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Research Article

Relative Effect Of Varied Velocities Of Ballistic Training Followed By Speed Training On Acceleration Speed And Speed Endurance Among Novice College Athletes

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Abstract

The purpose of the study was to find out the effect of high velocity ballistic training followed by speed training and low velocity ballistic training followed by speed training on acceleration speed and speed endurance among novice college athletes.To achieve this purpose of the study, forty five male students studying in department of physical education, Annamalai University, Chidambaram, Tamil Nadu, India, were randomly selected and divided into three groups of fifteen each. The age of the subjects, ranged from 18 to 24 years. This study consisted of two experimental group's high velocity ballistic training followed by speed training group (HVBTWS) and low velocity ballistic training followed by speed training group (LVBTWS). The allotment of these groups was done at random, thus Group-I underwent high velocity ballistic training followed by speed training, Group-II underwent low velocity ballistic training followed by speed training for three days per week for twelve weeks, Group-III was acted as control. All the subjects were tested prior to and immediately after the experimentation period. The collected data were statistically treated by using ANCOVA, and 0.05 level of confidence was fixed to test the significance. When the obtained 'F' ratio was significant, Scheffe's post hoc test was used to find out the paired mean difference. The results of the study revealed that there was a significant difference among high velocity ballistic training followed by speed training group, low velocity ballistic training followed by speed training group as compared to control group on acceleration speed and speed endurance. And also, it was found that there was a significant improvement on acceleration speed and speed endurance due to high velocity ballistic training followed by speed training as compared to low velocity ballistic training followed by speed training among novice College athletes.

KEY WORDS: *High velocity ballistic training with speed training, Low velocity ballistic training with speed training, Acceleration Speed, speed endurance.*

Introduction

In fact, improvements in a variety of athletic performance measures have been observed after periods of ballistic power training (Cormie et al., 2007; Hakkinen et al., 1985; Harris et al., 2000; Harris et al., 2008; McBride et al., 2002; Wilson et al., 1993; Winchester et al., 2008) as well as heavy strength training (Kaneko et al., 1983; Stone et al., 1979; Stowers et al., 1983; Wilson et al., 1993) in relatively weak individuals. Although the training stimulus varies considerably between these two modalities, short-term (i.e., 4–12 wks) exposure to either type of training has stimulated neuromuscular adaptations necessary to improve strength, power, and speed in such individuals (Cormie et al., 2007; Hakkinen et al., 1985; Harris et al., 2000; Wilson et al., 1993). However, it remains unclear if improvements in athletic performance and the mechanisms driving adaptations in relatively weak individuals differ between ballistic power training and heavy strength training programs commonly used by strength and conditioning practitioners (i.e., typical load, repetition, and set combinations of complex, multijoint, sports-specific movements). This evidence is essential to develop effective training programs for athletes with limited strength training background and to gain an enhanced understanding of the mechanisms responsible for performance improvements after training with sports specific movements.

Ballistic power training is commonly used to target improvements in maximal power output and athletic performance. This training modality involves exercises that require the athlete to exert as much force as possible in short periods of time (i.e., ballistic movements), with the goal of projecting the accelerated object into free space (e.g., jumping, throwing, kicking). Improvements in performance after ballistic power training are common throughout the literature and typically include increases in maximal power output (Cormie et al., 2007; Harris et al., 2008; McBride et al., 2002; Winchester et al., 2008), rate of force development (RFD) (Hakkinen et al., 1985; Winchester et al., 2008), movement velocity (Cormie et al., 2007; McBride et al., 2002), jump height (Cormie et al., 2007;) and speed performance (Harris et al., 2008; McBride et al., 2002; Wilson et al., 1993).

Sprint ability is an important factor in a range of athletic activities and in many instances can define performance success. A specific example can be seen in the 100-m track and field sprint event, where the fastest sprinter will typically win the race (Gomez et al., 2013). However, quicker athletes will have an advantage in team sports as well.Depending on the sport, the importance of speed can be affected by the distance traveled during a sprint effort. For strength and conditioning coaches, understanding the number of sprints and associated distances is important for sport-specific speed development. Previous research has emphasized the value of acceleration (i.e., sprints of less than 20 m) for field sport athletes (Duthie et al., 2006; Lockie et al., 2011; Sleivert et al., 2004). For example, most (approximately 68%) sprint distances in professional rugby league were less than 20 m (Gabbett et al., 2012). The importance of short sprint speed, Gabbett (2012), stated that the most common (approximately 46%) sprint distance for the positional grouping of hit-up forwards was 6–10 m, which emphasizes the ability to accelerate.

