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KINEMATICS ANALYSIS IN JUMPING SERVE OF THAI WOMEN VOLLEYBALL NATIONAL TEAM

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ABSTRACT

The analysis was conducted on the performances of the jumping serves of 8 women volleyball players, all of whom are members of the Thai National Team. There were two parts of analysis: the anthropometric and the kinematic. **Objectives:** To define the kinematics and total mechanics of the energy differences between the jumping serve skills of women volleyball players. **Methods:** The kinematics data were recorded by using 4 cameras, utilizing Casio Ex-Fc 100 (1280×720 pixel) technology and the 2D Motion Analysis system. Kinematics data included linear and angular velocity, and the linear and angular acceleration of the upper and lower extremity and the center of gravity, as well as the kinetics and potential energy during ball contact. The statistics were measured in mean and SD. **Results:** The average of ages was 25.2±4.1 years, bodyweight 66.1±3.9 kg, body height 176.6±3.8 cm, arm length 80.2±9.6, leg length 103.2±3.1 and the width of arm to arm 182.6±7.3 cm The maximum of linear velocity of finger, wrist, elbow, hip, and knee were 16.32, 13.25, 6.12, 1.95, and 4.22 m/s, respectively. The maximum of linear velocity of shoulder and ankle were 3.57, and 4.95 m/s respectively. The maximum of linear acceleration of wrist, elbow, and hip were 271.85, 110.03, and 25.09 m/s², respectively. The maximum of linear acceleration of the finger and shoulder were 271.74 and 53.88 m/s², respectively. The maximum of the linear acceleration of the knee was 18.69 m/s². The maximum of the linear acceleration of the ankle and toe were 40.4 and 50.95 m/s², respectively. The maximum of the angular velocity of the wrist, hip, and ankle were 397.35, 536.66, and 286.5 deg/s, respectively. The maximum of the angular velocity of the elbow and knee were 1186.7 and 304.73 deg/s, respectively. The maximum of the angular velocity of the shoulder was 493.61 deg/s. The average velocity of the center of gravity was 2.07±0.65 m/s, and the maximum was 3.15 m/s. The maximum relative of the height of C.G. and body height was 86.8%, and the average total mechanical energy was 1039.5 ±219.4 Nm. **Conclusions:** The appearance of the upper body joints of elite volleyball players during ball contact could be used as a criterion of jumping serve skill and as a measure of basic-performance.

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KEYWORDS: KINEMATICS, JUMPING SERVE

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INTRODUCTION

The serve is the first attacking move in the modern game of volleyball. One of the most dramatic skills in modern volleyball is the spike serve, or the jump serve, which demonstrates an exciting and dynamic skill. Since the late 1980s, when it was pioneered by Brazilian players, the spike serve entails the player starting behind the end line of the court, using a fast and explosive run up, a dynamic spike takeoff, and an exciting spike action at the peak of their jump to send the ball across the net. The spike serve is somewhat similar to the spike at the net, except the velocities after impact are somewhat lower for the serve when compared to the spike (Tant, Greene et al. 1993). The player strikes the ball with maximum force at the peak of his jump, and tries to place it so that the opposing player cannot receive it cleanly. A successful spike is determined by three factors, which are similar to those of the jump serve. These factors include the position of the ball at impact, the speed of the ball after impact, and the direction of the ball's movement after impact (Chung, Choi et al. 1990). In the jump serve, the ball's position at impact is determined by the toss of the server - an effective serve requires a perfectly-placed toss and a perfectly-timed run-up. The higher the point of impact, the sharper the downward angle of the serve, thereby allowing more margin for error for the server to utilize a higher ball velocity. The movements and timing involved in the technique will improve the skills of players at all levels. Even if these extreme positions are difficult for players of lower strength and flexibility levels, their attempts to increase the range of their movement, their joint movement timing, and their jump height will improve the effectiveness of their jump serve skills. Therefore, it was the aim of this study to provide descriptive kinematics and energy analysis of the biomechanical factors involved in "jump" serve.

MATERIAL AND METHOD

Eight international players from Thailand were filmed in training using 4 cameras with Casio Ex-Fc 100, filming at 50 Hz with a 2-D Motion analysis system. Three successful serves were recorded, and one successful attempt for each subject was then chosen for analysis. The lengths of the arms and legs were measured, and the statistics were measured as mean and SD.

RESULTS & DISCUSSION

The data has shown that in the Thai women's volleyball team, the two tallest players, who stand 180cm tall, have the longest arms and legs, while the shortest player, who stands 168cm tall, has the shortest arms and legs. When we studied the linear and angular velocity and the linear and angular acceleration of a hand hitting a ball, we observed both parts of the body, comprising the upper body (i.e. fingers, wrist, elbow and shoulder) and the lower body (i.e. hip, knee, ankle and toe). We found that when a hand hits a ball, the fingers, wrist, elbow, hip and knee of O showed the highest linear velocity at 16.32, 13.25, 6.12, 1.95 and 4.22 m/sec, respectively. That measurement of PI's shoulder and ankle is 3.57 and 4.95 m/sec, respectively. Moreover, we found that when hitting a ball with the hand, the wrist, elbow and hip of O showed the highest

