

A KINEMATICAL ANALYSIS OF THE TAEKWONDO APCHAGI

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The purpose of this study was to investigate the kinematical characteristics of Apchagi in Taekwondo kicking motion using the techniques of three dimensional cinematographic techniques. Four college athletes were selected as subjects. After analyzing Apchgi motion, it is concluded the followings. In performing Apchagi, the average time was 0.61 ± 0.02 seconds and the center of body moved right-left (X-axis) 3.7 ± 0.8 cm, forward-back (Y-axis) 46.1 ± 4.5 cm, up-down (Z-axis) 14.4 ± 2.4 cm. Y-axis movement showed the biggest scale among these three direction variances because it need to move the body forward to kick the target. In preparing the motion, pelvic angle showed $150.9 \pm 1.05^\circ$ and in kicking motion $118.5 \pm 1.28^\circ$. Knee's angle was $71.0 \pm 1.33^\circ$ in flexion motion. On the other hand, Ankle angle was $113.2 \pm 1.73^\circ$ for preparing the motion and $136.1 \pm 4.16^\circ$ for taking off motion. For flexion phase it increased up to $162.1 \pm 5.85^\circ$ and decreased to $150.9 \pm 3.50^\circ$ in kicking motion.

KEY WORDS: Kinematic, Taekwondo, Apchagi, kicking motion

INTRODUCTION: Fight including Taekwondo is originated as a method of self-defense which is human basic instinct. Nowadays, it has been developed to a part of sports, according to its social and cultural circumstances. Korea is the source nation of Taekwondo and takes it as a national sports. Taekwondo is known to worldwide and it became a 2000 in Sydney Olympic game. Up to now, Korea is the best in the international competition of Taekwondo but they did not make an effort not only to develop its theoretical techniques and but to establish its system. In Taekwondo, it is played using hands and foots. Especially, kicking technique is better than the technique by hands in obtaining winning points. Apchagi is the one of the most popular technique because it gives more speedy and power motion than any other kickings during Taekwondo competitions.

Therefore, the purpose of this study was to investigate the kinematical characteristics of Apchgi motion and to give the basic information for the better coaching.

METHODS: The subjects were four college athletes with more than 10 years experiences. Two S-VHS video cameras were used for the data collection. The cameras were located at the front-left and front-right side with 80 degrees and 1.2 m high. Also rectangular shape control object containing 36 control points of known coordinates, which encompassed the space of Apchagi movement, was set up and filmed to permit calibration of the field of Apchagi movement. After filming the control point, it was removed and Apchagi motion of each subject was filmed. The DLT techniques was employed to obtain 3-D position coordinates of 21 joints landmarks and a cubic spline function was used for smoothing and differentiation. It also calculated the center of mass using Plagenhoef's data.

In This study, the Apchagi motion was divided into 4 events (RED:ready posture, TO:kicking foots leaving point, MFL:knee of kicking foot's maximum bent point, IMP:kicking the target point) for the data analysis. From those, timing of performing motion, movement of center of body, the angle of leg joint were calculated.

RESULT AND DISCUSSION:

Table 1 Performance Timing (unit:sec).

Subject	TO	MFL	IMP
M	0.44	0.54	0.61
SD	0.02	0.02	0.02

Timing of performing motion: Timing of performing motion is the timing of interval between the signal of stimulus and completion of performance, which is the sum of reaction and performance timing.

The average of four athletes' timing of performance is 0.61 ± 0.02 seconds. Compared with other chagi studies, Dolgae-chagi record, 0.80 ± 0.07 seconds and Apdolryo-chagi record 0.62 ± 0.22 seconds, Back-chagi record 0.67 ± 0.1 seconds, Chiggi record 0.78 ± 0.07 seconds, Back-huro-chagi record 0.71 ± 0.05 seconds, the record studied in this paper shows faster than any other records. Because Apchagi motion does not need a twisted upper body, the attack by Apchagi motion can be completed in a moment.

If we assume the all Apchagi performance time 100%, then preliminary phase is 72% (0.44 seconds) and flexion-phase is 11% (0.07 seconds) and extension phase is 11% (0.07 seconds). On the other hand, in Sung's paper (1986), on the basic chagi motion, he reported that preliminary phase took 63% and in Kim's paper (1991) 'Huryo-chagi motion preliminary phase took 68%. Recently, Kang's paper (1988), preliminary phase took 71%. Comparing with these studies, we get the result that preliminary phase rate is higher than before. This means that time rates of flexion-phase and extension phase are reduced because of better skills. However, in order to reduce the total performance time, it needs training of reducing reaction time of preliminary phase.

Table 2 Variance of the Center of Body (unit:cm).

