

**THE APPLICATION OF RANGE OF MOTION (ROM) AND COORDINATION ON
VOLLEYBALL SPIKE**

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The purpose of this study was to investigate the suitable timing and coordination of body segments during volleyball spike, and find the critical concepts applied on spiking-learning in the air. Cinematography (250 frame/sec, sagittal plane) was used in this study, and Kwon 3D software was used to analyze the timing and coordination of arm swing motion in the air among top and second level female volleyball athletes. The results of this study as following:

1. Enough range of motion (ROM) before ball hitting is the main factor of spiking technique;
2. Proper time-distribution of back-swing, turn-swing and forward-swing cause the proper time of ball hitting.

The conclusion of spiking technique was described as following hint concepts:

1. “lead”: leading back swing at the beginning of takeoff,
2. “pull”: back swing by pull of elbow and wrist, simultaneously,
3. “turn”: make a enough ROM of swing phase,
4. “up”: during up,
5. “hit»: hitting ball by arm and body momentum.

KEY WORDS: spike, range of motion, angular momentum

INTRODUCTION

Volleyball spike is one of the few striking techniques performed in the air, which without ground reaction force. According to the general height (0.5~0.8 m) of the jumping ability by spiker, and kinematic formula $h = (1/2)gt^2$, the duration of spiking performance in the air could be estimated as 0.6~0.8 second. Technically, the spiker should finish the spiking performance within half of the duration (0.3~0.4 second) in the air, if the aim of hitting ball at highest was demanded. And the spiking technique, since the body off the ground, could be divided into the following phases:

- back-swing,
- turn-swing,
- and forward-swing

(Shown as figure 1), and these phases should be performed within about half second. Therefore, spiking technique is one of the complicated skills in sports. Hitting powerful is the basic characteristic for elite spiker, so the range of motion of the arm swing (shown as Figure 2) is relative to the power of spike. Besides, based on the 3rd Newton's laws of motion “action and reaction force”, and the conservation of angular momentum, the angular momentum of all the segments take action in the air were conserved. The spiking, it's impossible to be performed by only the main action of swing arm, but exiting the reactions of other segments (shown as Figure 2), simultaneously. Previous studied (Liu, 1998; Chang, 2001; Hu, 2003; Cheng, 2003) only indicated the importance of swing motion of spike, and ignored the suitable timing and coordination of segments during volleyball spike. Therefore, the purpose of this study was to investigate the suitable timing and coordination of segment applied on spiking.

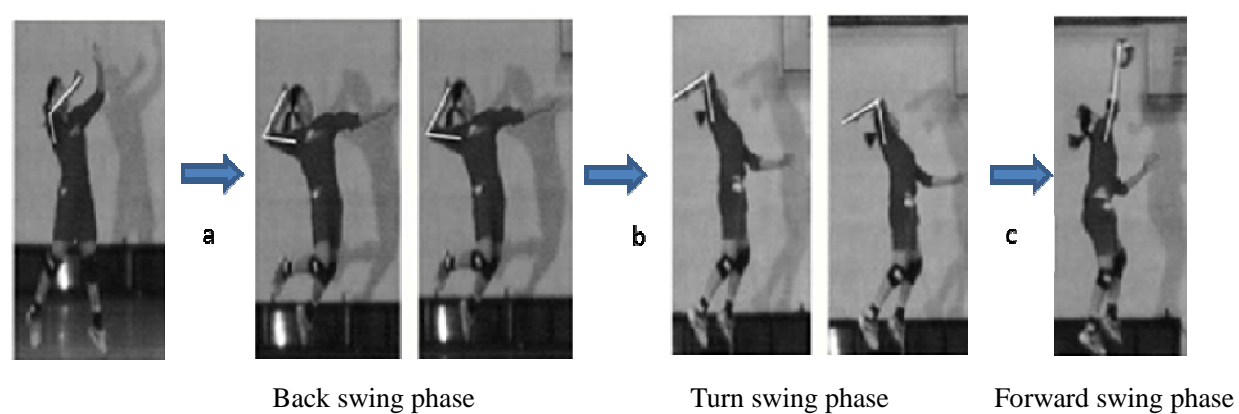


Figure 1: Segment motion of arm swing: (a) back swing phase, (b) turn swing phase, (c) forward swing phase