linear acceleration at 271.85, 110.03 and 25.09 m/sec^{2,} respectively, while the acceleration of Pl's fingers and shoulder is 271.74 and 53.88 m/sec^{2,} respectively. T's knee and A's ankles and toes were recorded at the highest linear acceleration of 18.69, 40.4 and 50.95 m/sec^{2,} respectively. We found that when hitting a ball with the hand, Pl's wrist, hip and ankle showed the highest angular velocity at 397.35, 536.66, and 286.5 deg/sec, respectively. That of O's elbow and knee is 1186.7 and 304.7 deg/sec, respectively. Moreover, we found that when hitting a ball with the hand, Ta's shoulder showed the highest angular velocity at 493.61 deg/sec. The average velocity of the vertical center of gravity, when hitting the ball with the hand, is equal to 2.07 $\pm$ 0.65 m/sec. The highest was O, with the velocity at 3.15 m/sec, while the slowest was T, at 1.54 m/sec. O has the highest center of gravity, due to her height ,when hitting the ball, at 86.8%, while Pi, the lowest, was recorded at 50.5%. As for the energy used in jump serving, the average kinetic and potential energy used are 154.1 ± 107.3 and 885.4± 136.2 N.m, respectively. The average total energy used was 1,039.5 ± 219.4 N.m. O utilized the most energy in jump serving, with kinetic and potential energy at 358.1 and 1,073.5 N.m, respectively, with the average total energy used at 1,431.6 N.m. This compares with T, who utilized the least kinetic energy at only 71.3 N.m, and Pi who used the least potential energy at only 597.8 N.m. It was recorded that Pi had used up the least total energy in jump serving, observed at only 682.0 N.m. In this study, we found that the average height of Thai women volleyball players is 176.75 cm, which is similar to that of players measured in the year 2011, who were measured at 176.25 cm (Surasak, 2011). It should be noted that the players are almost the same as those who participated in the year 2011. Moreover, the tallest (180 cm) with longest arms (103 cm) and legs (103 cm) is A, who proved to be the most skilled in the net front hit and block. This also conforms to the linear velocity of her ankle and toe, which is the highest among all players, and which also helps her to jump higher. Moreover, the velocity of her center of gravity is in the upper range at 2.03 m/sec, as is that of Pl, who has the same height, and an arm length of 81 cm and a leg length of 109.5 cm. Pi also has a velocity of center of gravity as high as 3.0 m/sec. Our study has assured accuracy of the research result of Tant and Witte, maintaining that the velocity of the center of gravity of a body moving forward helps to accelerate ball velocity, along with arm and body movement. The higher the velocity, the more vertical is center of gravity. This velocity would be accumulated at the palms of the hands (Tant and Witte, 1991). The linear velocity of the wrist when hitting the ball showed that O had the top speed, at 13.25 m/sec. This could be compared to a reference record showing a male English player whose record was at 16.1 m/sec (Coleman, 2005), and 23.48 m/sec later.

Data of linear velocity and acceleration of the upper and lower limb are provided in Table 1-2.

Table 1. Linear velocity of upper and lower limb during contact ball (m/sec)

	Average	SD	Maximum	Subject Name
Fingers	9.30	3.20	16.32	O
Wrist	7.40	2.06	13.25	O
Elbow	3.66	1.34	6.12	O
Shoulder	1.89	1.05	4.80	O
Hip	1.53	0.36	1.95	O
Knee	2.75	0.81	4.22	O
Ankle	3.08	1.05	4.95	PI
Toe	3.04	0.88	4.94	PI

Table 2. Linear acceleration of upper and lower limb during contact ball (m/sec^2)

	Average	SD	Maximum	Subject Name
Fingers	223.07	56.34	271.74	PI
Wrist	158.22	33.61	271.85	O
Elbow	58.72	25.18	110.03	O
Shoulder	26.22	14.31	53.88	PI
Hip	12.45	6.57	25.09	O
Knee	11.97	5.23	18.69	T
Ankle	16.42	11.03	40.40	A
Toe	26.68	15.9	50.95	A

Data of maximum angular velocity of upper and lower limb during ball contact are provided in Table 3.

Table 3. Maximum Angular velocity of upper and lower limb during ball contact (deg/sec).

	Maximum	Subject Name
Wrist	397.35	Pl
Elbow	1,186.70	O
Shoulder	493.61	T
Hip	536.66	Pl
Knee	304.73	O
Ankle	286.50	Pl

Data of average vertical velocity of center of gravity during ball contact are provided in Table4.

Table 4. Average velocity of center of gravity during ball contact (m/sec)

Subject Name	A	M	O	Pi	Pl	R	S	T	average	SD
	2.03	1.73	3.15	1.57	3.0	1.95	1.56	1.54	2.07	0.65

Data of ratio of the body height and height of center of gravity during ball contact are provided in Table 5.

Table 5. Ratio of body height and height of center of gravity during ball contact (%)

Subject Name	A	M	O	Pi	Pl	R	S	T	average
	137/180	142/178	152/175	90/178	149/180	154/178	141/177	140/168	
	76.1%	79.7 %	86.8%	50.5%	82.7%	86.5%	79.6%	83.3%	78.15%

Data of kinetics and potential energy during ball contact in jump serve are provided inTable6.

Table 6. Kinetics and potential energy during ball contact (Nm)

Subject Name	A	M	O	Pi	Pl	R	S	T	average	SD
K.E	144.1	93.9	358.1	84.2	284.3	114.1	82.5	71.3	154.1	107.3
P.E	940.2	879.9	1073.5	597.8	921.1	942.1	822.6	885.4	885.4	136.2
Total	1,084.3	973.8	1,431.6	682.0	1,205.4	1,020.6	1,024.7	893.9	1,039.5	219.4

CONCLUSION

In summary, when studying kinematic and kinetic attributes, it is obvious that the player with the highest jump serve demonstrates the highest kinematic and kinetic value. Conclusively, some researchers have said the jump serve and spike serve are the same, more or less, as the net front hit. However, the speed of the ball after being served is lower than that of the net front hit (Tant, Greenc et al, 1993). This study is based on movement analysis during training periods, but can be beneficial for players and coaches to utilize in order to improve their skills.

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