A KINEMATIC ANALYSIS OF DIFFERENT JUMPING METHODS FOR SPIKING IN VOLLEYBALL

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This study was designed to analyze kinematic characteristics of different types of volleyball spikes at take-off. It compared the hop jump and step-close jump with different stride distances (25cm-35cm and 45cm-55cm). Twelve male college volleyball players volunteered for this study. The displacement of squatting, striding, and horizontal hop jumps were shorter than those data of step-close jump. However, when compared with vertical displacement, the performance of hop jump was better than step-cross jump. The angles of lower limbs during the hop jump landing, body mass center in the lowest position, and take-off were significantly narrower than those displayed during step-cross jump. Therefore, the step-close jump demonstrated significantly better kinematics compared to the hop jump.

KEY WORDS: step-close jump, hop jump, level step distance.

INTRODUCTION: In volleyball, there are two methods of jumping when spiking: hop jumping and step-close jumping. The characteristics of the hop jump can be summarized by adopting flexed knees in preparation, followed by explosive extension into the jump. Another method, the step-close jump is characterized by the fact both feet do not contact the ground at the same time in preparation for jumping. These methods of jumping are often applied separately (ref). The hop jump method is beneficial to enhance the jumping power and shorten jumping preparation time. The step-cross method is featured when more flexibility in jump timing is needed and is generally used when rushing forward to jump. (Lu, 1995; Peng, 1997; Lee,2000; Chang, 2001; Lu, 2003).
Some researches pointed out that the increase in distance of the last step may amplify the counter movement squat of the jumper during the approach, thus speeding up the vertical velocity. An appropriate counter movement squat has been shown to increase jump height as it activates the stretch-shortening cycle of the lower limb musculature (Asmussen & Petersen, 1974; Komi & Bosco, 1978; Pandy & Zajac, 1991; Anderson & Pandy, 1993; Zajac, 1993). This situation could be highly beneficial to volleyball athletes in their quest to maximize jump height prior to spiking the ball. Thus this research focused on the kinematic analysis of different jumping techniques when spiking. It contrasted kinematic differences between the hop jump and two step-close jumps (25cm-35cm and 45cm-55cm stride distance).

METHODS: Twelve elite male volleyball players volunteered for this study. A single high speed camera capturing at 120Hz (Mega Speed) was used for 2-D capture and analysis of the sagittal-dimensional parameter of each subject. Each subject jumped five times in the three different types of jumps (Type A: hop jump, Type B: step-close jump with a 25cm-35cm stride, and Type C: step-close jump with a 45cm-55cm stride). All variables measured are shown in Tables 1-5.
The differences between the hop jump and the step-close jumps were tested with a repeated measures one-way ANOVA. Parameters that were captured for the experiment were analyzed using SPSS V13.0 for Windows. The level of significance was set at $p \leq 0.05$.

RESULTS: When comparisons of take-off time were made, jump type A displayed significantly short times compared to both jump type B and C (Table 1). Horizontal movement of the body mass center when squatting was significantly larger in jump type C compared to both jumps type B and C (Table 2). Horizontal movement of the body mass center when striding was significantly larger in jump type C compared to both jump type A and B (Table 2).

Vertical movements when striding and in the air of jump type A were significantly larger than jumps type B and C (Table 2). Joint angle changes during landing were significantly larger in the left and right ankle, right knee and left hip during jump type B and C compared to type A while those of jump type C were significantly larger than type B. Joint angle changes in left knee during jump type A were significant larger than type B and C while those of jump type B were significant larger than type C (Table 3). When body mass center was at the lowest position, joint angles of the left ankle, left knee and left hip were significantly larger during jumps type B and C compared to type A (Table 4). During take-off, the left ankle, left knee, and left hip angles displayed during jump type B and C were significantly larger than type A (Table 5).

Table 1: Comparison mean (±SD) and posterior comparisons of take-off time.

Take-off time	type A	type B	type C	posterior comparisons
Total movement time(sec)	0.32(0.03)	0.37(0.04)	0.39(0.03)	B > A, C > A
Squat movement time(sec)	0.14(0.02)	0.19(0.02)	0.20(0.03)	B > A, C > A

Table 2: Comparison mean (±SD) and posterior comparisons of Movement of body mass center in each period.

Body mass center (m)	type A	type B	type C	posterior comparisons
Horizontal movement when squatting	0.30(0.01)	0.47(0.03)	0.54(0.01)	B > A, C > A, C > B
Horizontal movement when striding	0.21(0.01)	0.20(0.03)	0.24(0.02)	A > B, C > A, C > B
Vertical movement when striding	0.50(0.01)	0.46(0.02)	0.46(0.02)	A > B, A > C
Horizontal movement when in the air	0.16(0.02)	0.17(0.02)	0.22(0.03)	B > A,C > A,C > B
Vertical movement when in the air	0.57(0.03)	0.55(0.02)	0.55(0.02)	A > B,A > C
Horizontal velocity(m/sec)	0.31(0.03)	0.33(0.03)	0.46(0.03)	C > A,C > B

Table 3: Comparison mean (±SD) and posterior comparisons of Each joint angles of lower limbs when landing.

