KINEMATIC CHARACTERISTICS OF LOWER EXTREMITY DURING 50M BREATHHOLD OF FIN SWIMMING

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The purpose of this study was to determine the kinematic Characteristic of the lower extremity as well as the mono-fin during short distance fin swimming in Chinese fin swimmers. Eight Chinese fin swimmers were asked to perform 50m while holding the breath at maximum effort for three trials. One cycle of fin swimming motion at mid-way was videotaped. Two-dimensional analysis methods were employed to analyse the movement of fin swimrning. The vertical velocity and vertical acceleration of the fin tail, average velocity of total body centre of mass (COM), angular velocity of the thigh, and angular velocity of the shank were calculated and normalised for one cycle of fin swimming. Results showed that the peak value of horizontal velocity of the total body COM occurred when the fin tail reached its maximum downward velocity.

KEY WORDS: fin swimming, lower extremity, kinematics

INTRODUCTION: During fin swimming, the upper trunk is fixed with the arms fully stretched forward and the propulsion force is generated by the lower extremity and mono-fin. Therefore, the movement of the lower extremity has significant influence on the fin swimming performance. From the English literature, little is known about the kinematic characteristics of the lower extremity during fin swimming. Li (1989, 1990) completed a biomechanical analysis of fin swimming in the Chinese elite fin swimmers. Olbrecht, Ungerechts, Robben, Mader, & Hollmann (1990) studied the isokinetic characteristics of the lower extremity in fin swimmers. However, the kinematic profile of the lower extremity during fin swimming was lacking. To enhance the effect of training and swimming performance, a kinematic profile is useful for both coaches and athletes.
The purpose of this study was to determine the kinematic characteristics of the lower extremity and mono-fin during short distance fin swimming in Chinese fin swimmers.

METHOD: Eight Chinese fin swimmers including four males and four females participated in this study. Age, body weight and body height of the participants were 21.12 ± 4.29 years, 61.61 ± 9.8 kg and 163.21 ± 5.13 cm respectively. The training history was 21.37 ± 16.15 months. All the subjects were asked to perform 50 m apnea at maximum speed in a 50 m bng swimming pool for three trials. There was twenty minutes rest time between each trial. A XCD video camera (50Hz, JVC, GY-X2BE, Japan) was placed behind the under-water window with the lens axis being perpendicular to the plane of motion. The distance of the lens to the motion plane was 10.4 m. The fin swimming motion at the section of 22.5m to 27.8m from the start was filmed. The film was then analysed two-dimensionally (BAS, Germany). One cycle of the fin swimming movement was digitised and analysed for each trial. Five floating buoys served as calibration markers for distance measurements. The vertical velocity of the fin tail, vertical acceleration of the fin tail, horizontal velocity of the total body COM, angular velocity of the thigh and angular velocity of the shank were calculated for one cycle of fin swimming. The time consumed in one cycle of fin swimming was norrnalised into ten intervals. The starting point was the minimum vertical position of the fin tail and one cycle of fin swimming was defined as the movement of the fin swimmer between two successive minimum vertical positions of the fin tail. Figure 1 shows the stick figure model of fin swimmer employed for two dimensional (2D) motion analysis with a black dot representing the tail of the mono-fin.

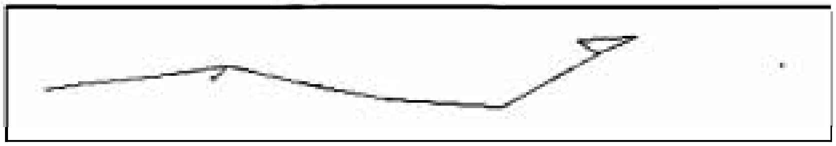

Figure 1 - Fin swimmer model employed for 2D motion analysis.

RESULTS: The numerical data of each kinematic parameter are shown in Table 1. All the parameters were normalised in accordance with each 10[th] percentile time in a complete cycle. The time-history of the vertical velocity of the fin tail, vertical acceleration of the fin tail, average velocity of the total body COM, angular velocity of the thigh and the angular velocity of the shankwithin one cycle of fin swimming are shown in Figure 2. The x-axis is the % time of one cycle of fin swimming from 0 to 100%.

