strength through the entire body. Improved strength levels will allow athletes to produce greater amounts of force while at the same time decreasing their ground contact time. Training the body to use the attained strength gains in a powerful fashion is the key to acceleration improvement. Power refers to the ability to generate the greatest amount of force in the shortest possible time. In a nutshell, the most powerful athletes spend less time on the ground, have longer strides, and can repeat them more rapidly than their less powerful counterparts.



Statement of The Problem

“The main purpose of the study was to find out the A Study on the Effect of Assisted and Resisted Sprint Training on Speed, Acceleration, and Sprint Kinematics among Male Sprinters”

Delimitations

The study was delimited to the following factors.

1. To achieve the purpose of the study, thirty male sprinters were selected as participants.
2. The study was delimited to the 18- to 20-year Age group only.
3. The selected participants (N=30) were classified into three equal groups of ten each (n=10) at random. Group I underwent assisted sprint training, group II underwent resisted sprint training, and group III acted as a control.
4. The study was delimited to selected Variables: Resisted Sprint Training on Left Foot to Right Foot Step Length,
5. The duration of the training period was restricted to twelve weeks, and the number of sessions per week was confined to three, which was considered adequate to cause changes in selected dependent parameters.

Limitations

The following uncontrollable factors associated with the study were considered limitations.

1. The changes in climatic conditions (*atmospheric temperature, relative humidity, wind velocity, and other meteorological factors*) during the period of experimentation and at the time of testing were considered limitations.
2. The growth and development of the participants, if any, during the period of experimentation and the possible influence on the criterion variable could not be controlled. However, the control group was involved to nullify the effect of anatomical and physiological maturation.
3. The participants were motivated verbally; no attempt was made to differentiate the motivation level during training and testing.
4. The previous experience of the participants in the field of sports and games, which might influence training and the data collection, was not considered.
5. Heredity and socio-economic conditions and their influence on the participants were not considered in this study.

Objectives of The Study

The primary research objectives are the following:

1. To analyse the changes in right foot to left foot step length meters and sprint kinematics due to the effect of assisted sprint training.
2. To analyse the changes in left foot to right foot step length (meters) and selected sprint kinematics due to the effect of resisted sprint training.
3. To compare the influence of assisted and resisted sprint training on selected sprint kinematics of male sprinters.
4. To analyse the changes in selected sprint kinematics of male sprinters that determine the transformation of performance in speed.

Methodology

selection of the subject:

To achieve the purpose of the study, the investigator selected thirty male sprinters from various colleges affiliated with Bangalore North University, Kolar, Karnataka state, as participants. The age of the participants ranged from 18 to 23 years. The selected participants were medically examined by a qualified physician. The selected participants were randomly segregated into three groups of 10 each. Group I underwent assisted sprint training; group II underwent resisted sprint training and group III acted as control.



The experimental groups were trained up in two modes of sprint training, which were given independently, with separate participants in each group. All participants were informed about the nature of the study, and their consent was obtained for cooperation till the end of the experiment.

Selection of Variables and Tests

The present study was undertaken primarily to assess the effect of assisted and resisted sprint training on selected sprint kinematics of male sprinters. The researcher reviewed the available literature and held discussions with various experts and his guide before selecting variables and tests. The availability of techniques for the purpose of analysis, feasibility, reliability of the procedure and the outcome was extensively taken care of before finalising the variable.

Table :1
Selection of the Variables and Tests

S. No.	Variables	Test Items	Unit of Measurement
1.	Right Foot to Left Foot Step Length meters)	50 m run	Meters
2.	Left Foot to Right Foot Step Length (meters)	50m Run	Meters

Orientation to the Participants

Before the commencement of the sprint training, several sessions were allowed to familiarise the participants with the techniques involved in executing the assisted and resisted sprint training exercises. The investigator explained the purpose of the programme to the subjects and their part in the study. For the collection of the data, the investigator explained the procedure of training and testing on selected variables and gave instructions about the procedure to be adopted by them for measuring. The subjects were sufficiently motivated to perform at their maximal level during the training and testing period. The control group had no specific training and was advised not to be involved in any sort of practice or specific training programme during the experimental period. All the participants who co-operated were well informed of the seriousness and importance of the study. Sixty volunteers met the study criteria and gave written informed consent to participate. This assured good orientation and cooperation from the participants.

