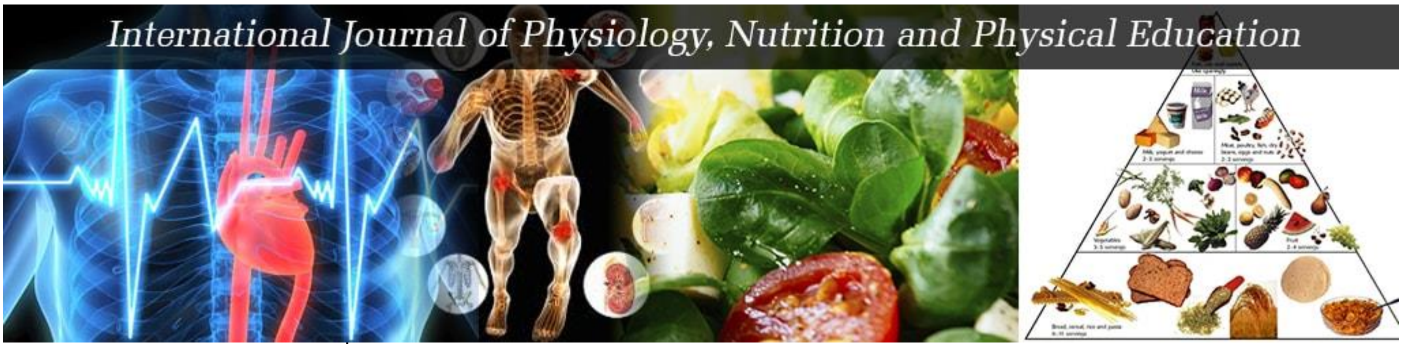

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Changes in physical performance variables in sprinters following sprint specific plyometric training program

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Abstract
Purpose: The ability to reach a high running velocity over a short period of time, quickness in movements and aerobic capacity is essential for sprinters to excel in competitions. The purpose of this study was to analyze the effect of the sprint training combined with plyometric training on physical performance.
Methodology: 40 university level sprinters volunteered and were randomly assigned into two groups, group 1 (G1; n=20) sprint specific plyometric training group (mean age 18.65±0.875; mean height 164.10±11.30cm; mean mass 59. 20±10.74kg) and group 2 (G2; n=20) control group (mean age 18.95±1.19; mean height 166.60±9.80 cm; mean mass 61.60±9. 24kg). Both sprint specific plyometric training group and control group were assessed for sprint speed by 20 m sprint test, agility by Illinois agility test, vertical jump height and balance using Kinematic Measurement System and VO_2 max by using Queens College Step Test.
Results: The results showed significant changes ($p<0.05$) in all the physical performance variables measured.
Conclusion: This protocol can be recommended to coaches for athletes or individuals as this type of training can be beneficial for increasing performance.

Keywords: Sprinters; agility; speed; plyometric; training

Introduction
Sprinting is a running short distance event on track and field. Plyometric exercises plays an integral role in strength and conditioning or in performance enhancement regardless the phase it has been used [1]. Plyometric used in the measurement of sports performance outcomes such as throwing velocity, jump height or sprint speed [2, 3, 4].
Plyometric training is involved in every sports to increase strength and explosiveness of muscles. [5]. Sprint running contributes in various sports for successful performances. Plyometric exercises used for training the athlete should match the characteristics of their sporting activity they are involved with. That is, to optimize the activity by the principle of specificity. For example, only jumping specific exercises will not increase the running speed. [6, 7]. Plyometric is a type of training which have the ability to develop force at high speed in dynamic movements. These dynamic movements includes the stretch of muscle immediately followed by an explosive contraction of the muscle. This is also termed as stretch-shortening cycle (SSC) [8].
Improvements in the physical aspects have important implications on team sports, as players perform numerous explosive movements like kicking, tackling, jumping, turning, sprinting and changing pace and directions during the match [9, 10] thus, plyometric drills usually involve stopping, starting and changing directions in an explosive manner [11]. Several research studies have confirmed that plyometric training can enhance muscle strength and power [12], speed [13, 14] and agility [15, 16, 17]. Additionally, numerous studies have discovered positive effects of short term plyometric training on jumping performance in basketball [18], soccer [16, 17, 19], volleyball [20, 21], handball [22, 23] and other team sport games.