Table 1 Kinematic Parameters (Mean and Standard deviation) within One Cycle of Fin Swimming

% of cycle[a]	VFT	AFT	VCOM	AVT	AVS
10%	0.63 (0.15)	29.18 (5.93)	2.26 (0.25)	-0.50 (1.41)	4.55 (0.75)
20%	1.86 (0.25)	13.12 (4.05)	2.26 (0.23)	-2.60 (1.56)	3.18 (0.99)
30%	2.14 (0.21)	-2.52 (3.26)	2.21 (0.23)	-3.83 (1.02)	1.01 (1.21)
40%	1.66 (0.20)	-13.12 (3.74)	2.14 (0.25)	-3.51 (0.67)	-1.69 (1.63)
50%	0.73 (0.31)	-17.80 (5.07)	2.12 (0.26)	-1.62 (1.48)	-3.98 (1.29)
60%	-0.37 (0.30)	-20.80 (9.33)	2.19 (0.23)	1.05 (1.76)	-4.66 (0.72)
70%	-1.54 (0.41)	-19.58 (7.86)	2.33 (0.22)	3.16 (1.33)	-3.40 (1.11)
80%	-2.40 (0.46)	-6.77 (5.82)	2.40 (0.25)	3.78 (0.72)	-0.64 (1.47)
90%	-2.17 (0.45)	16.98 (7.10)	2.35 (0.26)	2.79 (0.60)	2.41 (1.31)
100%	-0.66 (0.24)	31.98 (6.61)	2.30 (0.20)	0.94 (1.05)	4.23 (1.00)

Note. VFT = vertical velocity of fin tail; AFT = vertical acceleration of fin tail; VCOM = horizontal velocity of total body centre of mass; AVT = angular velocity of thigh; AVS = angular velocity of shank.
[a]Time percentage of one fin swimming cycle.

This study found that the vertical velocity of the fin tail reached its minimum value (-0.37 m/s) when the fin tail reached the minimum vertical position. Then this velocity increased gradually when the fin tail was rising, and reached the maximum value (2.14m/s) at the 30% of fin swimming cycle. Then the fin tail velocity decreased to zero when the fin tail raised to maximum vertical position. When the fin tail moved downward from its maximum vertical position. The velocity of the fin tail increased gradually and reached the maximum velocity (2.40 m/s) at 80% of one cycle of fin swimming.
The vertical acceleration of the fin tail reached the highest values when the fin tail reached its minimum vertical position. These values were 29.18 m/s^2 at the 10% and 31.98 m/s^2 at the 100% of fin swimming cycle. The maximum value of the vertical deceleration of the fin tail was 20.80 m/s^2 at 60% of fin swimming cycle.
The average horizontal velocity of total body COM was ranging from 2.12 m/s to 2.40 m/s within one cycle of fin swimming. The average velocity of total body COM decreased when the vertical position of the fin tail increased from the beginning of the cycle to 50% of the cycle. Then the average velocity of total body COM increased and reached the maximum

values (2.40m/s) at 80% of fin swimming cycle when the fin tail was moving downward from the highest position.

The angular velocity of the thigh ranged from -3.83 radls to 3.78 radls. The absolute value of angular velocity of the thigh increased gradually when the fin tail was rising. Similarly, the angular velocity increased gradually when the fin tail was moving downward. When the fin tail was moving downward, the local maximum angular velocity was 3.78 rad/s at 80% of fin swimming cycle.

The highest value of shank angular velocity (4.55 radls) appeared when fin tail reached the minimum vertical position (10% of fin swimming cycle). The angular velocity of shank became zero between 30 to 40% as well as 80 to 90% of fin swimming cycle.

DISCUSSION: Based on the variations of the total body COM velocity within one cycle of fin swimming, the recovery phase and propulsion phase can be seen. During the time when the fin tail was moving upward, the velocity decreased gradually and when the fin tail was moving downward the velocity increased gradually. The peak COM velocity was found at 80% of fin swimming cycle. When the fin tail moved downward form the maximum vertical position, the velocity of fin tail increased as well as the angular velocity of thigh. When the angular velocity of thigh reached its maximum value, the vertical velocity of fin tail also reached its maximum value as well as the COM velocity. This may explain why the movement of the thigh in tin swimming plays an important role on the overall performance. It is expected that to increase the swimming velocity, the power or force generated by the thigh should be increased in order to produce a large propulsive force.

CONCLUSION: The data of the variation of the horizontal COM velocity within one cycle of fin swimming showed that the peak value of horizontal velocity appeared at about 80% of the fin swimming cycle. At around 80% of fin swimming cycle, the downward velocity of fin tail reached its maximum value, the angular velocity of thigh reached its local maximum value. and the angular velocity of shank approximately equal to zero. Between 40 to 50% of fin swimming cycle, the fin tail reached its maximum vertical position (half cycle of fin swimming). At that moment, the maximum vertical deceleration of the fin tail, the angular velocity of thigh was approximately equal to zero, and the angular velocity of shank reached the maximum value (4.66 radls). The movement of the thigh played an important role on the overall performance of fin swimming.

