THE KINEMATIC ANALYSIS OF 500M SPRINT START IN 2005 WORLD SHORT TRACK SPEED SKATING CHAMPIONSHIP

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A field study was performed attempting a kinematic estimation for six female foreign skaters, who participated in the 500m female final round competition. The three dimensional motion analysis with DLT method was executed using four video cameras for analyzing the actual competition situation. The following conclusions are drawn; the elapsed time by phase in start motion of the foreign skaters appeared shorter than those of Korean skaters, so the start training of Korean skaters should be strengthened. Also the displacement of COG in the foreign skaters appeared shorter than those of Korean skaters. The velocity of COG and maximum velocity of skate blade of foreign skaters are faster than those of Korean skaters. And the foreign skaters showed the superior early velocity change.

KEY WORDS: kinematic analysis.

INTRODUCTION: One of the most important aspects of short track speed skating 500m competition is having the ability to enter the first corner with as much speed as possible as it can affect the player's position for the remainder of the race. Too get a good start for the race the maximum energy and power must be created in the shortest feasible time. To attain some scientific data and to understand this, the following study has been carried out. It involved acquiring kinematical data during actual competition conditions, the Olympics, for Korean and foreign short track 500m speed skaters. The outcome of the comparison of the Korean and foreign skaters during the start, will enlighten to us on how the starting technique of the race for Koreans can be improved.

METHOD:

Data Collection: The subjects for this study were the participatants in the Korean short track speed skating 500m competition i.e. four foreigners and two Koreans. The following table summarises their physical characteristics.

Table 1: Physical Characteristics of the subjects

Player	Latest Ranking	Position Entering First Corner	Age (yrs)	Height (cm)	Nationality
S1	1	1	22	166	Chinese
S2	3	2	25	167	Canadian
S3	2	3	20	153	Korean
S4	1	1	23	165	Chinese
S5	2	2	24	167	Canadian
S6	3	3	24	163	Korean

Data Analysis: The subjects´ starting phase was captured using 4 cameras (VX – 2000, Sony) each mounted on tripods and fixed into position. The four cameras were placed at 45˚ angled relative to the starting line capturing anterior and posterior views. The control box used was 6m in length, 2m height and 5m wide and the subjects were captured for five minutes and the data was then manipulated in the succeeding order.

Data Acquisition

1. 3 D analysis of the subject's joints was measured using DLT method.
2. 42 reference points were used for the calibration.
3. The anterior and posterior direction was defined as the y axis, the left and right direction was defined as the x axis and the perpendicular surface was defined as the z axis.
4. The camera's speed was 30 frames per second and so a cubic spline function was applied to interpolate between the 0.02 second intervals.
5. All this data acquisition was done using KWON3D Motion Analysis Package 3.0.

Events and periods

E_1: Initial take off of the left leg after the starting signal
E_2: Landing of the right leg
E_3: Initial take off of the left leg
E_4: Landing of the left leg
E_5: Second take off of the left leg
E_6: Second landing of the left leg
E_7: Second take off of the right leg
E_8: Second landing of the right leg
Phase 1: From E_1 to E_2. (left leg)
Phase 2: From E_3 to E_4. (right leg)
Phase 3: From E_5 to E_6. (left leg)
Phase 4: From E_7 to E_8. (right leg)

RESULTS AND DISCUSSION:

1. Timing of the various phases

The start reaction time and the phase times are summarized in the following table below.

Table 2: Various phases and the times (units: seconds)

Phase Subject	Reaction Time	L1	R1	L2	R2	Total
S1	0.22	0.34	0.42	0.44	0.44	1.86
S2	0.18	0.34	0.42	0.48	0.48	1.90
S3	0.28	0.26	0.44	0.50	0.42	1.86
S4	0.16	0.40	0.46	0.46	0.44	1.92
S5	0.36	0.18	0.50	0.54	0.52	2.06
S6	0.20	0.36	0.52	0.48	0.40	1.98
M±SD	**0.23±0.08**	**0.31±0.08**	**0.46±0.03**	**0.48±0.03**	**0.45±0.04**	**1.93±0.08**

According to table 2 the average reaction time to the starting signal was 0.23 ±0.08s and the fastest subject was S_4 with a reaction time of 0.16s and the slowest S_5 of 0.36s. To be able to produce the highest acceleration, the initial inertia must be broken by reducing the time and creating a passive starting position.

2. Horizontal Speed of the Player.

The following table 3 shows the horizontal speed of the skater's COG.