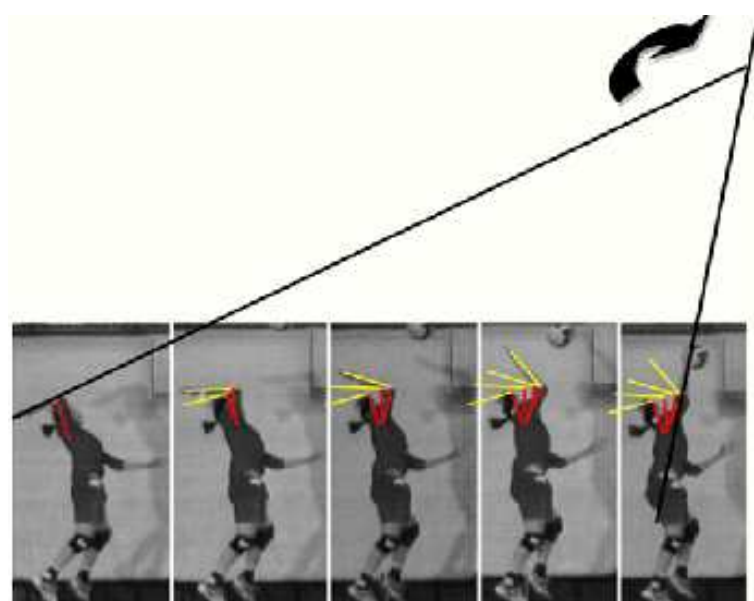


Figure 2: The definition of range of motion on volleyball spike

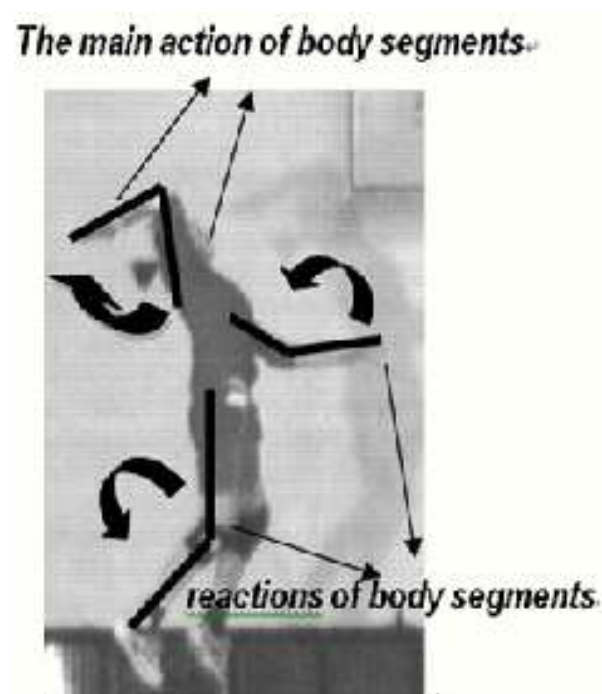


Figure 3: The main action and reactions of body segments during hitting ball on volleyball spike

METHOD:

The dynamics of hitting ball, hitting powerful and accuracy is the overall purpose of striking sports, and there are two tactics to approach the power or momentum:

- push-like motion - action only during contact the ball;
- impact-like (or collision) motion - produces momentum before contact the ball.

The main concepts of dynamics on both tactics were similar, but the performances to be approached were different. Theoretically, the impact-like motion take the most part of the action, since the duration of ball-contact was short as about 0.008 second. So the enough range of motion to generate the momentum is necessary. Especially in kinetic chain, acceleration and deceleration from proximal to distal segments sequentially, enough range of motion was the basic aspect to finish the movement.

Hitting high and power is the overall techniques of volleyball spiking. But losing the ground reaction force since jumping off the ground, the main action motion of swing arm should be generated and balanced by the other reaction segments (ex: the alternative arm and legs). It can be explained by the principle of conservation of angular momentum.