Training Programme

Based on the results of the pilot study, the training programme was designed. In this study, training was done under close supervision with frequent adjustments in training intensity to maintain the desired training stimulus. While constructing the training programmes, the basic principles of sports training were followed. The training programmes were scheduled for one session a day, each session lasted between one hour to one and a half hours, approximately including warming up and warming down. During the training period, the experimental groups underwent their respective training programme three days a week on alternative days for twelve weeks in addition to their curriculum. The group I performed assisted sprint training, group II resisted sprint training.

The assisted sprint training exercise included in this training programme was downhill running. The resisted sprint training exercises included in this training programme was running with weighted vest. The training distance comprised of 30, 40 and 50 metres and the initial intensity was fixed at 85% of the groups' personal best, as measured in the pilot study. The training intensity for each distance was derived based on the time taken to perform the particular training distance by the respective groups in the pilot study.

During every third week of a particular training intensity, one repetition is performed additionally. Further, the prescription of exercise allows four weeks of stabilization to a training intensity, and thereafter intensity of running for distance in time is increased, correspondingly the number of repetitions performed was reduced beyond the repetitions fixed for earlier weeks, with an increase in the intensity. The rest interval of 1:1 was provided between repetitions for incomplete recovery, and 1:3 between sets for almost complete recovery. The participants remained active during recovery period, by performing stretching exercises. The assisted sprint training group underwent downhill run with 3° inclination. During resisted sprint running with weighted vests weighing 7% of body mass were used. Both experimental groups performed the same volume, intensity and frequency of training as given in Table 2.



Table-2

Sprint Training Protocol

Weeks	Day	Set x Rep x Distance	Intensity	Recovery	
				Rep	Set
1 & 2	Mon	set-1: 6 rep of 30m	85%	1:1	1:3
	Wed	set-2: 5 rep of 40m			
	Fri	set-3: 4 rep of 50m			
3 & 4	Mon	set-1: 7 rep of 30m	85%	1:1	1:3
	Wed	set-2: 6 rep of 40m			
	Fri	set-3: 5 rep of 50m			
5 & 6	Mon	set-1: 5 rep of 30m	90%	1:1	1:3
	Wed	set-2: 4 rep of 40m			
	Fri	set-3: 3 rep of 50m			
7 & 8	Mon	set-1: 6 rep of 30m	90%	1:1	1:3
	Wed	set-2: 5 rep of 40m			
	Fri	set-3: 4 rep of 50m			
9 & 10	Mon	set-1: 4 rep of 30m	95%	1:1	1:3
	Wed	set-2: 3 rep of 40m			
	Fri	set-3: 2 rep of 50m			
11 & 12	Mon	set-1: 5 rep of 30m	95%	1:1	1:3
		set-2: 4 rep of 40m			
		set-3: 3 rep of 50m			

ADMINISTRATION OF THE TESTS

1. Left Foot to Right Foot Step Length

Purpose: To measure the left foot to right foot step length

Equipments: Video graphed 50 meters run performance of the subjects, Silicon Coach Software and the Computer system.

Procedure: The 50 meters run performance recorded on the subject was video graphed and analyzed frame by frame and selected the right performance frame to measure the left foot to right foot step length, using Silicon Coach Software. On selection of the right frames, it was measured from left foot strike to right foot strike. The distance was measured in meters with the help of Silicon Coach Software tools. The frames selected along with the scoring displayed by the accurate measurements in meters available in the software.

2. Right Foot to Left Foot Step Length

Purpose: To measure the right foot to left foot step length

Equipments: Video graphed 50 meters run performance of the subjects, Silicon Coach Software and the Computer system.

Procedure: The 50 meters run performance recorded on the subject was video graphed and analyzed frame by frame and selected the right performance frame to measure the right foot to left foot step length, using Silicon Coach Software. On selection of the right frames, it was measured from Right foot strike to Left foot strike. The length was measured in meters with the help of Silicon Coach Software tools. The frames selected along with the scoring displayed by the accurate measurements in meters available in the software.