Methodology
A total 40 university level sprinters (mean age, height, mass) volunteer and were randomly allocated in two groups, Group 1 (G1; n =20) sprint specific plyometric training group and

Group 2 (G2; n =20) control group. The procedure, benefits and potential risks of study was explained to the subjects before the test started and duly signed informed consent was taken. It was insured that the subjects were free of any musculoskeletal conditions or any neurological dysfunctions. This study was approved by the Institutional Ethics Committee of MYAS Department of Sports Sciences and Medicine, Guru Nanak Dev University, Amritsar. The allocated grouped participants of the study agreed not to change or increase their current exercise routine during the course of the study. The sprint specific plyometric training group participated in a six week exercise program thrice a week which included various jumping, bounding and sprinting exercises designed (table 1) where the control group continued their routine training schedule. Participants were tested before and after the six weeks training period. The sprint speed testing was done by using 20m sprint test, agility was measured by Illinois agility test, vertical jump test and balance which is in total number of contacts were measured by Kinematic Measurement System and maximum oxygen consumption capacity that is VO_2 max was measured by Queens College Step Test. The readings were taken before and after the six weeks exercise protocol.

Table 1: 6-week exercise program performed by the Subjects in the Plyometric Group [23]

Plyometrics program			Sprint program	
Week	**Exercise**	**Sets**	**Sprint distance (m)**	**Repetition**
1	Double leg tuck jump	5×8	40	5
	Double leg speed jump	5×8	40	5
2	Double leg tuck jump	5×8	40	5
	Single leg tuck jump	2×5	25	2
	Double leg speed jump	5×8	40	5
3	Double leg bound	2×6	50	2
	Single leg tuck jump	2×8	40	2
	Double leg speed jump	4×10	55	4
	Single leg hop	4×8	40	4
4	Double leg bound	4×6	50	4
	Single leg tuck jump	2×8	40	2
	Single leg hop	4×8	40	4
	Alternate leg bound	5×8	40	5
5	Single leg hop	2×8	40	2
	Single leg speed hop	2×8	35	2
	Alternate leg bound	8×8	40	8
	Alternate leg stair bound	3×8	30	3
6	Single leg hop	2×8	40	2
	Single leg speed hop	2×8	35	2
	Alternate leg bound	7×10	50	7
	Alternate leg stair bound	3×10	40	3

Results

Table 2: Descriptive data of both groups of sprinters

		Experimental group	**Control group**
Descriptive	Age	18.65±0.87	18.95±1.19
	Height (cm)	164.135±11.33	166.625±9.84
	Weight (kg)	59.2±10.74	61.6±9.24
	BMI (Kg/m^2)	21.745±2.25	22.185±3.06

Table 2 shows the distribution of mean values and standard deviation of different parameters amongst sprinters.

Table 3: Descriptive statistics values for 20 m sprint test in sprinters:

20 m sprint test	Experimental group		Control group	
	Pre	**Post**	**Pre**	**Post**
	3.55±0.59	3.36±0.59	3.56±0.52	3.80±0.53

Table 3 represents 20 m sprint test. In between group comparison the experimental group ($p<0.01$) and control ($p<0.00$), both group showed significant difference post training.

Table 4: Descriptive statistics values for Illinois agility test in sprinters:

Agility	Experimental group		Control group	
	Pre	**Post**	**Pre**	**Post**
	17.33±0.82	16.95±0.51	17.60±0.90	17.57±0.75

Table 4 represents agility test. In between group comparison the experimental group ($p<0.01$) and control ($p<0.84$), experimental group showed significant difference post training.

Table 5: Descriptive statistics values for vertical jump height test in sprinters

Vertical jump height	Experimental group		Control group	
	Pre	**Post**	**Pre**	**Post**
	0.33±0.04	0.38±0.07	0.40±0.44	0.33±0.44

Table 5 represents vertical jump height test. In between group comparison the experimental group ($p<0.02$) and control ($p<0.53$), experimental group showed significant difference post training.

Table 6: Descriptive statistics values for VO_2 max test in sprinters:

VO2 MAX	Experimental group		Control group	
	Pre	**Post**	**Pre**	**Post**
	48.33±4.75	50.41±5.59	49.09±6.42	49.30±6.13

Table 6 represents VO_2 max. In between group comparison the experimental group ($p<0.04$) and control ($p<0.69$), experimental group showed significant difference post training.

Table 7: Descriptive statistics values for balance test in sprinters:

Balance (no of contacts)	Experimental group		Control group	
	Pre	Post	Pre	Post
	22.25±5.02	3.55±0.59	27.15±5.66	27.95±5.37

Table 7 represents vertical jump height test. In between group comparison the experimental group ($p<0.00$) and control ($p<0.41$), experimental group showed significant difference post training.

