



Research Article

EFFECTIVENESS OF BALLISTIC SIX PLYOMETRIC TRAINING ON SERVING SPEED OF TENNIS PLAYERS

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ABSTRACT

Background: Peak performance for the overhead throwing athlete often depends on shoulder girdle strength particularly the rotator cuff. The purpose of this study is to find out the effectiveness of 6 weeks ballistic six plyometric training of rotator cuff on the serving speed of tennis players.

Methods: It was an experimental study in which 30 tennis players (males=9, females=21) aged 13-18 (mean 13.66±1.06) years were recruited. The intervention was carried out for 6 weeks with a theraband and a medicine ball with progressively increasing training intensity using 10RM. The serving speed of the players was recorded using Radar-gun Pre and Post training.

Result: Pre-training evaluation demonstrated high correlation ($r=0.8$) between height of players and serving speed. The serving speed of players showed significant improvement ($p<0.0001$) from 131.02±16.90 (pre-training) to 131.20±16.93 (2nd week) to 133.58±16.95 (4th week) to 134.76±16.97 (6th week).

Conclusion: The Ballistic Six Plyometric training was significantly effective in improving the serving speed of tennis players.

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INTRODUCTION

Tennis is a racket sport that can be played individually against a single opponent (singles) or between two teams of two players each (doubles). Tennis enjoys some considerable followers in India, although it is limited to urban areas but still it is counted among the most popular sports in India. (Robertson, Max, 1974). India has produced a number of tennis players, who have achieved international recognition and have made their presence in some of the top tennis tournaments and grand slams. In 1997 India won their first Grand Slam title at the French open, in the Mixed Doubles. Since then Indians have won Grand Slam titles in the Mixed Doubles, Men's Doubles, Women's Doubles besides Girl's Doubles events.

Tennis is the largest individual sport in terms of registered players and viewing audiences as reported every year during the Wimbledon Championships. These players are the most prestigious tennis champions in the world and attract the largest global audience. In different countries every individual has equal opportunities to produce good athletes. Different countries have different factors that help tennis being a successful sport. These factors include-tournament, structure, professionalism and structural aspects of the federation, departments, and clubs, the coaches' education system; the training facilities for elite tennis players and the overall

budget of the federation and budget for elite sport. (Ales Filipic *et al.*, 2013)

Tennis injuries are about 5 injuries per 1,000 hours of participation. The causes for this are high-velocity and repetitive arm movements that are required in tennis which tend to be overuse in nature. Few other causes for tennis injury risk factors maybe- poor physical conditioning, poor injury rehabilitation and poor warm up, stretch and cool down. (John Miller, 2008). Muscle imbalance, micro trauma, insufficient recovery, and biomechanical compensations are said to be among the top health risks that tennis players encounter when competing and practicing too much. Along with optimal performance, reduced risk of injury are the key goals to attain for tennis players who adhere to the training program. (Babette Pluim *et al.*, 2004)

Most sports involve fast movements for which forces must be generated quickly. Great serves in tennis are often faster serves. While tennis serve speed is not the only barometer for serving greatness, it is also a major factor that makes a serve difficult to return. This is because, the less time the opponent has to return the serve, the better are the chances of winning the point outright. There are many strength and conditioning programs and rehabilitation programs have dramatically changed over the past several years. (Chmielewski *et al.*, 2006).

Success in tennis depends on several physical, technical and psychological factors. And in order to be competitive, players require a mixture of speed, agility, and power combined with medium to high aerobic and anaerobic capacity. Although performance cannot be defined by one predominant physical attribute, strength and power seem to be influential in tennis performance, with functional links observed between muscular strength in the dominant lower and upper extremities. (Jaime Fernandez, 2013)

Plyometric exercises called the "Ballistic Six" were proposed by Pretz in 2004 to improve upper extremity muscular performance. Plyometric is a traditional form of resistance training emphasizing the loading of muscles during an eccentric muscle action, which is quickly followed by a rebound concentric action. Among the numerous types of available exercises, plyometrics assist in the development of power, a foundation from which the athlete can refine the skills of their sport. (Davis G *et al.*, 2015).