COLLECTION OF THE DATA

The data was collected on selected sprint kinematics as per the methods described above. The pretest data were collected prior to the training programme and posttest data was collected immediately after the twelve weeks of assisted and resisted sprint training from the experimental and control groups.



EXPERIMENTAL DESIGN AND STATISTICAL TECHNIQUE

The experimental design in this study was a random group design involving 30 subjects, who were divided at random into three groups of ten each. All three group participants were selected from the same population. No effort was made to equate the groups before the commencement of the experimental treatment. The pretest means of the selected dependent variable were used as a covariate. To nullify the initial differences, the data collected from the three groups before and post-experimentation on selected dependent variables were statistically analysed to find out the significant difference if any, by applying the analysis of covariance (ANCOVA). Since three groups were involved, whenever the obtained 'F' ratio for adjusted post-test means was found to be significant, the Scheffé S test was applied as a post hoc test to determine the paired mean differences (Broota, 1989). In all the cases level of confidence was fixed at 0.05 for significance.

To analyse the changes in selected sprint kinematics that determine the transformation on performance of speed, the mean gain was computed. Further, the Enter method of multiple regression analysis was utilised to select the minimum number of sprint kinematics that could determine speed with the highest multiple coefficients. In all cases, the level of confidence was fixed at 0.05 for significance.

Analysis of the Data

The pre- and post-test data collected from the assisted, resisted, and control groups on sprint kinematics were statistically analysed, and the results are presented below.

Analysis of Right Foot to Left Foot Step Length (meters)

The data collected during the pre and post-test period among assisted, resisted sprint training groups and control group on right foot to left foot step length (meters) have been statistically analyzed and the details are presented in table-4.9.

Table – 3

Analysis of Covariance on Right Foot to Left Foot Step Length of Assisted Resisted Sprint Training Groups and Control Group

	Assisted Group	Resisted Group	Control Group	S o V	Sum of Squares	df	Mean squares	'F' ratio
Pre test	1.23	1.13	1.20	B	0.93	2	0.31	0.19
Mean	01.27	0.18	0.32	W	90.00	27	1.61	
SD								
Post test	1.32	1.68	1.01	B	366.85	2	122.28	9.10*
Mean	0.91	0.39	0.75	W	752.00	27	13.42	
SD								
Adjusted	1.21	1.33	1.17	B	362.36	2	120.78	8.95*
Post test				W	741.91	26	13.48	
Mean								

*Significant at .05 level of confidence

(The required table value for significance at 0.05 level of confidence with degree of freedom 2 and 27 is 2.77 and degrees of freedom 2 and 26 is 2.77)

Table-3 shows that the pre-test means and standard deviation on right foot to left foot step length (meters) of assisted sprint training group, resisted sprint training group, and control group are 1.23 ± 0.27 , 1.13 ± 0.18 , and 1.20 ± 0.32 respectively. The obtained 'F' ratio value of 0.19 was less than the required table value of 2.77 for the degrees of freedom 2 and 27 at 0.05 level of confidence, which proves that the random assignment of the subjects were successful as the pre test scores on right foot to left foot step length (meters) among groups didn't differ significantly.

The post-test means and standard deviation on right foot to left foot step length (meters) of assisted sprint training group, resisted sprint training group, and control group are 1.32 ± 0.91 , 1.68 ± 0.39 , and 1.01 ± 0.75 respectively. The obtained 'F' ratio value of 9.10 on right foot to left foot step length was greater than the required table value of 2.77 for the



degrees of freedom 2 and 27 at 0.05 level of confidence. It implies that significant differences existed between the groups during the post test period on right foot to left foot step length (meters).

The adjusted post-test means on right foot to left foot step length (meters) of assisted sprint training, resisted sprint training, and control groups are 1.21, 1.33, and 1.17 respectively. The obtained 'F' ratio value is 8.95 of right foot to left foot step length was greater than the required table value of 2.77 for the degrees of freedom 2 and 26 at 0.05 level of confidence. The result of the study reveals that, significant differences exist among experimental and control group on right foot to left foot step length (meters).