Although it is clear that speed over short distances is a requirement for most team sport athletes, a high maximal running velocity is also an important trait. Maximal velocity for team sport athletes is typically achieved during a longer sprint of 30–40 m (Duthie et al., 2006; Vescovi and JD, 2012; Young et al., 2001). This has value to athletes, as maximal sprints in team sports can often be initiated from a moving start (Duthie et al., 2006). The sprints of these distances are less frequent in match play (Di Salvo et al., 2010; Ingebrigtsen et al., 2014) athletes could have the opportunity to attain maximal velocity during a sprint effort if they begin the sprint while moving. This suggests that despite the importance of acceleration development for most athletes, speed over longer distance sprints (i.e., 30 m, 50m or greater) should also be developed. On the basis of these collective research findings, strength and conditioning coaches should therefore use distance-specific training for their athletes when looking to enhance speed.

To improve the speed qualities associated with various sports, coaches implement various types of training modalities (e.g., free, assisted, and resisted sprinting, resistance training, and plyometrics) (Cronin et al., 2008; Lockie et al., 2012). However, despite the wide-spread use of many training methods, there is limited information as to whether certain protocols are better used to persuade speed improvements over specific distances (i.e., shorter or longer distance sprints). For this reason, it would be of great benefit for strength and conditioning coaches to have a resource that centralizes information regarding different speed training protocols and how they influence sprint performance over various distances.

Mostly the speed training protocols established within the literature as being able to enhance speed performance. It is more important, because this study will highlight the training protocols that could be used to improve speed and speed endurance over specific distances for athletes. Thus the present study was undertaken to explore the influence of high velocity ballistic training followed by speed training and low velocity ballistic training followed by speed training on acceleration speed and speed endurance among novice college athletes.

Methodology

The purpose of the study was to determine the influence of high velocity ballistic training followed by speed training and low velocity ballistic training followed by speed training on acceleration speed (30m) and speed endurance (150m) among novice college athletes. To achieve the purpose of this study, forty five male students studying bachelor's degree in the Department of Physical Education, Annamalai University, Chidambaram, Tamil Nadu, India, were selected as subjects at randomly. The selected subjects were randomly divided into three groups and each group consisted of fifteen subjects. The groups were randomly segregated as high velocity ballistic training followed by speed training group, low velocity ballistic training followed by speed training group and control group. Group-I underwent high velocity ballistic training programme followed by speed training programme, Group-II underwent low velocity ballistic training programme followed by speed training programme for three days per week for twelve weeks, Group-III was acted as control group and they did not participate in any special training programme. Acceleration speed was selected as criterion variable and was measured by acceleration speed with 30 meters dash in nearest one tenth of a second, and speed endurance was selected as criterion variable and was measured by speed endurance with 150 meters dash in nearest one tenth of a second. The subjects of all three groups were tested on acceleration speed and speed endurance, prior to and immediately after the training programme.

Training load

The experimental group-I underwent high velocity ballistic training followed by speed training programme and group-II underwent low velocity ballistic training followed by speed training programme for a period of twelve weeks. The training regimen for high velocity ballistic training followed by speed training and low velocity ballistic training followed by speed training consisted of three sets eight exercises per day, three days per week. After selecting the exercise I RM was found for each exercise separately. I RM is the maximum amount of weight a person can successfully lift one time only through the full range of motion.High velocity ballistic training followed by speed training group started with 60% of intensity and was increased once in two weeks by 5% and 3 sets × 12 repetitions was given for twelve weeks. Low velocity ballistic training followed by speed training group started with 60% of intensity and was increased once in two weeks by 5% and 3 sets × 6 repetitions was given for twelve weeks and rest interval of two minutes between repetition and five minutes between set was confined. The control group did not participate in any special training programme during this period.

Statistical technique

All the subjects of three groups were tested on dependent variables prior to and immediately after the training programme. The analysis of covariance (ANCOVA) was used to analyze the significant difference, if any among the groups. Since, three groups were compared, whenever the obtained 'F' ratio for adjusted post- test was found to be significant, the Scheffe's post hoc test was applied to find out the paired mean differences, if any. The 0.05 level of confidence was fixed as the level of significance to test the 'F' ratio obtained by the analysis of covariance, which was considered as appropriate.

Result of study

The influence of high velocity ballistic training followed by speed training and low velocity ballistic training followed by speed training on each criterion variables were analyzed separately and the results are presented below.

Analysis of Acceleration Speed

The descriptive analysis showing mean, percentage of improvement and't' ratio of the collected data on acceleration speed among experimental and control groups are presented in table I.