The word plyometrics is actually a derivation from the Greek words 'plythein' or 'plyo', which means to increase and metric, which means to measure. Consequently, the purpose of plyometrics may be thought of as "to increase the measurement." (Heiderscheit B.C. *et al.*, 1996) (Schulte Edelemann *et al.*, 2005.).

Biomechanics of plyometrics can be explained as utilization of the stretch-shortening cycle (SSC) by using a lengthening movement (eccentric) which is quickly followed by a shortening movement (concentric). (Chu Da Panariello Ra. ,1989) (Ebben W P *et al.*, 2008).The various phases of plyometrics include eccentric pre stretch, amortization phase and concentric shortening phase.Plyometric training has already been proven to be useful in various sports such as cricket, baseball etc. This study has aimed to evaluate the effectiveness of 6 weeks ballistic six plyometric training of the rotator cuff on the serving speed of tennis players.

MATERIALS AND METHODS

Methods

Study design: Experimental Study

Sampling: convenient sampling

Sample size- 30

Age- 13-18 years

Study setup- various academies across Pune

Study duration- 6 weeks

Materials

Theraband, Medicine ball, Speed gun

Inclusion criteria:

Subjects playing tennis regularly for more than 2 years.

Exclusion criteria:

Subjects with any history of upper extremity injury.

Procedure

Synopsis was approved by the Institute and Ethical Committee. Tennis academies across the city were searched online and visited for recruitment of tennis players. Tennis players with minimum 2 years of training were approached (n=65) amongst which 45 agreed for participation in the study. Players were explained about the research purpose and intervention protocol and an informed consent was taken.8 players were excluded because of history of upper limb injury. 37 underwent baseline evaluation and the average of 3 serve speeds was taken using a radar gun. All the subjects were asked to perform warm-up exercises before the start of the training. These included 1.5 minutes of jogging, 2 minutes of stretching and 1.5 minutes of serving practice. Each subject was then given 3 sets with 10 repetitions of ballistic six plyometric training 3 times a week. Progression was made on the basis of 10 RM and the speed was recorded every 2 weeks. Amongst these players, 7 did not continue the 6 weeks of intervention program so were dropped out from the analyses.

As demonstrated in Fig. 1; the exercises performed included:

1. Elastic external rotation
2. 90-90 elastic external rotation
3. Overhead medicine ball throw
4. 90-90 external rotation side throw
5. Deceleration baseball throw
6. Kneeling baseball throw

RESULTS

Statistical analyses using repeated ANOVA was used to find out improvement on serving speed. The correlation between height of the player and serving speed was analysed using Pearson's Correlation Coefficient test.

In the pre-training evaluation, it was found that there was a high correlation ($r=0.8$) between the height of the players and his/her serving speed. (Table 1).



Fig. 1 90-90 External rotation side throw

The serving speed of players showed significant improvement ($p < 0.0001$) from 131.02 ± 16.90 (pre-training) to 131.20 ± 16.93 (2nd week) to 133.58 ± 16.95 (4th week) to 134.76 ± 16.97 (6th week). (Table 2)

Table 1 Correlation between Height and Serving speed of Tennis player

Height (cm)	Pre-speed (km/hr)
150-160	116.06 ± 7.70
161-170	125.64 ± 10.25
171-180	144.77 ± 11.87
181-190	180 ± 12.73

Table 2 Serving speed of Tennis players pre and post training

Serving speed	Pre-training (km/hr)		Post-training (km/hr)		p-value
		2nd week	4th week	6th week	
mean±sd	131.02 ± 16.90	131.20 ± 16.93	133.58 ± 16.95	134.76 ± 16.97	< 0.0001

DISCUSSION

A strong correlation between the subject's height and speed was found. This could be possible because longer lever arm allows more good force transfer on the ball. Many biomechanical analyses have normalized force and torque for subject's height because taller subjects can exert more force and torque through the upper extremity as they have a longer lever arm. (Aguinaldo AL *et al.*, 2007.) (Davis JT *et al.*, 2009)

In the present study there is a significant increase in the speed of the serves in these tennis players. This can be supported by the results of a study by Swanik *et al.* which said that this could be due to the adaptations in the elastic properties of the muscle, which enables the muscle to utilize stored energy more efficiently. (swanik K A *et al.*, 2002) Also the subjects underwent neural component adaptations, which contributed towards increasing the motor unit recruitment and increased power. Proprioception and kinesthesia due to peripheral and central neural adaptations were significantly improved, due to plyometric training. Endurance in the rotator cuff musculature is important for reestablishing functional stability which can be promoted through plyometric exercises.