Table 3: Speed of the Player's COG for the various phases (unit: cm/s)

Event Subject	E1	E2	E3	E4	E5	E6	E7	E8
S1	108	502.1	197.3	523.7	246.3	647.0	335.6	516.1
S2	98.3	186.6	282.6	287.1	423.9	499.8	372.9	463.3
S3	117.6	269.9	192.2	317.5	415.7	505.5	351.9	460.9
S4	124.7	219.6	282.5	387.3	316.1	329.0	428.7	555.0
S5	98.4	410.3	240.4	328.4	402.4	439.7	327.7	538.9
S6	141.8	324.4	127.5	246.4	232.6	420.7	533.1	401.0
M±SD	**117±16.9**	**338±119.7**	**220±60.2**	**348±97.7**	**339±86.7**	**473±106.4**	**391±78.1**	**489±57.9**

From all the variables over the designated distance the horizontal speed of the player is the by far most important factor in deciding the outcome of the race. The main objective for increasing performance is to be able to reduce the overall time for the race. From observing the Chinese player the maximum speeds of their COG for E_1 was 116.3cm/s, E_3 was

239.3cm/s and E_8 was 535.5cm/s. Whereas the Korean players´ times were the following for E_1, E_3 and E_8 : 129.7cm/s, 159.8cm/s and 430.9cm/s. The Chinese player's E_1 phase initial take off was slow but the movement through the other phases rapidly increased.

3. Perpendicular and horizontal COG displacements over the various phases

The COG horizontal, perpendicular variables are shown in table 4 and 5.

Table 4: Horizontal displacement of the player's COG (units: cm)

Phase Subject	L1	R1	L2	R2
S1	70.6	151.4	175.7	214.4
S2	66.5	146.7	187.0	240.8
S3	54.0	141.1	188.3	200.4
S4	88.3	140.9	200.8	218.2
S5	38.7	176.5	208.1	245.8
S6	75.2	168.6	175.6	183.4
M±SD	**65.6h±17.3**	**154.2±33.3**	**189.3±13.2**	**217.2±23.7**

According to table 4 the average displacement for the Chinese player's COG L_1 is 79.5cm, R_1 is146.1cm, L_2 is 188.2cm and R_2 is 216.3cm. Whereas for the Korean player's COG L_1 is 64.6cm, R_1 is 154.8cm, L_2 is 181.9cm and R_2 is 191.9cm. By observing the data it is known that as the time progressed, the Chinese player's motion became larger and larger.

Table 5: Vertical height of the player's COG (units: %)

Phases Subject	Start position	L1	R1	L2	R2
S1	45	46	48	51	52
S2	47	49	50	51	50
S3	50	51	52	53	53
S4	46	46	50	50	53
S5	47	46	47	49	50
S6	48	50	52	55	55
MEAN±SD	**47±1.7**	**48±2.6**	**49.8±2.3**	**51.5±3**	**52.1±3.3**

The average height for the player's COG at the start is 47±1.7%, for the Korean player's S_3 and S_6 the average value is 49% whereas the Chinese player's is 45.5%. According to Korean researcher Jinho Baek, the vertical height of the player's COG for Korea's elite was 49.5% and the lower it was the more effective the player was (2002). The reason for the low COG is that the lower the COG the more propulsion that can be created. To be able to push the leg out effectively a low starting position and a high finishing position is desired. So as to achieve this ability the legs must be strength trained.

4. Stroke Rate

The stroke rate is defined as the number of strokes per second. The result of four strokes is presented in table 6. The average stroke rate is 2.68±6.2, and the average stroke rate in Jinho Baek's (1999) research paper revealed a stroke rate of 2.91±0.14 which verifies the validity of our results. Also, in Baek's 1997 research on the male and female national players revealed that a shorter starting time was created by a higher stroke rate and a longer stroke.

Table 6: Stroke rate (units: strokes/sec)

Subject	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**M±SD**
Strokes	2.82	2.59	2.72	2.78	2.51	2.69	2.68±6.2

The average stroke rate for the Chinese was 2.80 strokes/sec in comparison to the Korean players 2.70 strokes/sec was faster. As we already know, strengthening the ankle joint will shorten the start time. The reason for this is because by increasing the stroke length the

stroke rate will increase. The stroke length is limited by the anatomical joints and ROM, therefore it is necessary for the player to increase their stroke rate to improve performance. During the initial departure and the subsequent movements it is necessary for the player to be in a stable position so as to be able to smoothly progress through from one stroke to another. This seamless connection between strokes can be improved through training.

CONCLUSION: Research was carried out during the 2005 World Short Track Speed Skating Championship which had foreign and Korean, four and two players respectively participating. The following was concluded.

1. The average time to R_2 is 1.93±0.08s, for S_1 a Chinese player 1.85s and S_6 a Korean player 1.98s. This shows that the time for the Korean player is longer than for the Chinese player and so displays the ability of the player to adjust swiftly from a starting position to motion.
2. There was a large difference for the Korean and Chinese player's COG displacement, especially at the start of the race. The Chinese players pushed their COG more forward during the first motion than the Korean players and so this meant that they were able to accelerate quicker.
3. The average stroke rate was 2.68±7.1, but for S_1 (Chinese) 2.82 and S_6 (Korean) 2.69 and so for the Korean player to improve their stroke rate they need to increase their explosive power.
4. The Chinese player's COG speed was initially slow at E_1 but rapidly increased through the subsequent movements and thus did their acceleration during the start.

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