KINEMATICAL ANALYSES OF TWO STYLES IN BREAST STROKES SWIMMING

Hashem Kilani*, Maher Al-Kilani, and Bahaa Duka***

***University of Jordan, Faculty of Physical Education, Amman, Jordan**
****Hashemite University, College of Sport Sciences, Zarqa, Jordan**

In order to determine the best wave style technique for the youth Jordanian breaststrokers and to accurately pin point the differences in the kinematics variables a 3D analysis was conducted. Therefore, the purpose of this study was to investigate some kinematics variables of both styles: the Hip Wave Undulation (HWU) and the Hip Wave Undulation with Feet Breaking Surface (HWUBS), and to compare the variables: Stroke Length SL, Stroke Rate SR, Velocity V, Stroke Time ST, Hip Displacement HD and Feet Displacement FD. Subjects were assigned to swim at their maximum speed with both styles at different order so that the best trial according to their time was analyzed. Both males and females showed an intriguing feature of the CG body velocity curve per cycle and both had decreasing velocity in slow rate when they used (HWUBS). Thus, one may conclude that an exaggerated hip undulation was executed to allow for feet to break the surface of the water which affected their velocity reduction during the stroke cycle.

KEY WORDS: breaststroke, wave dolphin motion, kinematics.

INTRODUCTION:

It is well understood why flat style breaststrokers create more drag forces than wave style breaststrokers and less drag during leg recovery. Velocity measurements of many flat style breaststrokers have shown that their forward speed decelerates markedly when they recover the legs in this manner. In fact, many came to a dead stop during this phase of the stroke cycle (Maglisho, 1999). On the other hand, the wave (dolphin motion) style created by reaching down with the hands, followed sequentially by downward undulation of the head and shoulders and upward undulation of the hip, may create a summation of forces that could provide additional propulsive force during the in-sweep of the breast stroke kick. Researchers in this view have shown that these force summations during the dolphin kick in the butterfly were observed (Sanders et al 1995).There were doubt that the body wave is a propulsive reality in the breaststroke. The reverse body wave while undulating the hip upward as the swimmers kick back may contribute to propulsive force during breaststroke swimming. The rule SW 7.5 allow for the feet to break the surface of the water unless followed by a downward dolphin kick. The members of the Jordanian national team for youth breaststrokers have the opportunity to train on the wave style with hip undulation without having their feet to break the surface of the water(hip wave undulation) and with breaking the surface on another time(hip wave undulation with feet breaking surface) . They were not sure whether they have the right kinematics' patterns on the advantages of their technique nor would that one style affect the forward velocity tracings of their swimming's centers of mass. The purpose of the study was to investigate some kinematics variables of both styles and to compare these variables: the Stroke Length SL, Stroke Rate SR, Velocity V, Stroke Time ST, Hip Displacement HD and Feet Displacement FD.

METHODS:

Four breaststrokers were intentionally chosen to serve in this analysis (2 males and 2 females) from the Jordanian national team for youth swimmers and their demographic descriptive data are shown in table(1).

Table 1 - Mean and standard deviation of mass, height and age of the subjects

Gender	variables	mean	SD
	Mass(kg)	65.95	0.06
Male	Height(cm)	167.95	0.10
	Age(year)	17.75	0.03
	Mass(kg)	58.85	0.07
Female	Height(cm)	164.65	0.09
	Age(year)	16.85	0.04

They were filmed using 4 Sony digital cameras when they executed three trials of each wave style: HWU and the HWUBS. Subjects have had at least six month of training periods on the two styles. Figure (1) illustrates the positioning of the cameras according to the swimming trials which were set at 50 Hz per second.