Rapid change of direction of a limb or the entire body without external loads is due to neuromuscular overload, which takes place with the help of plyometric exercises. The total overload amount is the result of total work and repetitions, sets etc., and /or the range of motion (ROM) the athlete moves through. The concept is that within the specific ROM there is employment of muscle activation and stretch reflex. These help facilitate to enhance the force of production through movement pattern. By rapidly and intensely performing the movement temporal overload or in other words amortization phase i.e. the time to rebound which should be as short as possible can be achieved. This could be one of the keys for increased force production. A shorter time to rebound allows effective transmission of force from eccentric pre-stretch to concentric power performance phase of the plyometric movement. During plyometric training volume should be increased in a progressive manner to decrease the risk of injury or overtraining. It can be done by calculating the load, number of repetitions, sets, etc. Also the number of exercise sessions i.e. frequency during the training can also affect the speed. (DaviesGj *et al.*, 2001) (Todd Es *et al.*, 2015)

The eccentric pre-stretch phase of plyometrics can be described as the readiness, pre-loading, pre-setting, preparatory, facilitatory, potentiation, counter-force, or counter-movement phase. (Asmussen E *et al.*, 1974) (Eldred E.Am, 1967). Dynamic neuromuscular stabilisation plays an important role in an overhead throwing athlete. The ligaments of the shoulder are sufficient for static stability however, along with that dynamic stability is required which can be achieved with the muscles of rotator cuff. Also during an overhead activity such as a serve, internal and external torques are produced and the rotator cuff acts concentrically as well as eccentrically.

(Dillman, C.J *et al.*, 1993) (Fleisig, G.S *et al.*, 1995) (Mikesky, A.E *et al.*, 1995) (Wilk, K.E. *et al.* 1993)

According to several researchers (Amrinder Singh *et al.*, 2014) (ErtugrulGelen *et al.*, 2012), the resultant concentric muscle contraction is enhanced due to the eccentric pre-stretch. The eccentric pre-stretch consists of three variables which are magnitude, rate and duration of the stretch (Eldred E, 1967). A significant effect is seen on amount of the energy stored during eccentric pre-stretch if any of these variables are manipulated.

In a study subsequently higher functional ratio is because of the increase in eccentric strength. This occurs if the basic principles of plyometrics are applied properly for maximum output in minimum time (Andrew B C *et al.*, 2007). In a study conducted on baseball players who participated in a 10 week plyometric programme recorded significant improvement in the throwing speed as compared to control group subjects. This could be because the ballistic nature of the bench throws is similar to ballistic six exercises (Mcevoy K I *et al.*, 1998) According to Amrinder *et al.* involvement of series of functional exercises that are performed at high volumes during the ballistic six training programme facilitates in stimulating the movements, positions, and forces involved with the overhead throwing motion. To decrease the amortisation phase of the SSC training in a high velocity manner was conducted. This helped to take advantage of the stretch reflex. The upper extremity plyometric training had a positive effect on the bowling velocity which may be due to the result of improved proprioception, kinaesthesia and endurance of the rotator cuff muscles in addition to increased strength and power. (Amrinder Singh *et al.*, 2014)

The present study revealed that upper extremity plyometric training had a positive effect on serving speed of tennis players due to various variables as well as improved proprioception, kinesthesia, endurance of the rotator cuff muscles, increased strength and power as an effect of Ballistic Six Plyometric Training.

This study has evaluated effectiveness of supervised Ballistic six plyometric training program. Follow up study can be done to evaluate whether training effects continued after exercises been stopped. Also effects of well-designed unsupervised program can be done to evaluate long term benefits in players performance.

CONCLUSION

Ballistic Six Plyometric training was effective in improving the serving speed of tennis players. There was high correlation between the height and serving speed of the tennis players.

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