Table – I

Descriptive Analysis of the Data on Acceleration Speed

Variable	Groups	Pre-Test Mean	Post-Test Mean	MD	%	't' ratio
Acceleration Speed	HVBTWS	4.47	4.31	0.16	3.57	9.16*
	LVBTWS	4.45	4.33	0.12	2.69	10.40*
	Control Group (CG)	4.46	4.48	0.02	0.44	1.65*

**Significant at 0.05 level for the df of 1 and 14 is 2.15*

It is clear from the table I, that there were significant differences between pre-test and post-test data on acceleration speed of high velocity ballistic training followed by speed training group (HVBTWS), low velocity ballistic training followed by speed training group (LVBTWS) and control group because obtained 't' ratio of 9.16, 10.40, are greater than the required table value of 2.15 at 0.05

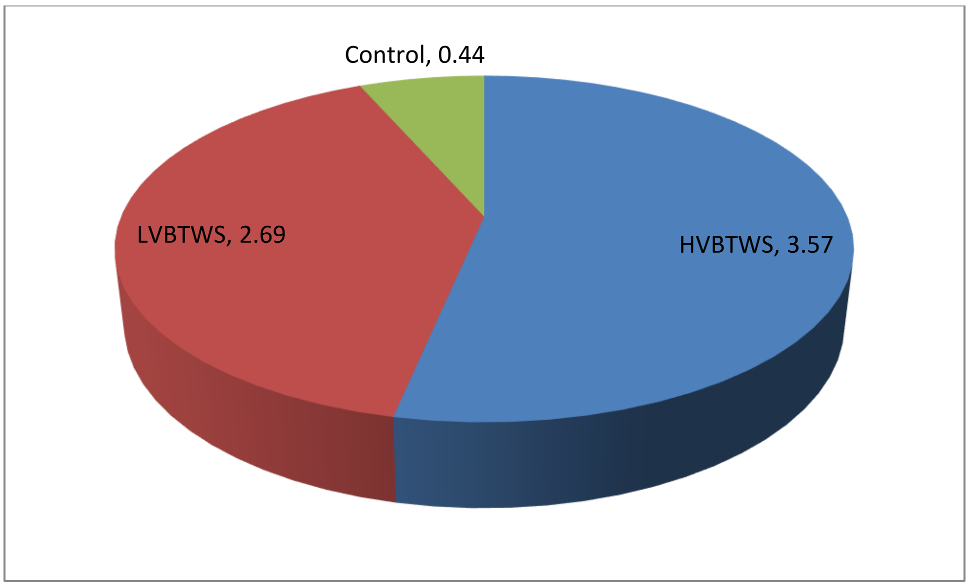
level of significance for the df of 1 and 14. However the't' ratio of 1.65* are less than the table value of 2.15 at 0.05 level of significance.

The results of the study also produced 3.57% of changes in acceleration speed due to high velocity ballistic training followed by speed training, 2.69% of changes due to low velocity ballistic training followed by speed training and 0.44% of changes in control group.

The percentage of changes on acceleration speed of high velocity ballistic training followed by speed training group, low velocity ballistic training followed by speed training group and control group are given in the figure 1.

Figure 1

Pie Diagram Showing the Percentage of Changes on Acceleration Speed



The data collected from the three groups on acceleration speed was statistically analyzed by ANCOVA and the results are presented in the table II.

Table-II

ANACOVA FOR BEFORE TRAINING AND AFTER TRAINING ON ACCELERATION SPEED OF EXPERIMENTAL AND CONTROL GROUPS

Test	HVBTWS	LVBTWS	Control	SoV	SS	DF	MS	F
Pre test				BG	0.002	2	0.001	0.39
Mean	4.47	4.45	4.46	WG	0.126	42	0.003	
SD (±)	0.055	0.053	0.056					
Post-test				BG	0.275	2	0.0137	50.59*
Mean	4.31	4.33	4.48	WG	0.114	42	0.003	
SD (±)	0.051	0.048	0.055					

Adjusted Post-test Mean	4.50	4.47	4.41	BG	0.022	2	0.011	4.67*
				WG	0.097	41	0.002	

**Significant, Table value, 2 to 42 & 2 to 41 is 3.23*

Table II, shows that pre-test mean values on acceleration speed of high velocity ballistic training followed by speed training group, low velocity ballistic training followed by speed training group and control group are 4.47, 4.45 and 4.46 respectively. The obtained 'F' ratio of 0.39 pre-test score was lesser than the required table value of 3.23 for df 2 and 42 for significance at 0.05 level of confidence on acceleration speed. The post-test mean values on acceleration speed of high velocity ballistic training followed by speed training group, low velocity ballistic training followed by speed training group and control group are 4.31, 4.33 and 4.48 respectively. The obtained 'F' ratio value of 50.59 for post-test score was greater than the required table value of 3.23 for the df of 2 and 42 for significance at 0.05 level of confidence on acceleration speed.