Since, the adjusted post-test mean 'F' value was found to be significant, the data on right foot to left foot step length (meters) is subjected to post hoc analysis using Scheffé S test and the results are presented in table-4.10.

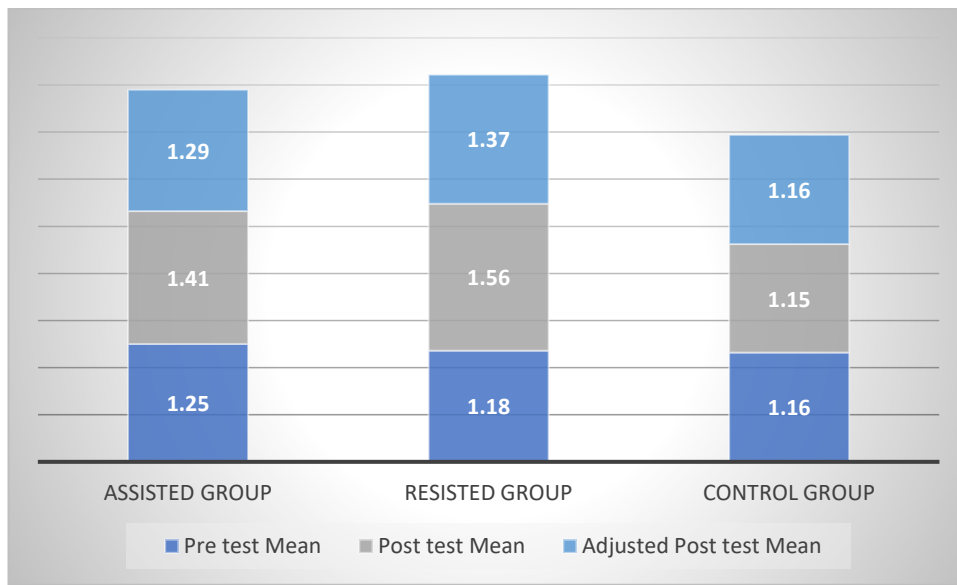


Figure:1

Analysis of Covariance on Right Foot to Left Foot Step Length of Assisted Resisted Sprint Training Groups and Control Group

Table – 4

Scheffé S Test for the Differences between the Adjusted Post Test Paired Means on Right Foot to Left Foot Step Length

Variable	Adjusted Post Test Mean			Mean Differences	Confidence Interval
	Assisted Sprint Training	Resisted Sprint Training	Control Group		
Right Foot To Left Foot Step	1.21	1.33		0.12	0.16
	1.01		1.17	0.16*	0.16
		1.33	1.17	0.16*	0.16

*Significant at .05 level.

Table-4 shows that the adjusted post-test mean differences on right foot to left foot step length between assisted sprint training and control groups, resisted sprint training and control groups, are 0.96, 0.64, which are greater than the confidence interval value of 3.86. However, the mean differences between assisted and resisted sprint training groups, 0.12, which are lesser than the confidence interval value of 0.16 at 0.05 level of significance.

From the result of the study it was concluded that the right foot to left foot step length of the assisted, resisted sprint training group subjects was significantly changed. However, when comparing the experimental groups there was no significant differences existed between them in altering the right foot to left foot step length.

4.2.6: Analysis of Left Foot to Right Foot Step Length

The data collected during the pre and posttest period among assisted, resisted sprint training groups and control group on left foot to right foot step length have been statistically analyzed and the details are presented in table-4.11.



Table – 5

Analysis of Covariance on Left Foot to Right Foot Step Length of Assisted
Resisted Sprint Training groups and Control Group

	Assisted Group	Resisted Group	Control Group	S o V	Sum of Squares	df	Mean squares	'F' ratio
Pre-test	1.25	1.18	1.16	B	0.83	2	0.002	0.002
Mean SD	0.05	0.38	0.03	W	763.87	27	13.64	
Post test	1.41	1.56	1.15	B	168.89	2	56.29	10.26*
Mean SD	0.68	0.23	0.78	W	307.10	27	5.48	
Adjusted	1.29	1.37	1.16	B	170.21	2	56.74	12.31*
Post test Mean				W	253.50	26	4.61	