One Redlake high speed video cameras (250 frame/s, sagittle plane) was used in this study, and Kwon3D software was used to analyze the timing and coordination of arm swing motion in the air for top and second level female volleyball athletes. Their mean age, height, weight, and training experience are provided in Table 1.

Table 1: Participant’s information

Subjects	Age (yrs.)	Height (cm)	Weight (kg)	Training experience (yrs.)
Top level female athletes	20,3	172.5±4.1	64.7±4	11
Second level female athletes	20,3	162.8±3	54±6	2.2

RESULTS AND DISCUSSION:

Analysis of range of motion of swing arm: Figures 4 and 5 show the motion of forearm of different level athletes. The range of motion of second level athletes was significantly smaller than top level female athletes, meaning that the elite players have larger range of motion to accelerate the swing segment and produce more momentum for hitting ball.

Timing of swing arm of spike in air: The best range of motion and coordination of motion of spike that all needed to completed in large time. So the elite players performed the three phases, back-swing, turn-swing, and forward-swing, as soon as possible instead of starting the swing while jump at highest. The common mistake, for beginners, is hitting the ball while the body is going down. The reasons probably were the timing of execute the back-swing and forward swing too late.

Reaction of the alternative segments of body: It is about how larger the power the swing segment could generate. The considerations could be divided into two parts of body segment: upper segments and lower segments (elbow joint of spike and right knee joint, respectively). The results of top level female athletes showed two curves of the same trend, meaning that the actions of right elbow joint and right knee joint were the coordination of reactions. The characteristics were not similar in the second level athletes (Figures 6 & 7). Upper joints (right elbow joint and left elbow joint of spike): One curve was high and another was low, meaning forward swing of right arm and inward concentration and stretching of left arm (Figure 8). The

result also indicated second level athletes' lack of balance of the arms (Figure 9). Therefore, the motion of hitting powerful and high were difficult to learn in short time of volleyball spike. It is difficult to generate power to hit the ball in the air for beginners, even the stronger athletes (not volleyball event). The reasons could be explained that the coordination of alternative segments was not well-trained.