Joint angles (deg)	type A	type B	type C	posterior comparisons
Left Ankle	101.37(0.94)	107.93(1.24)	111.67(1.44)	B > A,C > A,C > B
Right Ankle	110.58(1.68)	118.91(1.50)	123.60(1.17)	B > A,C > A,C > B
Left Knee	140.88(1.42)	93.13(0.80)	85.94(1.03)	A > B,A > C,B > C
Right Knee Joint(deg)	149.33(1.22)	158.41(1.33)	159.38(1.43)	B > A,C > A,C > B
Left Hip Joint(deg)	107.60(1.38)	121.28(1.17)	128.21(1.10)	B > A,C > A,C > B
Right Hip Joint(deg)	112.36(1.16)	123.07(2.43)	123.32(1.06)	B > A,C > A

Table 4: Comparison mean(±SD) and posterior comparisons of Each joint angles of lower limbs when body mass center is at the lowest position.

Joint angles (deg)	type A	type B	type C	posterior comparisons
Left Ankle Left Knee	114.71(1.14)	134.61(1.15)	143.78(1.28)	B > A,C > A,C > B
Right Knee	110.62(1.69)	140.83(1.40)	151.83(1.40)	B > A,C > A,C > B
Left Hip	99.51(1.51)	100.79(1.50)	98.81(1.40)	A > C,B > A,B > C
Right Hip	106.99(1.13)	113.72(1.42)	116.00(1.28)	B > A,C > A,C > B
	106.81(0.94)	108.03(1.24)	109.16(1.25)	B > A,C > A,C > B

Table 5: Comparison mean(±SD) and posterior comparisons of Each joint angles of lower limbs when take-off.

Joint angles (deg)	type A	type B	type C	posterior comparisons
Left Ankle	150.19(1.40)	160.20(1.40)	159.69(1.82)	B > A,C > A,B > C
Left Knee	169.78(1.59)	180.75(2.01)	179.65(2.39)	B > A,C > A,B > C
Left Hip	169.98(1.48)	175.43(1.93)	171.72(2.45)	B > A,C > A,B > C
Right Hip	174.11(1.66)	174.98(1.48)	178.73(2.42)	C > A,C > B

DISCUSSION: In this study, the hop jump (type A) was performed significantly faster than both the step-close jumps (type B and C). This result replicates those found in previous studies (Coutts, 1982; Huang, 2001; Chang et al., 2009; Huang, 2009). Typically, step-close jumps start from the moment when both feet contact the ground simultaneously while the hop jump begins from when both feet contacting the ground separately.

The long stride step-close jump (type C) generally exhibited the largest horizontal and smallest vertical movement as well as the largest horizontal velocity of the body mass center. These findings are similar to those reported in previous studies, (Huang, 2001); Chang et al., 2009; Huang, 2009). According to characteristics of movement, the step-cross jump starts from the moment both feet contact the ground parallel and simultaneously, therefore, no horizontal movement is established during squatting. However, hop jump will produce a stride when squatting due to both feet contact the ground separately. This stride may help to create larger horizontal movement when squatting detracting from the vertical jump. This difference shows the step-close jump can result in a higher vertical height when in the air.
Generally, the hop jump displayed the smallest ankle and hip angles while the large stride step-close jump displayed the largest. Similar angle kinematics were shown by Huang (2001) and Dapena, McDonald & Cappaert (1990). Step-close jumps start from the moment both feet contact the ground simultaneously while hop jumps begin as both feet contacting the ground separately. When the first contacting foot lands, its main function is to support the body that is still moving. Thus, this is the reason why the step-close jumps showed bigger joint angle changes than the hop jump. When the subject's body mass center was at the lowest position, the hop jump displayed the smallest angles in the left ankle as well as both left and right hips. This finding can be explained by the step-close jumps establishing longer distance between both feet and longer movement time, therefore, larger joint angles changes of lower limbs when body mess center is at the lowest position (Huang, 2001; Hu, 2003; Huang, 2009).
During take-off, the hop jump displayed the smallest angles in left ankle, left knee and both left and right hips. These differences can be explained by the wider stance and longer movement time adopted during the step-close jumps compared to the hop jump (Hu, 2003).

CONCLUSION: The study shows that in volleyball spiking, the hop jump can be completed in a shorter time compared to the step-close jump. Further, squatting, striding, and horizontal displacement of hop jump is smaller than that of the two step-close jumps studied. When comparisons of vertical displacement were made, the performance of hop jump was worse than both the step-close jumps. This can be attributed to the lower limb joint angles in the three phases of the jump (landing, body mass center is at the lowest position and take-off) which were significant smaller angles than those displayed during step-close jumps. Additionally, for horizontal jump performance, the step-cross jumps were significantly better than hop jump, and this can be seen through the longer horizontal distance gained during these jumps.

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