The adjusted post-test means of high velocity ballistic training followed by speed training group, low velocity ballistic training followed by speed training group and control group are 4.50, 4.47 and 4.41 respectively. The obtained 'F' ratio value of 4.67 for adjusted post-test score was greater than the required table value of 3.23 for df 2 and 41 for the significance at 0.05 level of confidence on acceleration speed. It was concluded that differences subsist among the adjusted post-test means of high velocity ballistic training followed by speed training group, low velocity ballistic training followed by speed training group and control group on acceleration speed. The 'F' value in the adjusted post-test means was found significant, hence the Scheffe's test was applied to assess the paired mean difference and the results are presented in table –III.

Table - III

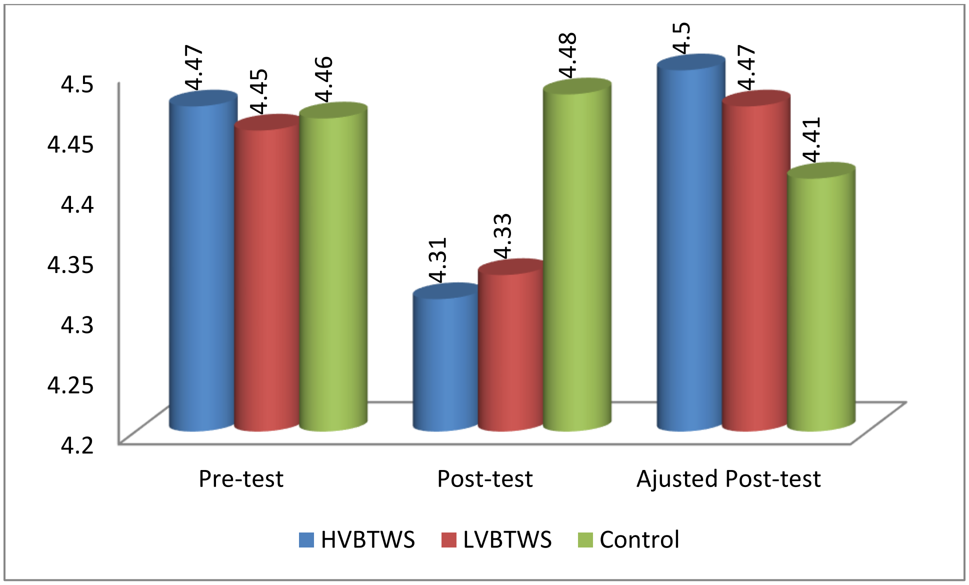
Scheffe's test for the Differences between Paired Means on Acceleration Speed

HVBTWS Group	LVBTWS Group	Control	MD	CI
4.50	4.47		0.03	0.10
4.50		4.41	0.09	0.10
	4.47	4.41	0.06	0.10

From the table III, it was imperative that both the experimental groups differed significantly from control group on acceleration speed. Significant differences were found between high velocity ballistic training followed by speed training group and low velocity ballistic training followed by speed training group in improving acceleration speed of novice college athletes. Therefore, twelve weeks of high velocity ballistic training followed by speed training showed greater improvement than low velocity ballistic training followed by speed training among novice college athletes. The findings of the study implies that both the groups improved but high velocity ballistic training followed by speed training were significantly better in improving acceleration speed than other groups confined to this study. The changes in acceleration speed are presented in figure-II.

Figure - II

The Pre, Post and Adjusted Post Test Means of Experimental and Control Groups on Acceleration Speed



Speed Endurance

The descriptive analysis showing mean, percentage of improvement and't' ratio of the collected data on speed endurance among experimental and control groups are presented in table-IV.

Table – IV

Descriptive Analysis of the Data on Speed Endurance

Variable	Groups	Pre-Test Mean	Post-Test Mean	MD	%	't' ratio
Speed Endurance	HVBTWS	21.91	21.43	0.48	2.19	7.10*
	LVBTWS	21.90	21.56	0.34	1.55	5.63*
	Control					