*Significant at .05 level of confidence

(The required table value for significance at 0.05 level of confidence with degree of freedom 2 and 27 is 2.77 and degrees of freedom 2 and 26 is 2.77)

Table-5 shows that the pre-test means and standard deviation on left foot to right foot step length of assisted, resisted sprint training groups and control group are 1.25 ± 0.05 , 1.18 ± 0.38 , and 1.16 ± 0.03 respectively. The obtained 'F' ratio value of 0.002 on left foot to right foot step length was less than the required table value of 2.77 for the degrees of freedom 2 and 27 at 0.05 level of confidence, which proved that the random assignment of the subjects were successful as the pre test scores on left foot to right foot step length among groups didn't differ significantly.

The post test means and standard deviation on left foot to right foot step length of assisted, resisted sprint training groups and control group are 1.21 ± 0.68 , 1.56 ± 0.23 , and 1.35 ± 0.78 . The obtained 'F' ratio value is 10.26 of left foot to right foot step length was greater than the required table value of 2.77 for the degrees of freedom 2 and 27 at 0.05 level of confidence. It demonstrates that significant differences existed between the groups during the post test on left foot to right foot step length.

The adjusted post test means on left foot to right foot step length of assisted, resisted sprint training groups and control group are 1.219, 1.37, 1.31 and 1.36. The obtained 'F' ratio value is 12.31 of left foot to right foot step length was greater than the required table value of 2.77 for the degrees of freedom 2 and 26 at 0.05 level of confidence. The result reveals that, significant differences exist among the experimental and control groups on left foot to right foot step length. Since the adjusted post test mean 'F' value was found to be significant, the data on left foot to right foot step length are subjected to post hoc analysis using Scheffé S test and the obtained results are presented in table –4.12.