Discussion

The current study focuses on changes in the physical performance parameters following a 6 weeks sprint specific plyometric training in sprinters. In our study Illinois agility test was done to assess agility there was improvement found in the time to complete the test when compared with control group. This may be due to the ability of lower limb plyometric exercises to improve lower body strength, decrease the contact time of foot during agility tasks and increase change of direction speed. Significant differences in our results indicate that the plyometric training improved in agility test because of either better motor recruitment or neural adaptations occurred during training. In previous study of plyometric training, the authors postulated that improvements were the result of enhanced motor unit recruitment patterns (Potteiger *et al*, 1999) [26,]. Neural adaptations usually occur when athletes respond or react as a result of improved co-ordination between the CNS signal and proprioceptive feedback (Craig, 2004) [27]. Therefore, we found positive relationship between plyometric training and Illinois agility test. Another study done by Singh *et al.* (2018) explained improvement in agility following 6 weeks agility training is beneficial for athletes who require quick movements while performing their sport and support results from other studies.

The data reported in the present study indicate that sprint specific plyometric training is an effective training method for the improvement of vertical jump height. It is important to point that improvements observed in the vertical jump could have been induced by various neuromuscular adaptations, such as increased neural drive to the agonist muscles, changes in muscle-tendon, mechanical stiffness characteristics, alterations in muscle size and/or architecture and changes in single-fibre mechanics (de Villarreal *et al*., 2009; Potteiger *et al*., 1999; Thomas *et al*., 2009) [28, 26,]. The results of the study observed that sprint specific plyometric training made greater improvements in balance measured by kinematic measurement system when compared between training group with control group the number of contacts reduced in the training group as compared to its counterpart. The results were in line with the study postulated by Abbas Asadi *et al*., (2013) [16]. where they evaluated the effects of in-season plyometric training program on balance and sprint performance in basketball players. Fishbeck *et al* (2013) [31]. stated that plyometric training and agility training at higher intensity intervals increases balance in middle ages and older adults population. Similar study done by Singh *et al*. 2017 [32]. postulated that 6 weeks agility training lessen the number of contacts as a result of increased functional ability to maintain balance and posture. Hence we postulate that by enhancing balance and by controlling body positions during various movements, proprioception and postural stability should improve.

The sprint specific intervention appears to have had the greatest effect on sprint performance in the initial acceleration phase. Potential mechanisms for improvements in sprint performance include changes in temporal sequencing of muscle activation for more efficient movement, preferential recruitment of fastest motor units, increased nerve conduction velocity, a frequency or degree of muscle recruitment and rapid firing throughout the sprint (Ross *et al*., 2001) [29]. Several previous studies have suggested that plyometric training can enhance sprinting ability just because it is based on the use of Stretch Shortening Cycle (de Villarreal *et al*., 2008). Study done by Shenoy *et al* (2018) [33]. explained increase in 20 m sprinting ability of female volleyball players as a result of neural drive to muscle post dynamic stretching. As there is a lacuna of studies assessing the sprint specific plyometric training our study focused the effects of sprint specific plyometric training on variables which showed significant effects. The improvements were derived from an increase of step frequency, decrease of ground contact time during support phase resulting in an increase of running speed. The addition of plyometric training to sprint training seemed mostly to augment gains in the variability of kinematics of the single running step executed at maximum velocity. The present study found that the sprint specific plyometric made significant changes in the maximum oxygen uptake by increasing the VO_2 max post training when compared with control group. The improvement in training group is noteworthy that it could make adaptations across the physiological systems that improve performance. The results that refer to study done by Saunders *et al*., 2006 [30]. which explained improvement in running economy and VO_2 max due to plyometric and explosive speed training are consistent but they don't state the reasons for this. Some comparative studies of speed and plyometric protocols need to be conducted to obtain clearer understanding of how to get the ultimate improvement of running economy and VO_2 max and performance for different subjects. There are some factors that determine the best type of training for an individual to improve running economy and performance such as individual strengths, weaknesses and capacity for adaptations to training stimuli.

Therefore, such type of training protocols can be incorporated during preparation seasons, as well as competition seasons to increase lower-body strength and agility and endurance in sprinters and other games for improving performance.

Conclusion

Results of our study highlights and suggests the benefits of 6 weeks sprint specific plyometric training in improving agility, vertical jump height, balance, 20 m sprint test and VO_2 max. In addition of plyometric combined with sprint training seemed mostly to augment gains in overall performance.

Practical Implications

The most important finding of this study is that a sprint specific plyometric training program can increase the neuromuscular recruitment of lower limb muscles. Explosive speed is required in many sports and physical activities; coaches and participants should therefore consider plyometric training program that incorporates sprint specific activities.

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