	Group (CG)	21.96	21.92	0.04	0.18	10.99

**Significant at 0.05 level for the df of 1 and 14 is 2.15*

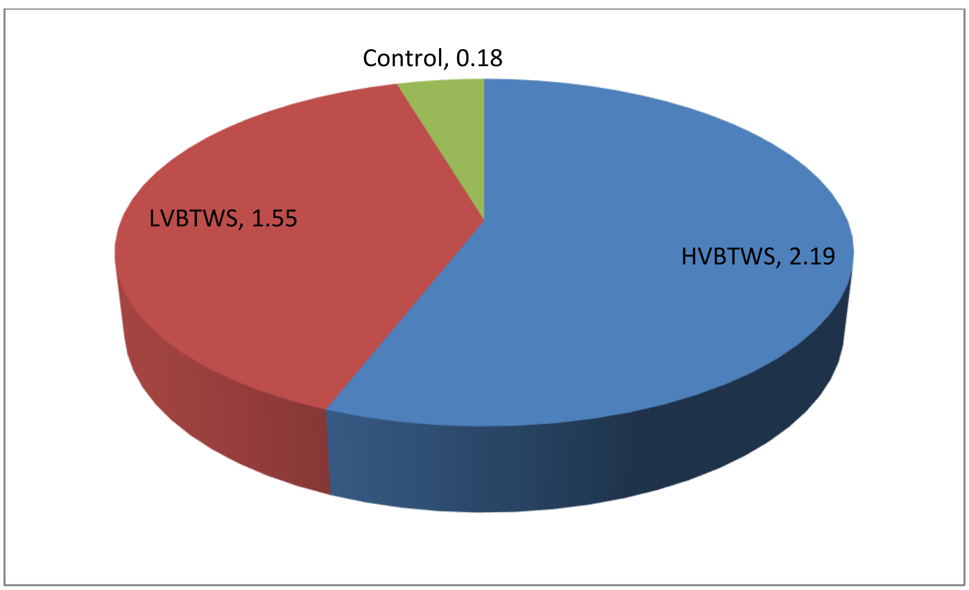
It is clear from the table IV, that there were significant differences between pre-test and post-test data on speed endurance of high velocity ballistic training followed by speed training group , low velocity ballistic training followed by speed training group and control group because obtained 't' ratio of 7.10, 5.63 and 10.99 are greater than the required table value of 2.15 at 0.05 level of significance for the df of 1 and 14.

The results of the study also produced 2.19% of changes in speed endurance due to high velocity ballistic training followed by speed training, 1.55% of changes due to low velocity ballistic training followed by speed training and 0.18% of changes in control group.

The percentage of changes on speed endurance of high velocity ballistic training followed by speed training group, low velocity ballistic training followed by speed training group and control group are given in the figure III

Figure III

Pie Diagram Showing the Percentage of Changes on Speed Endurance



The data collected from the three groups on speed endurance was statistically analyzed by ANCOVA and the results are presented in the table-V.

Table-V

ANACOVA FOR BEFORE TRAINING AND AFTER TRAINING ON SPEED ENDURANCE OF EXPERIMENTAL AND CONTROL GROUPS

Test	HVBTWS Group	LVBTWS Group	Control	SoV	SS	DF	MS	F
Pre test Mean SD (±)	21.91 0.167	21.90 0.051	21.96 0.487	BG	0.035	2	0.180	0.19
				WG	3.764	42	0.090	
Post-test Mean SD (±)	21.43 0.220	21.56 0.235	21.92 0.482	BG	1.922	2	0.961	8.55*
				WG	4.721	42	0.112	
Adjusted Post-test Mean	22.06	21.95	21.76	BG	0.492	2	0.246	7.41*
				WG	1.359	41	0.033	

**Significant, Table value, 2 to 42 & 2 to 41 is 3.23*

Table V, shows that pre-test mean values on speed endurance of high velocity ballistic training followed by speed training group, low velocity ballistic training followed by speed training group and control group are 21.91, 21.90 and 21.96 respectively. The obtained 'F' ratio of 0.19 pre-test score was lesser than the required table value of 3.23 for df 2 and 42 for significance at 0.05 level of confidence on speed endurance. The post-test mean values on speed endurance of high velocity ballistic training followed by speed training group, low velocity ballistic training followed by speed training group and control group are 21.43, 21.56 and 21.92 respectively. The obtained 'F' ratio value of 8.55 for post-test score was greater than the required table value of 3.23for the df of 2 and 42 for significance at 0.05 level of confidence on speed endurance.

The adjusted post-test means of high velocity ballistic training followed by speed training group, low velocity ballistic training followed by speed training group and control group are 22.06, 21.95 and 21.76 respectively. The obtained 'F' ratio value of 7.41 for adjusted post-test score was greater than the required table value of 3.23 for df 2 and 41 for the significance at 0.05 level of confidence on speed endurance. It was concluded that differences subsist among the adjusted post-test means of high velocity ballistic training followed by speed training group, low velocity ballistic training followed by speed training group and control group on speed endurance. The 'F' value in the adjusted post-test means was found significant, hence the Scheffe's test was applied to assess the paired mean difference and the results are presented in table-VI.