Subject	Left-Right(X)				Before-Behind(Y)				Verticality(Z)			
	RED	TO	MFL	IMP	RED	TO	MFL	IMP	RED	TO	MFL	IMP
M	19.3	17.9	16.9	15.6	-17.4	5.8	27.8	28.7	87.9	89.9	101.1	102.3
SD	0.54	0.72	0.77	0.80	2.41	1.15	3.74	4.50	1.50	2.15	3.04	2.49

Movement of center of body: As the position of the center of body should be adjusted appropriately, the ability of performance can be approved during the action of Apchagi. Left-right variance X-axis is from RED to IMP and the variance of the center of body shows almost no difference as right to left, about 3.7 ± 0.8 cm, which means in chagi motion the center of body moves forward, i.e. from backward to forward that is kicking direction. And the center of body moves about 46.1 ± 4.5 cm forward to kicking direction (Y-axis). This record is similar to Dolryo-chagi's 43 cm investigated by Kang's paper (1998). This difference is determined by the length of the player's leg. According to the height level of the center of body, i.e. so called, variance of Z-axis factor, from preliminary phase to impact the variance of movement is an average of 14.4 ± 2.4 cm. For all subjects, there is no movement from preliminary phase to the phase of leaving the ground but after taking off the Z-axis factor is increasing up. When reached the highest point, it impacts the target.

Table 3 Angle of Leg Joint (unit: degree).

Subject	Pelvic joint angle				Knee joint angle				Ankle joint angle			
	RED	TO	MFL	IMP	RED	TO	MFL	IMP	RED	TO	MFL	IMP
M	150.9	141.0	130.9	118.5	170.2	141.8	71.0	131.2	113.2	136.1	162.1	150.3
SD	1.05	0.72	0.96	1.28	0.76	1.90	1.33	2.25	1.73	4.16	5.87	3.50

The angle of leg joint: In Apchagi motion, the variance of pelvic joint, leg joint, ankle joint of kicking leg is evaluated according to the events. Pelvic angle is the angle between the body and pelvic. The average pelvic angle of subjects is $150.9 \pm 1.05^\circ$ at RED, $141.0 \pm 1.03^\circ$ at TO, $130.9 \pm 0.96^\circ$ at MFL and $118.5 \pm 1.28^\circ$ at IMP. This shows that pelvic angle is gradually decreasing and shaping as a bent form. The reason is that moving the center of body forward and turning pelvic upward quickly is a little better than making the pelvic angle big.

The angle of knee, the angle between pelvic and leg, is around $170.2 \pm 0.76^\circ$ at RED, $141 \pm 1.90^\circ$ at TO $71.0 \pm 1.33^\circ$ at MFL and $131.2 \pm 2.25^\circ$ at IMP. This variance of angle means that it needs extension of knee joint and curved form in order to kick the target powerfully. In Koo's paper (1998) studied on Apchagi for man's national athletes, the angle of knee joint is

reported as 142.1° at RED, 135.7° at TO, 73.0° at MFL, 118.5° at IMP. According to Koo's paper, the angle of knee joint at preliminary phase is smaller than the results I got in this study but it is bigger at the curved phase.

The ankle angle which is the angle between leg and the ankle, is $113.2 \pm 1.73^\circ$ at RED, $136^\circ \pm 4.16$ at TO, $162.1 \pm 5.87^\circ$ at MFL, $150.3 \pm 3.50^\circ$ at IMP. Comparing with Koo's study (1998), 94.9°, 118.8°, 156.7° and 157.7°, the record of the ankle angle in this study is bigger. Further, ankle angle is rapidly increasing at the moment that kicking leg is taking off the ground and reaches the maximum at the curved point. The reason of this is that in order to kick the target subjects make extension the top side of the foot.

CONCLUSION:

1. In Apchagi motion, The mean of four athletes' performance timing is 0.61 ± 0.02 seconds.
2. The average movement of four subjects' center of body is 3.7 ± 0.8 cm for left and right (X-axis), 14.4 ± 2.4 cm for back and forward (Y-axis) and 14.4 ± 2.4 cm for Z-axis. This shows the movement of Y-axis is biggest because it needs to move the body forward to when attack the target.
3. The angle of pelvic joint is decreasing form $150.9 \pm 1.05^\circ$ at RED to $118.5 \pm 1.28^\circ$ at IMP. The angle of knee at the MFL is $71.0 \pm 1.33^\circ$, which is smaller than any other phase. Finally, the angle of ankle is $113.2 \pm 1.73^\circ$ at RED, $136.1 \pm 4.16^\circ$ at TO, $162.1 \pm 5.87^\circ$ at MFL and $150.3 \pm 3.50^\circ$ at IMP. Thus in order to kick efficiently, it needs to reduce the reacting time and making leg joint fast flexion and extension.

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