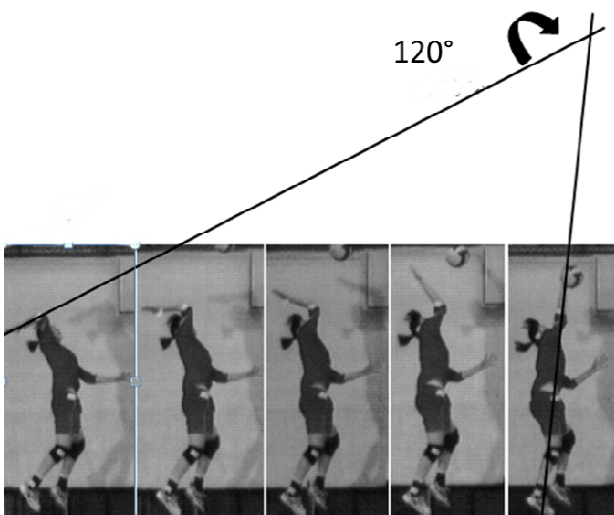


Figure 4. Range of motion of top level athletes

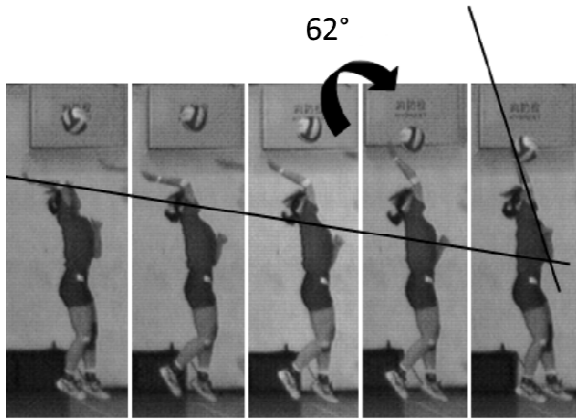


Figure 5. Range of motion of second level athletes

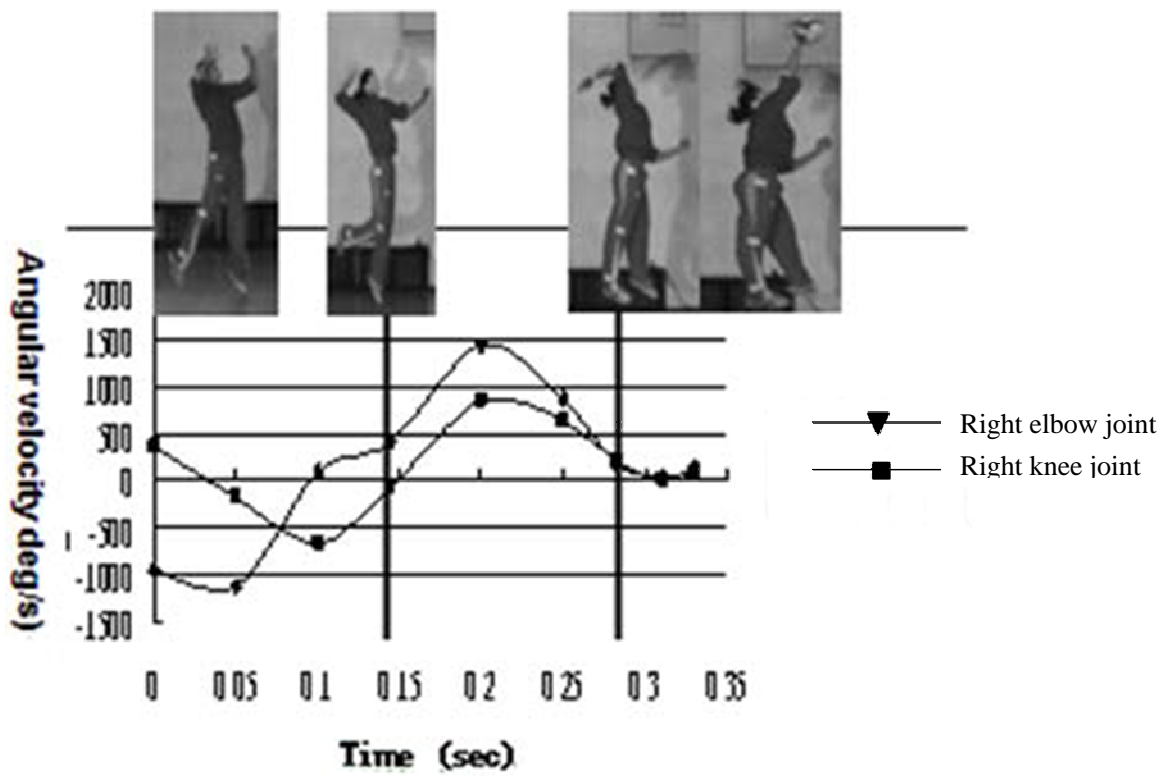