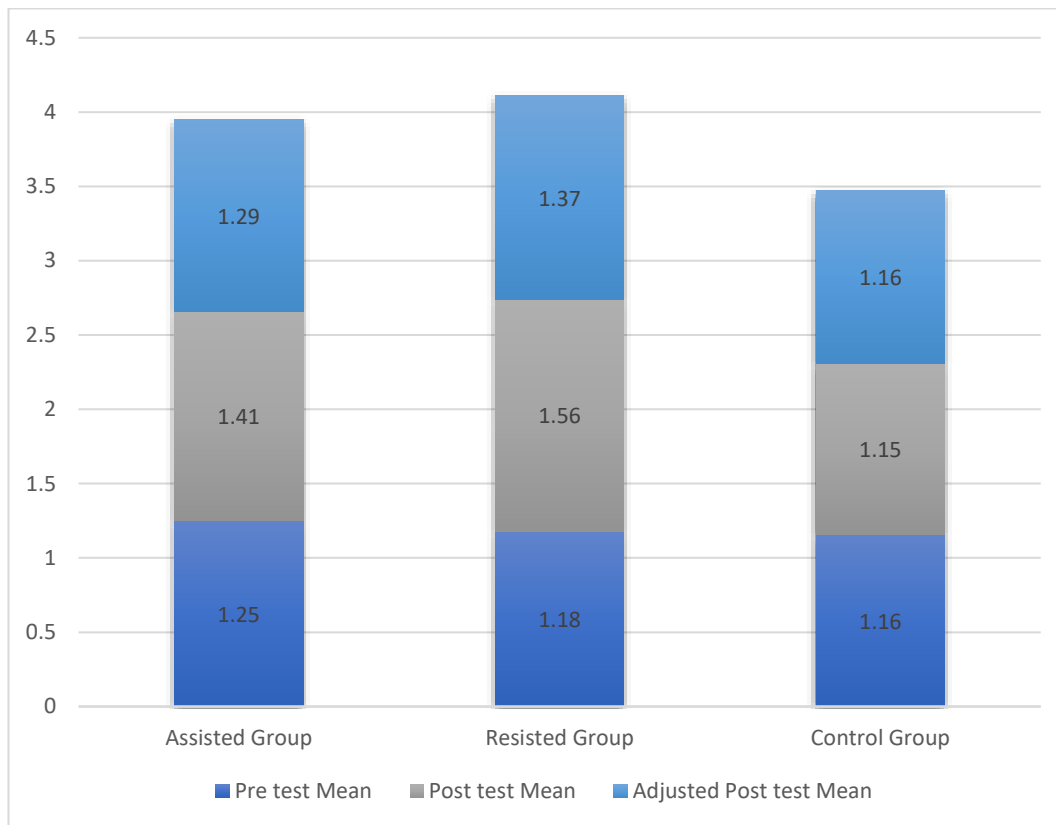


Figure:2

Analysis of Covariance on Left Foot to Right Foot Step Length of Assisted Resisted Sprint Training Groups and Control Group

Table –6

Scheffé S Test for the Differences between the Adjusted Post Test Paired Means on Left Foot to Right Foot Step Length

Variable	Adjusted Post Test Mean				Mean Differences	Confidence Interval	
	Assisted Training	Sprint	Resisted Training	Sprint			Control Group
Left Foot to Right Foot Step Length	1.29		1.37			0.08	0.10
	1.29				1.16	0.13*	0.10
			1.37		1.16	0.21*	0.10

*Significant at .05 level.

Table-6. shows that the adjusted post test mean differences on left foot to right foot step length of assisted sprint training and control groups, resisted sprint training and control groups, are 0.13, 0.21, which are greater than the confidence interval value of 0.10. However, the mean differences between assisted and resisted sprint training groups, 0.08, which are lesser than the confidence interval value of 0.10 at 0.05 level.

From the result it was found that due to the effect of assisted, resisted sprint training the left foot to right foot step length of the subjects are significantly changed. However, no significant differences existed between the experimental groups in altering the left foot to right foot step length.

Discussion of Findings

Based on the statistical analysis of data the following conclusions have been drawn. Twelve weeks of assisted, resisted sprint training have produced significant changes on sprint kinematics. Previous studies have reported the beneficial effects of sprint training on sprint kinematics.

Athletic training programs are designed to enhance performance of all phases of sprinting and include a combination of plyometric training, sprint training [non resisted, resisted (chutes, sleds, weighted vests, uphill running) and assisted (downhill running)], and resistance training (Alcaraz, *et al.*, 2008; Callister, *et al.*, 1988; De Villarreal, *et al.*, 2008). Studies have shown that nonresisted sprint training (Marcovic, *et al.*, 2007; Spinks, *et al.*, 2007), uphill and downhill sprint training (Paradis and Cooke, 2006), and resisted sprint training (Kristensen, *et*



al., 2007; Zafeiridis, *et al.*, 2005) significantly increased acceleration and sprinting speed. In addition, the combination of sprint and resistance training has been shown to be effective for enhancing maximal speed, speed endurance, power, and strength of the lower body (Kraemer, *et al.*, 2000; Ratamess, *et al.*, 2007).

Conclusion

Based on the findings of the study, it was concluded that both assisted sprint training and resisted sprint training significantly improved the selected sprint kinematic variables, namely Right Foot to Left Foot Step Length and Left Foot to Right Foot Step Length, among male sprinters when compared with the control group. Although both training methods were effective, the Resisted Sprint Training Group showed comparatively greater improvement in the selected sprint kinematic variables than the Assisted Sprint Training Group. Therefore, it may be concluded that assisted and resisted sprint training are effective training methods for enhancing sprint kinematics and can be incorporated into sprint training programmes to improve sprint performance among male sprinters.