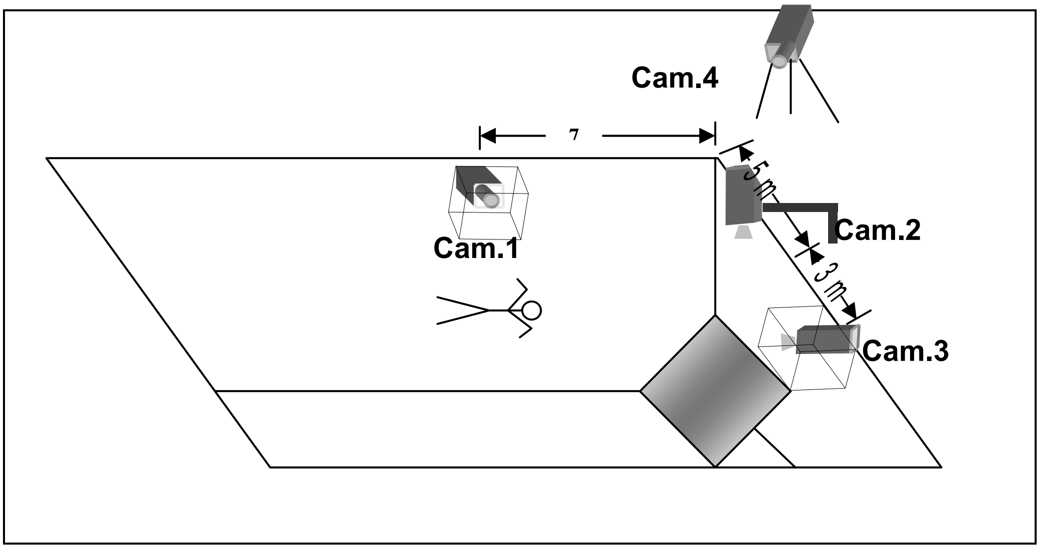

Figure 1 - Schematic illustration showing data capturing set ups. Camera2 was positioned vertical to view through the mirror.

Special equipment has been made in-house to facilitate data capturing and to insure the highest accuracy in three –dimensional movement reconstruction which was validated by repeating the analyses using the methods of Psycharakis et al. (2005). This includes a reflective mirror and glass for water wave breaking and a glass box inserted half way in the swimming pool by putting metal weights in it. A calibration frame cube has been hanged and tied by robs prior to the swimming trials and was marked with 16 points as a reference for data digitizing and analyzing. Each subject swam as fast as he can from inside a 25m swimming pool using the wall as a starting point where he/she can push him/herself. There was 3-5 minutes rest for recovery between the trials and 10 minutes rest between performing the two styles (HWU) and (HWUBS).The best trial according to best time recorded for the breast wave style swimming was digitized using APAS system. An 18 point body model was used for determining the CG of the swimmers for analysis. Cameras were field synchronized by light bulb idiot using the frame matched. Digitized data were smoothed with a Butterworth digital filter at 2-4Hz. The CG location of the subject was determined by segmental analysis and described graphically. CG velocities and accelerations were also calculated and presented as a function of time between wave styles and subjects. SL and SR have been calculated based on the methods presented by Chollet and Pelayo, (1999).

RESULTS and DISCUSSION:

The kinematics variables are presented in tables 2 and 3 for the two styles (HWU) and (HWUBS). It was obvious from these tables that male swimmers reported greater V, Acceleration, SL, ST, SR and FD except in the HD variable. This could be explained by virtue of flexibility level that female usually possess on the trunk hip region. None parametric statistics revealed significant differences in V for the (HWU) and in HD and FD for the (HWUBS) (table 4). In this case, a word of caution is in order about undulating too much. The amount of body undulation should be considerably less than that used by butterfly swimmers. Exaggerating the downward movement of the legs simply to produce a large upward undulation of the hips would only reduce propulsion from the breaststroke kick. Hence, the breaststrokers in this study should concentrate on kicking back allowing the natural downward movement of the legs produce the proper amount of upward hip undulation, and should not try to enhance the upward movement of the hips. (Maglisho, 2003). In addition to that, figure (2) shows the forward velocity pattern of CG in both styles as an intriguing feature of the curve. The (HWU) curve has similar fashion of those shown in the literatures while the (HWUBS) has a slope that is less steep which takes longer time for velocity reduction and velocity recover for velocity reduction and velocity recover during the stroke cycle and how propulsion may be affected by each style differently. Mean values of SL, ST, and SR were similar to those reported in a previous research despite of difference in subjects, time and procedures. (Kilani and Statieh, 2006).