Figure 6. Curves of right elbow joint and right knee joint of top level athletes

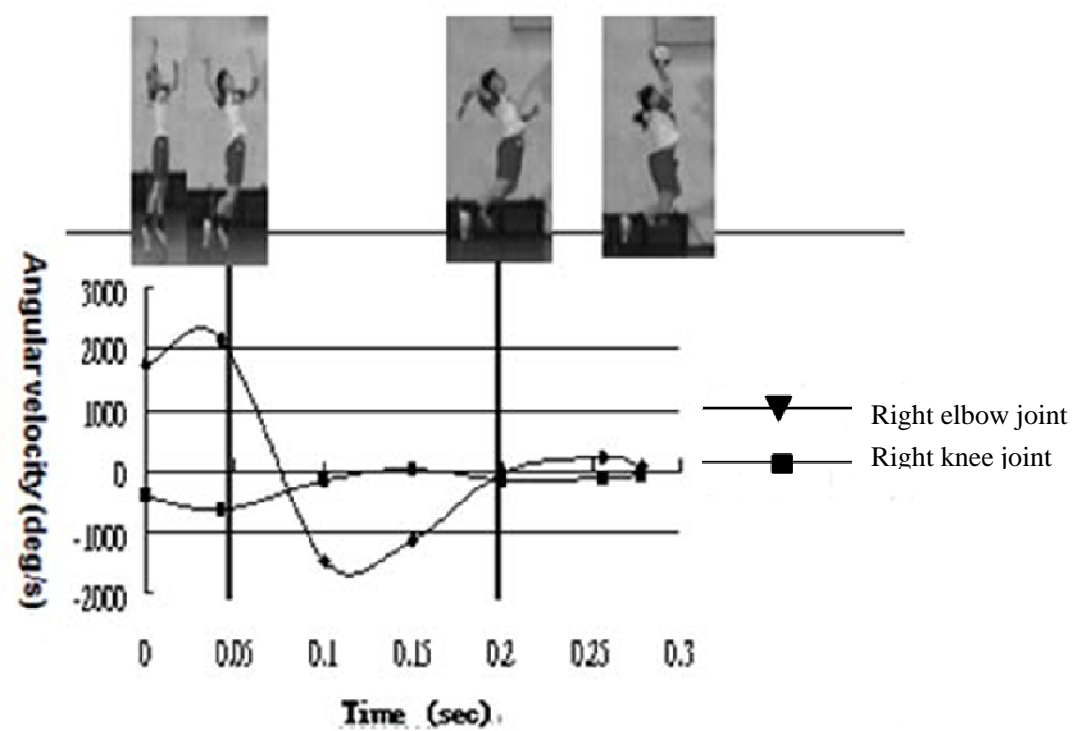


Figure 7. Curves of right elbow joint and right knee joint of second level athletes