Table- VI

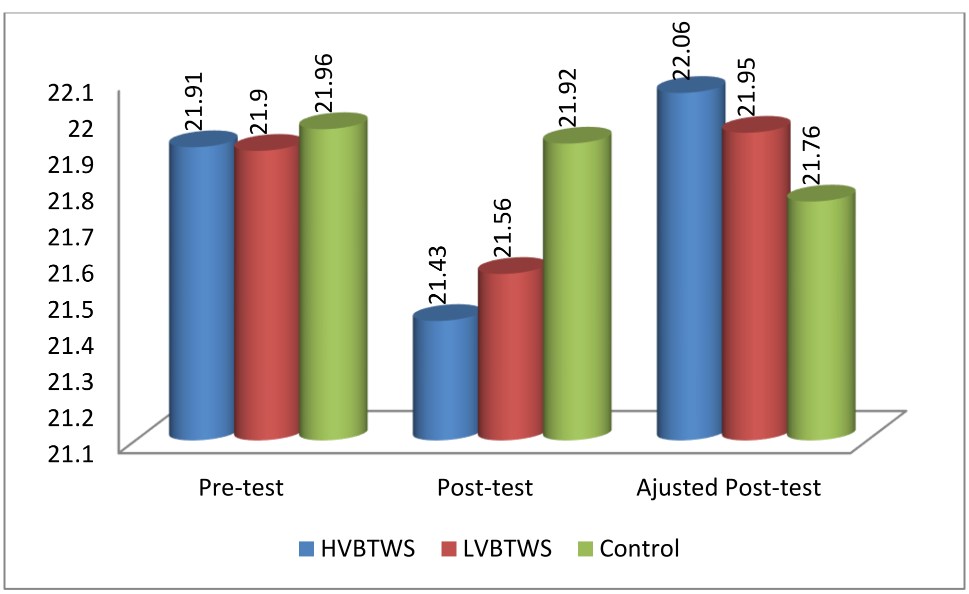
Scheffe's test for the Differences between Paired Means on Speed Endurance

HVBTWS Group	LVBTWS Group	Control	MD	CI
22.06	21.95		0.11	0.16
22.06		21.76	0.3	0.16
	21.95	21.76	0.19	0.16

From the table VI, it was imperative that both the experimental groups differed significantly from control group on speed endurance. Significant differences were found between high velocity ballistic training followed by speed training group and low velocity ballistic training followed by speed training group in improving speed endurance of novice college athletes. Therefore, twelve weeks of high velocity ballistic training followed by speed training showed greater improvement than low velocity ballistic training followed by speed training o novice college athletes. The findings of the study implies that both the groups improved but high velocity ballistic training followed by speed training were significantly better in improving speed endurance than other groups confined to this study. The changes in speed endurance are presented in figure IV.

Figure-IV

The Pre, Post and Adjusted Post Test Means of Experimental and Control Groups on Speed Endurance



Discussion on findings

The result of present study was that acceleration speed and speed endurance has increased significantly for high velocity ballistic training followed by speed training and low velocity ballistic training followed by speed training as compared to control group. However, the result of this study also reveals that increase in acceleration speed and speed endurance has significantly more for high velocity ballistic training followed by speed training than low velocity ballistic training followed by speed training among novice college athletes.The findings of the study implies that both the groups were improved, but high velocity ballistic training followed by speed training were significantly better in improving acceleration speed and speed endurance then low velocity ballistic training followed by speed training confined to this study.

It is inferred that endurance training has produced statistically significant effect on acceleration speed and speed endurance. However, acceleration speed and speed endurance also improved significantly after ballistic training protocol. High velocity ballistic training and low load ballistic training is related to an ability to produce force quickly and has implications for activities of daily living as well as athletic endeavors. High velocity exercise results in specific high velocity adaptations and should be employed when attempting to increase high speed movements. Since maximizing speed is one of the most desired goals for fitness and performance, implementing innovative high speed methods within a training program can aid in maximizing performance. Hence speed requires greater power of repetitive movement and speed development is greater for ballistic training. (Olsen and Hopkins, 2003) conducted a study on effect of attempted ballistic training on force and speed of movements and concluded that the training group has significantly improved in speed when compared to control group. (Kotzamanidis et al., 2005) also found significant improvements in 30m sprint following a heavy strength training program, but also highlighted the lack of skill transfer which the argued that since sprinting involves high levels of interlimb coordination, there is little or no learned effect from the gym based strength training. (Comfort et al., 2012) also showed similar improvements in 20m-sprint performance following an eight week period of strength training. However his study was held in the pre-season. Plyometric and ballistic type training methods are commonly used for improving sprint and potentially soccer playing performance. (Ronnestad et al., 2008) established that a seven- week combined plyometric and strength training program resulted in overall improvements in acceleration, peak running velocity and 40m-sprint time.

