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Kinematic analysis of velocity of jump serve among national level volleyball players

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Abstract
Jump serve is the difficult serve among all other volleyball serves. It has relatively short time of flight because the ball travels with greater velocity and topspin which leads to a fast drop down of the ball. A powerful jump serve often results an ace because either the opponent may not get adequate time for the reception or the player may not get the control on the received ball. In jump serve, the player jump from behind the end line, hit the ball in the air inside the court and land at the middle of the court. In effect, when comparing other serves by standing behind the end line; the ball contact of the jump serve takes place inside the court. This allows the served ball to travel less distance with greater speed towards the opponents' court. Considering the importance of velocity of the serve, the present research investigates its characteristics through video analysis. The preset research attended to find out the relationship between selected linear kinematic variables of jump serve and velocity of the ball among national level male volleyball players. The purpose of the study was achieved with participation of 10 national level male volleyball players who have represented Kerala in national level competitions Two dimensional video analysis using the captured trials of different techniques by the sample (N= 20) trials for each techniques considered. The Kinovea motion analysis software was used as the tool for the same. The data collected through the video analysis method was statistically assessed by using Pearson's Product Moment Correlation Coefficient and found that there was significant positive relationship between velocity of the ball with take-off velocity, height of CG at ball contact, reach height and distance of jump.

Keywords: Velocity of the ball, jump serve

Introduction
Jump serve is one of the most exciting serve in volleyball, which offers more delightful dynamic skill, which is entrancing for players and spectators equally. A great jump server can produce a number of successful attempts over the course of a match. Hence, it has become a powerful offensive weapon for the top volleyball teams among the world. The jump serve in volleyball is one of the most aggressive and exciting skills within the modern game. The player starts well outside of the court, and by using an explosive run up, jump, and hit at the peak of their flight – send the ball over the net at rapid speeds and with large amounts of topspin. The jump serve is a valuable offensive skill in volleyball, due to its high intensity and the difficulty for opponents to react in time to accurately return the ball. There are biomechanical performance enhancing benefits in regards to the distance of the ball toss, as it provides the server with time whilst the ball is in flight to generate horizontal velocity through the run up (Tilp, Wagner, & Müller, 2008) [12]. By analyzing a player's movement throughout the entire skill, we can see that by throwing the ball out of the hitting hand players have a greater range of motion in regards to their hitting arm and trunk position, meaning they are able to create a longer lever arm, thus generating greater velocity for the hit (Tant & Witte 1991) [11]. In order for athletes to transfer their momentum into vertical velocity, they undergo a process called 'loading up' their legs (Miyamoto *et al*., 2011) [9]. When loading up their legs, athletes eccentrically contract their hip, knee, and ankle extensors, consequentially increasing flexion of their knees and hips, and stretching muscles prior to the jump. Due to the conservation of momentum (Alexander & Honish, – n.d), it is reported that athletes with a longer run up are more likely to be able to jump higher in volleyball (Khayambashi 1977; Maxwell, Bratton *et al*. 1980) [6, 8] and so most volleyball players utilize a four step run up to maximize their run up distance.

Furthermore, horizontal velocity gained through the run up will lead to a harder hit and faster serve, due to the horizontal velocity of the run up being added to that of the serving arm. Once in the ready position for take-off with feet planted and torso, knees and hips flexed, the server begins to extend their body to push them off the ground. Due to the body's continual horizontal velocity, the back leg will extend first – the body then moving upwards and over the left leg which sequentially extends resulting in the player jumping off the ground. Prior to the leg extension however, the upward arm swing is used to propel the server upwards by helping generate force and vertical momentum (Tang, 2013) [10]. The backswing actually begins during the takeoff phase of the skill, with the server moving their hitting arm behind their body after the jump. From the back swing ready position, the server's shoulders will rotate rapidly to the left, from hyperextension into flexion. Following this, the trunk starts to rotate forward and the servers arm also begins to rotate towards striking the ball. In the volleyball jump serve, the ball will ideally be impacted at the peak of the servers jump, and with their arm outstretched as high as possible. The arm will be fully extended above the shoulder, with the trunk also leaning in order to increase the height of the hitting hand. Considering the biomechanical importance of the techniques the present research investigated the relationship of selected kinematic variables with the velocity of ball in jump serve.