Since the kinematic profile of tin swimming was lacking in the previous study, the profile from the national fin swimmers will be useful for fin swimming technique improvement and comparison.

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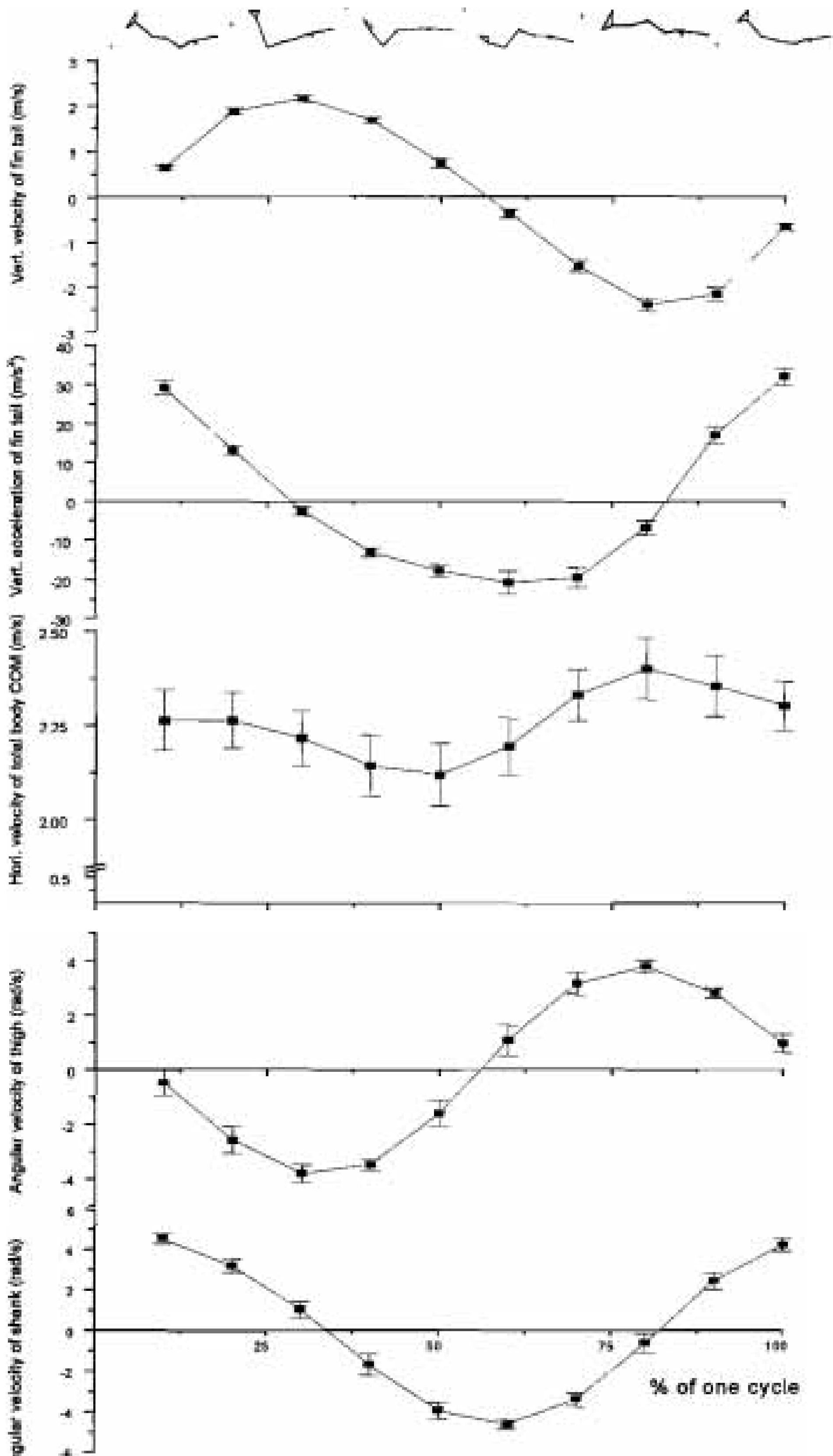

Figure 2 - The figure sbouws the variations of the time normalised kinematic parameters (±SE) within one cycle of fin swimming.