Reference

1. Alcaraz, PE, Palao, JM, Elvira, JL, and Linthorne, NP. (2008). Effects of three types of resisted sprint training devices on the kinematics of sprinting at maximum velocity, *J Strength Cond Res.*, 22: 890–897.
2. Andre, M.J. Winchester, J.B. Ambegaonkar, J.P. Caswell, S.V., Nelson., A.G., Fry, A.C. (2011). Effects of 6 weeks of assisted and resisted sprint mechanical training on sprint performance, *Medicine & Science in Sports & Exercise.*, Volume 43 - Issue 5 - p 799.
3. Avery, D. Faigenbaum, James E. McFarland, Fred B. Keiper, William Tevlin, Nicholas A. Ratamess, Jie Kang and Jay R. Hoffman. (2007). Effects of a short-term plyometric and resistance training program on fitness performance in boys age 12 to 15 years, *Journal of Sports Science and Medicine*, 6, 519-525.
4. Bartolini, J. A., Brown, L. E., Coburn, J. W., Judelson, D. A., Spiering, B. A., Aguirre, N. W., Carney, K. R., Harris, K. B., (2011). Optimal elastic cord assistance for sprinting in collegiate women soccer players, *J Strength Cond. Res.*, 25(5):1263-70.
5. Bramble, D., Lieberman, D. (2004) Endurance running and the evolution of Homo, *Nature*, 432, 345–352.
6. Burgomaster, KA., Heigenhauser, GJ., And Gibala, MJ. (2006). Effect of Short-Term Sprint Interval Training on Human Skeletal Muscle Carbohydrate Metabolism during Exercise and Time Trial Performance, *J Appl Physiol.*, 100:6, pp.2041.
7. Chen, George., and Patten, Carolyn (2006). Treadmill training with harness support: Selection of parameters for individuals with post stroke hemiparesis, *Journal of Rehabilitation Research & Development.*, 43, 4, P, 485–498.
8. Clark, K. P., Stearne, D. J., Walts, C. T., and Miller, A. D., (2010). The Longitudinal effects of Resisted Sprint Training Using Weighted Sleds vs. Weighted Vests, *Journal of Strength and Conditioning Research*, 24(12): 3287-3295.
9. Cristea, A. *et al.*, (2008). “Effects of Combined Strength and Sprint Training on Regulation of Muscle Contraction at the Whole muscle and Single-fiber Levels in Elite Master Sprinters”, *Acta Physiol (oxf)*. 193(3):275-289.
10. Danion, F., Varraine, E., Bonnard, m., and Pilhous, J. (2003). Stride variability in human Gait: The Effect of Stride Frequency and Stride Length, *Gait Posture*, 18 (1), pp. 69-77.
11. DeVillarreal, ES, Gonzalez-Badillo, JJ, and Izquierdo, M. (2008). Low and moderate plyometric training frequency produces greater jumping and sprinting gains compared with high frequency, *J Strength Cond Res.*, 22: 715–725.
12. Gray, M., and Sauerbeck, J.A. (2004). “Speed Training Program for High School Football Players”, *Archives*, 7(1).



13. Hall, C., Figueroa, A, Fernhall, B & Kanaley, J.A. (2004) Energy expenditure of walking and running: Comparison with prediction equations, *Medicine & Science in Sport & Exercise*, 36 (12), 2128–2134.
14. Harrison, A. J, and Bourke, G. (2009). The Effect of Resisted Sprint Training on Speed and Strength Performance in Male Rugby Players, *Journal of Strength and Conditioning Research*, 23(1): 275-283.
15. Kevin, S. Heffernan., Christopher A. Fahs., Kevin K. Shinsako., Sae Young Jae., Bo Fernhall. (2007). Heart rate recovery and heart rate complexity following resistance exercise training and detraining in young men, *American Journal of Physiology*, vol. 293 no. 5.
16. Lockie, R. G., Murphy, A. J., Schultz, A. B., Knight, T. J., Janse de Jonge , X. A. (2011). The Effects of Different Speed Training Protocols on Sprint Acceleration Kinematics and Muscle Strength and Power in Field Sport Athletes, *Journal of Strength and Conditioning Research*, Sep 9.sprinting. *Am. J. Sport Med.* 14:501–510.
17. Marcovic, G, Jukic, I, Milanovic, D, and Metikos, D. (2007). Effects of sprint and plyometric training on muscle function and athletic performance, *J Strength Cond. Res.*, 21: 543–549.
18. Mario Nogueira, Nuno Viriato, Mario Vaz, Joao Carvalho and Filipe Conceicao. (2011). Dynamometric analysis of resisted sled on sprint run, *Portuguese Journal of Sport Sciences*, 11 (Suppl. 2).