Methodology

The present investigation 10 national level male volleyball players with an age range from 19 to 25 years were selected as subjects. For the kinematic analysis of selected linear kinematic variables of jump serve, the players were filmed using Sony Alpha 7sii, while they executed each technique during a single training session. The data captured was fed to the computer for analysis using Kinovea motion analysis software. The data on selected linear kinematic variables were also assessed with the help of Kinovea motion analysis software. The details of the variables considered for the present study is given in Table 1. The data was analysed using statistics such as Arithmetic Mean (AM), Standard Deviation (SD), in order to get basic idea about the data distribution. Pearsons's Product Moment Correlation Co-efficient was calculated to assess the relationship between selected kinematic variables and the velocity of ball in jump serve

Results of the Study

Table 1: Analysis of Linear Kinematic Variables of Jump Serve

Variable	N	Range	Minimum	Maximum	Mean	Std. Deviation
Distance between Feet (Stance) (m)	20	0.10	0.70	0.80	0.76	0.03
Height of CG (Stance) (m)	20	0.33	0.99	1.32	1.22	0.07
Approach Distance (m)	20	0.95	3.90	4.85	4.39	0.27
Duration of Approach Run (s)	20	0.56	1.18	1.74	1.45	0.16
Velocity of Approach Run (m/s)	20	1.29	2.36	3.65	3.06	0.39
Length of Penultimate Step (m)	20	0.38	1.20	1.58	1.34	0.11
Height of CG (Penultimate Step) (m)	20	0.25	0.92	1.17	1.04	0.06
Height of CG (Cross Step) (m)	20	0.14	0.95	1.09	1.02	0.03
Duration of Take Off (s)	20	0.07	0.12	0.19	0.16	0.02
Take Off Velocity (m/s)	20	1.59	2.20	3.79	2.94	0.46
Duration of Flight Till Ball Contact (s)	20	0.32	0.34	0.66	0.48	0.10
Height of CG at Ball Contact (m)	20	0.46	1.80	2.26	2.04	0.13
Reach Height (m)	20	0.65	2.58	3.23	2.92	0.20
Velocity of the Ball (m/s)	20	3.99	22.45	26.44	24.20	1.04
Flight Time (s)	20	0.24	0.65	0.89	0.78	0.09
Distance of Jump (m)	20	0.98	1.61	2.59	2.10	0.36

The mean of distance between feet at stance was 0.76m with a standard deviation of 0.03m. The minimum and maximum of distance between feet at stance was 0.70m and 0.80m respectively and the range was 0.10m.The mean of height of CG at stance was 1.22m with a standard deviation of 0.07m. The minimum and maximum of height of CG at stance was 0.99m and 1.32m respectively and the range was 0.33m.The mean of approach distance was 4.39m with a standard deviation of 0.27 m. The minimum and maximum of approach distance was 3.90m and 4.85m respectively and the range was 0.95m.The mean of duration of approach run was 1.45s with a standard deviation of 0.16s. The minimum and maximum of duration of approach run was 1.18s and 1.74s respectively and the range was 0.56s. The mean of velocity of approach run was 3.06m/s with a standard deviation of 0.39m/s. The minimum and maximum of velocity of approach run was 2.36m/s and 3.65m/s respectively and the range was 1.29m/s. The mean of length of penultimate step was 1.34 m with a standard deviation of 0.11m. The minimum and maximum of length of penultimate step was 1.20m and 1.58m respectively and the range was 0.38m.The mean of height of CG at penultimate step was 1.04m with a standard deviation of 0.06m. The minimum and maximum of height of CG at penultimate step was 0.92m and 1.17m respectively and the range was 0.25m.The mean of height of CG at cross step was 1.02m with a standard deviation of 0.03m. The minimum and maximum of height of CG at cross step was 0.95m and 1.09m respectively and the range was 0.14m.The mean of duration of take-off was 0.16s with a standard deviation of 0.02s. The minimum and maximum of duration of take-off was 0.12s and 0.19s respectively and the range was 0.07s.The mean of take-off velocity was 2.94m/s with a standard deviation of 0.46m/s. The minimum and maximum of take-off velocity was 2.20m/s and 3.79m/s respectively and the range was 1.59m/s. The mean of duration of flight till ball contact was 0.48s with a standard deviation of 0.10s. The minimum and maximum of duration of flight till ball contact was 0.34s and 0.66s respectively and the range was 0.32s.The mean of height of CG at ball contact was 2.04m with a standard deviation of 0.13m. The minimum and maximum of height of CG at ball contact was 1.80m and 2.26m respectively and the range was 0.46m. The mean of reach height was 2.92m with a standard deviation of 0.20m. The minimum and maximum of reach height was 2.58m and 3.23m respectively and the range was 0.65m. The mean of velocity of the ball was 24.20m/s with a standard deviation of 1.04m/s. The minimum and maximum