(Loturco et al., 2015) have examined the effect of jump squat training at the distance of 50m. It is difficult to determine whether these changes are due to improvements in the early (acceleration) or later (maximum speed) phase of running, because no split times were measured in the study. Nevertheless, given the abundant of improved sprint performance over short distances (i.e. 5-30m), the data seem to suggest that the greatest improvements occurred during the acceleration phase of sprint running. (Delecluse et al., 1995) the weighted ballistic actions included in the training could possibly have resulted in higher production of explosive ground reaction forces resulting in better sprint times. (Harris et al., 2008) have found that in 50m sprint, significant improvements from pre-to mid-training (-1%, $p=0.02$), as well as from mid –to post-training (-1.9%, $p \leq 0.001$) were observed in his study. Numerous studies found significant improvements in sprint time after jump squat training over distances ranging from 5 to 50 m, as well as in an agility test. (Sleivert and Taingahue, 2004) a relationship between maximal concentric jump power and sprint acceleration was found. This is perhaps logical since longer ground contact time is needed during the acceleration phase of running compared to maximum running speed. (Zafeiridis et al., 2005) also noticed that, resisted sprint training improves acceleration but unresisted sprint training improves performance in maximum speed phase. The result of these studies support and prove that high velocity ballistic training followed by speed training and low velocity ballistic training followed by speed training was significant improvement on acceleration speed and speed endurance among novice college athletes.

Conclusion

There was a significant improvement on acceleration speed and speed endurance on high velocity ballistic training followed by speed training and low velocity ballistic training followed by speed training as compared to control group. However, the result of this study also reveals that increase in acceleration speed and speed endurance, significantly more for high velocity ballistic training followed by speed training than low velocity ballistic training followed by speed training among novice college athletes.

References

1. Comfort, P, Haigh, A and Matthews, MJ. (2012). Are Changes in Maximal Squat Strength During Preseason Training Reflected in Changes in Sprint Performance in Rugby League Players, *J Strength Cond Res* 26: 772–776.
2. Cormie, P., McCaulley, G. O., & McBRIDE, J. M. (2007). Power versus strength-power jump squat training: influence on the load-power relationship. *Medicine and science in sports and exercise*, *39*(6), 996-1003.
3. Cronin, J., Hansen, K., Kawamori, N., & McNair, P. (2008). Effects of weighted vests and sled towing on sprint kinematics. *Sports Biomechanics*, *7*(2), 160-172.
4. Delecluse, C, Van Coppenolle, H, Wilems, E, Van Leemputte, M, Diels, R, and Goris, M. (1995), Influence of High Resistance and High Velocity Training on Sprint Performance. *Med Sci Sports Exerc* 27: 1203-1209.
5. Di Salvo, V., Baron, R., González-Haro, C., Gormasz, C., Pigozzi, F., & Bachl, N. (2010). Sprinting analysis of elite soccer players during European Champions League and UEFA Cup matches. *Journal of sports sciences*, *28*(14), 1489-1494.
6. Duthie, G. M., Pyne, D. B., Marsh, D. J., & Hooper, S. L. (2006). Sprint patterns in rugby union players during competition. *Journal of Strength and Conditioning Research*, *20*(1), 208.
7. Gabbett, T. J. (2012). Sprinting patterns of national rugby league competition. *The Journal of Strength & Conditioning Research*, *26*(1), 121-130.
8. Gómez, J. H., Marquina, V., & Gómez, R. W. (2013). On the performance of Usain Bolt in the 100 m sprint. *European journal of physics*, *34*(5), 1227.
9. Häkkinen, K., Komi, P. V., Alén, M., & Kauhanen, H. (1987). EMG, muscle fibre and force production characteristics during a 1 year training period in elite weight-lifters. *European journal of applied physiology and occupational physiology*, *56*(4), 419-427.
10. Häkkinen, K., Komi, P. V., & Alen, M. (1985). Effect of explosive type strength training on isometric force-and relaxation-time, electromyographic and muscle fibre characteristics of leg extensor muscles. *Acta Physiologica Scandinavica*, *125*(4), 587-600.