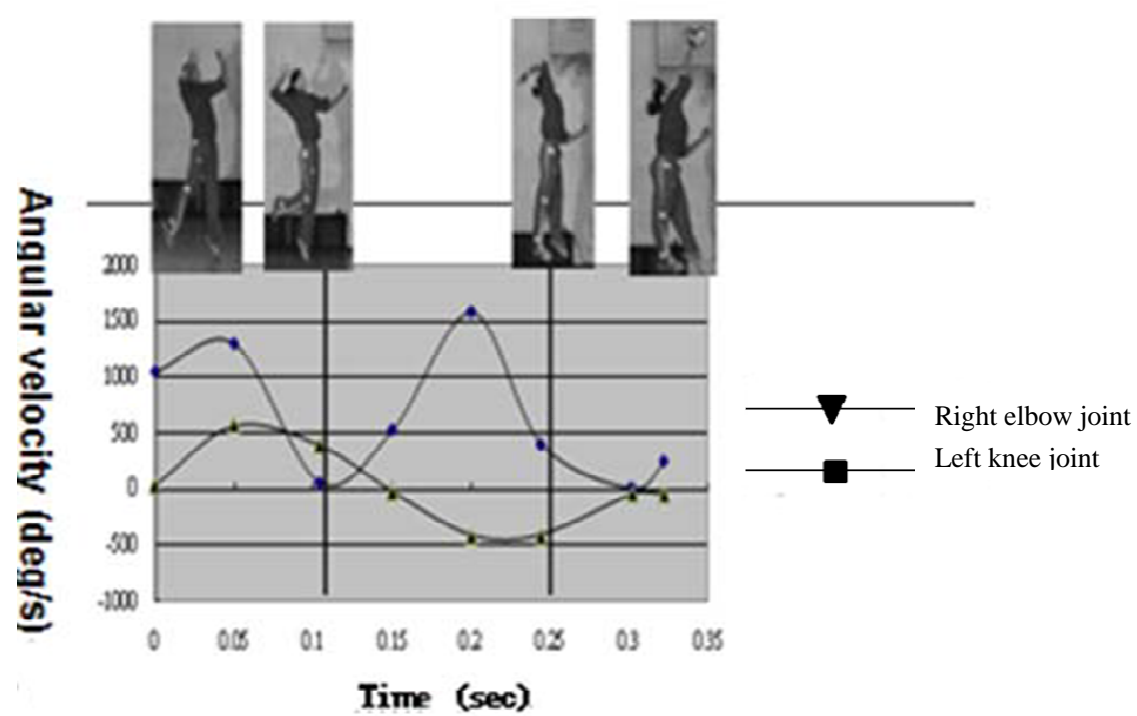


Figure 8. Curves of right elbow joint and left knee joint of top level athletes

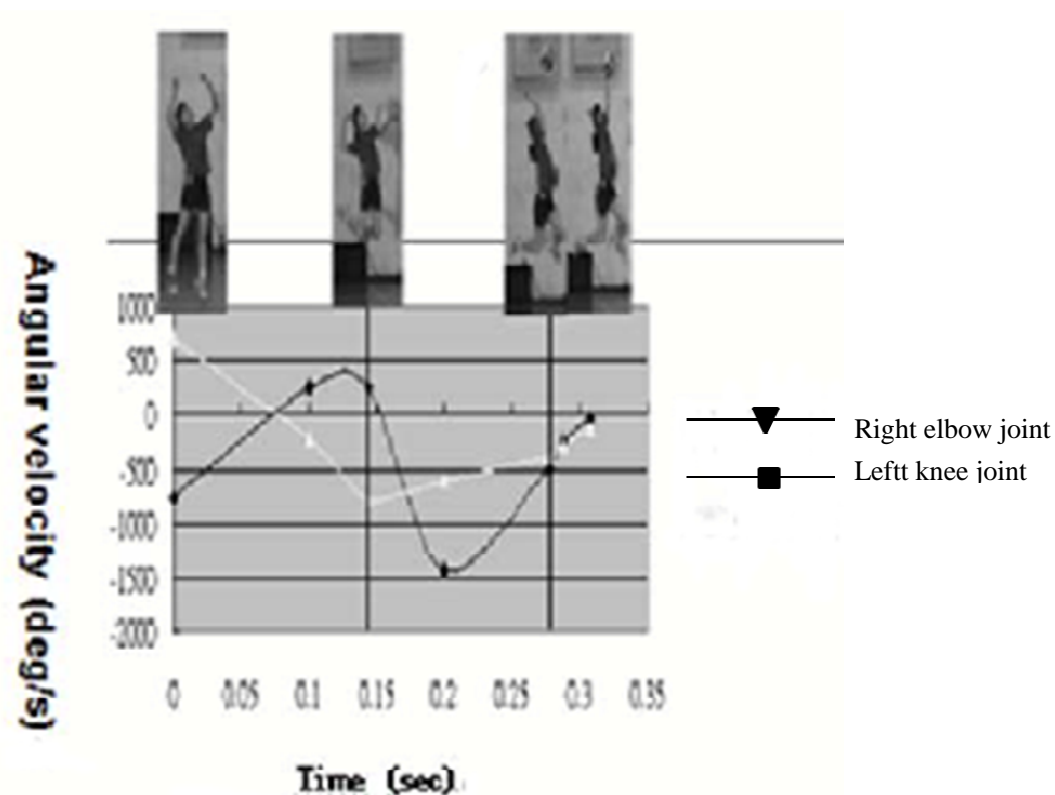


Figure 9. Curves of right elbow joint and left knee joint of second level athletes

CONCLUSION

The results of this study concluded as following:

- Enough range of motion (ROM) before ball hitting is the main factor of spiking technique.
- Proper time-distribution of back-swing, turn-swing and forward-swing cause the proper time of ball hitting.

The conclusion of spiking technique was described as following hint concepts: 1."lead": leading back swing at the beginning of takeoff, 2."pull": back swing by pull of elbow and wrist, simultaneously. 3."turn": make an enough ROM of swing phase. 4."up": during up, 5."hit": hitting ball by momentum.

Besides, in the whole spiking phase, depended on conservation of angular momentum, both arms, hitting arm and leg, execute the anti-direction actions of coordination, simultaneously. Including "forward leading and backward cock", "down press and kick", "inward concentration and stretching", are the key phase of coordination of non-hitting arm and legs.

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