of velocity of the ball was 22.45m/s and 26.44m/s respectively and the range was 3.99m/s. The mean of flight time was 0.78s with a standard deviation of 0.09s. The minimum and maximum of flight time was 0.65s and 0.89s respectively and the range was 0.24s. The mean of distance of jump was 2.10m with a standard deviation of 0.36m. The minimum and maximum of distance of jump was 1.61m and 2.59m respectively and the range was 0.98m.

Table 2: Correlation between the velocity of the ball and linear kinematic variables of jump serve

Variable		N	r	Sig.
Velocity of the ball	Distance between Feet (Stance)	20	0.084	0.723
	Height of CG (Stance)	20	- 0.142	0.551
	Approach Distance	20	- 0.348	0.133
	Duration of Approach Run	20	0.005	0.984
	Velocity of Approach Run	20	- 0.150	0.529
	Length of Penultimate Step	20	- 0.405	0.076
	Height of CG (Penultimate Step)	20	0.208	0.378
	Height of CG (Cross Step)	20	0.042	0.860
	Duration of Take Off	20	- 0.325	0.163
	Take Off Velocity	20	0.971	0.000
	Duration of Flight Till Ball Contact	20	- 0.021	0.931
	Height of CG at Ball Contact	20	0.678	0.001
	Reach Height	20	0.724	0.000
	Flight Time	20	- 0.094	0.693
	Distance of Jump	20	0.910	0.000

Table 2 indicated that velocity of the ball showed significant positive relationship with take-off velocity (r =0.971, p<0.05); velocity of the ball showed significant positive relationship with height of CG at ball contact (r = 0.678, p<0.05); velocity of the ball showed significant positive relationship with reach height (r = 0. 724, p<0.05); and velocity of the ball showed significant positive relationship with distance of jump (r = 0.910, p<0.05). There was no significant relationship between velocity of the ball with distance between feet at stance (r = 0.084, p>0.05), height of CG at stance (r = -0.142, p>0.05), approach distance (r = -0.348, p>0.05) duration of approach run (r = 0.005, p>0.05), velocity of approach run (r = -0.150, p>0.05), length of penultimate step (r = -0.405, p>0.05), height of CG at penultimate step (r = 0.208, p>0.05), height of CG at cross step (r = 0.042, p>0.05), duration of takeoff (r = -0. 3256, p>0.05), duration of flight till ball contact (r = -0.021, p>0.05) and flight time (r = -0.094, p>0.05).

Analysis of correlation between the velocity of the ball and the selected linear kinematic variables of jump serve indicted that there was significant positive relationship between velocity of the ball with take-off velocity, height of CG at ball contact, reach height and distance of jump. Huang and Hu, (2007) also reported that the ball velocity of jump top spin serve (25.4 m/s ± 5.1 m/s) was significantly correlated (r=0.55; p<0.01) with horizontal velocity of COM at takeoff. In line with the present study the ball velocity was found to have significant positive correlation between the position of the centre of gravity at the time of ball contact and velocity of the ball(r=0.74; p<0.01) (Häyrinen *et al*., 2011).

Conclusions

1. The velocity of the ball of jump serve has a significant positive relationship with take-off velocity, height of CG at ball contact, reach height and distance of jump among national level male volleyball players.
2. It was also found that there was no significant relationship between velocity of the ball with distance between feet at stance, height of CG at stance, approach distance, duration of approach run, velocity of approach run, length of penultimate step, height of CG at penultimate step, height of CG at cross step, duration of takeoff, duration of flight till ball contact, and flight time of jump serve.

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