11. Harris, G. R., STONE, M. H., O'BRYANT, H. S., PROULX, C. M., & JOHNSON, R. L. (2000). Short-term performance effects of high power, high force, or combined weight-training methods. *The Journal of Strength & Conditioning Research*, *14*(1), 14-20.
12. Harris, N. K., Cronin, J. B., Hopkins, W. G., & Hansen, K. T. (2008). Squat jump training at maximal power loads vs. heavy loads: effect on sprint ability. *The Journal of Strength & Conditioning Research*, *22*(6), 1742-1749.
13. Ingebrigtsen, J., Dalen, T., Hjelde, G. H., Drust, B., & Wisløff, U. (2014). Acceleration and sprint profiles of a professional elite football team in match play. *European journal of sport science*, *15*(2), 101-110.
14. Kotzamanidis, C, Chatzopoulos, D, Michailidis, C, Papaiakovou, G, and Patikas, D. (2005).The Effect of A Combined High-Intensity Strength and Speed Training Program on the Running and Jumping Ability of Soccer Players. *J Strength Cond Res* 19: 369–375.
15. Lockie, R. G., Murphy, A. J., Knight, T. J., & De Jonge, X. A. J. (2011). Factors that differentiate acceleration ability in field sport athletes. *The Journal of Strength & Conditioning Research*, *25*(10), 2704-2714.
16. Lockie, R. G., Murphy, A. J., Schultz, A. B., Knight, T. J., & de Jonge, X. A. J. (2012). The effects of different speed training protocols on sprint acceleration kinematics and muscle strength and power in field sport athletes. *The Journal of Strength & Conditioning Research*, *26*(6), 1539-1550.
17. Loturco, I., Nakamura, F.Y., Kobal, R., Gil, S., Cal Abad, C.C., Cuniyochi, R., Pereira, L.A. and Roschel, H. (2015) Training for Power and Speed: Effects of Increasing or Decreasing Jump Squat Velocity in Elite Young Soccer Players. *The Journal of Strength and Conditioning Research* 29, 2771-2779.
18. McBride, J. M., Triplett-McBride, T., Davie, A., & Newton, R. U. (2002). The effect of heavy- vs. light-load jump squats on the development of strength, power, and speed. *The Journal of Strength & Conditioning Research*, *16*(1), 75-82.
19. Olsen.P and Hopkins.WG, (2003). The Effect of Attempted Ballistic Training on the Force and Speed of Movements. *The Journal of Strength and Conditioning Research*. 17(2):291-298.
20. Ronnestad, BR, Kvamme, NH, Sunde, A, and Raastad, T. (2008), Short-Term Effects of Strength and Plyometric Training on Sprint and Jump Performance in Professional Soccer Players. *J Strength Cond Res* 22: 773–780.
21. Sleivert, G. and Taingahue, M. (2004) the Relationship between Maximal Jump-Squat Power and Sprint Acceleration in Athletes. *European Journal of Applied Physiology* 91, 46-52.
22. Stone, M. H., Johnson, R. L., & Carter, D. R. (1979). A short term comparison of two different methods of resistance training on leg strength and power. *Athletic Training*, *14*(3), 158-160.
23. Stowers, T., McMillan, J., Scala, D., Davis, V., Wilson, D., & Stone, M. (1983). The short-term effects of three different strength-power training methods. *Strength & Conditioning Journal*, *5*(3), 24-27.
24. Vescovi, J. D. (2012). Sprint speed characteristics of high-level American female soccer players: Female Athletes in Motion (FAiM) study. *Journal of Science and Medicine in Sport*, *15*(5), 474-478.
25. Wilson, G. J., Murphy, A. J., & Walshe, A. D. (1997). Performance benefits from weight and plyometric training: effects of initial strength level. *Coach Sport Sci J*, *2*(1), 3-8.

26. Wilson, G. J., Newton, R. U., Murphy, A. J., & Humphries, B. J. (1993). The optimal training load for the development of dynamic athletic performance. *Medicine and science in sports and exercise*, *25*(11), 1279-1286.
27. Winchester, J. B., McBride, J. M., Maher, M. A., Mikat, R. P., Allen, B. K., Kline, D. E., & McGuigan, M. R. (2008). Eight weeks of ballistic exercise improves power independently of changes in strength and muscle fiber type expression. *The Journal of Strength & Conditioning Research*, *22*(6), 1728-1734.
28. Young, W., Russell, A., Burge, P., Clarke, A., Cormack, S., & Stewart, G. (2008). The use of sprint tests for assessment of speed qualities of elite Australian rules footballers. *International Journal of Sports Physiology and Performance*, *3*(2), 199-206.
29. Zafeiridis, A., Saraslanidis, P., Manou, V., & Ioakimidis, P. (2005). The effects of resisted sled-pulling sprint training on acceleration and maximum speed performance. *Journal of Sports Medicine and Physical Fitness*, *45*(3), 284.