Table 2 - Mean and standard deviations of kinematic variables for the males and females in (HWU)

Gender	Mean / SD	V m/s	Acceleration m/s^2	SL m/cycle	ST/s	SR Cycle/m	HD/cm	FD/cm
Males	mean	1.465	2.265	1.540	1.325	45.295	0.051	0.102
	SD	0.078	0.134	0.070	0.035	1.209	0.014	0.025
Females	mean	1.345	1.285	1.535	1.480	40.555	0.054	0.085
	SD	0.021	0.049	0.035	0.042	1.167	0.007	0.024

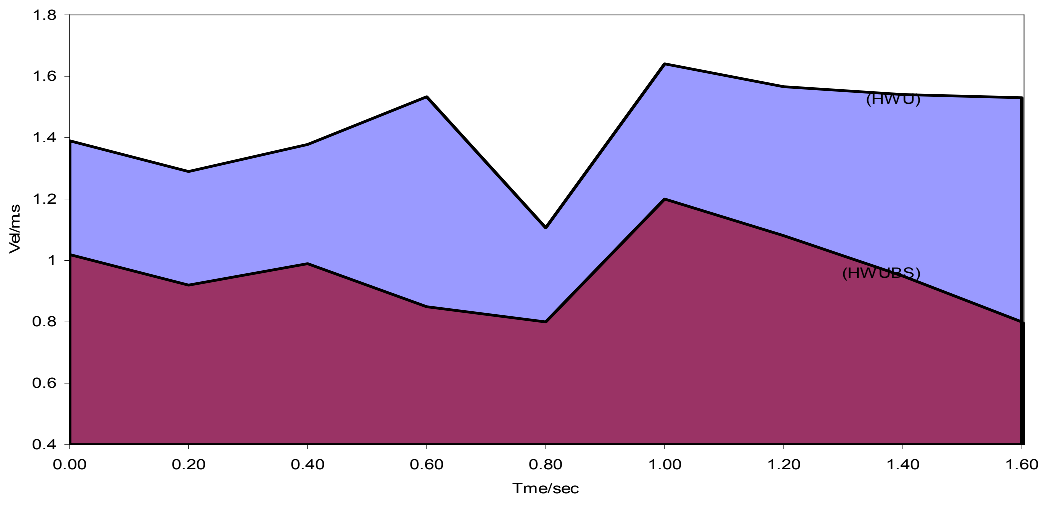

Figure 2 - Illustrates the differences on CG tracing forward velocity Breaststroke for the 2 styles (HWU) and (HWUBS). Time was scaled for the stroke cycle to facilitate comparison.

Table 3 - Means, standard deviations for the kinematical variables for the males and females in (HWUBS).

Gender	Mean / SD	V m/s	Acceleration m/s^2	SL m/cycle	ST/s	SR Cycle/m	HD/cm	FD/cm
Males	mean	0.945	1.545	1.589	1.575	38.415	0.123	0.081
	SD	0.007	0.078	0.055	0.205	4.999	0.009	0.006
Females	mean	0.915	1.890	1.640	1.585	37.850	0.144	0.095
	SD	0.007	0.042	0.028	0.007	0.170	0.049	0.015

Table 4 - Mann Whitney test results for the kinematical variables between the two swimming styles (HWU) and (HWUBS).

Variables	Style	Ranks Mean	Ranks Sum	Z Statistic	pro
Velocity	(HWU)	6.5	26	2.32	*0.021
	(HWUBS)	2.5	10		
Acceleration	(HWU)	4.5	18	0.00	1.00
	(HWUBS)	4.5	18		
Stride length	(HWU)	3	12	1.73	0.083
	(HWUBS)	6	24		
Stride time	(HWU)	3	12	1.73	0.083
	(HWUBS)	6	24		
Stride rate	(HWU)	5.5	22	1.15	0.248
	(HWUBS)	3.5	14		
Hip displacement	(HWU)	2.5	10	2.32	*0.021
	(HWUBS)	6.5	26		
Feet displacement	(HWU)	2.5	10	2.32	*0.021
	(HWUBS)	6.5	26		

CONCLUSION:

Breaststrokers in this analysis have not mastered the (HWUBS) in comparison with (HWU) and they need to concentrate on kicking back, allowing the natural downward movement of the legs to produce the proper amount of upward hip undulation and should not try to enhance the upward movement of the hips. It was suggested that breaststrokers should revise their techniques to optimize the sequence of downward undulation of the head and shoulders and upward undulation of the hip, which may create a summation of forces that could provide additional propulsive force during the in-sweep of the breast stroke kick.

REFERENCES:

Chollet, D. & Pelayo, P. (1999). Effects of Different Methodologies in Calculating Stroke Length in Swimming. *Journal of Human Movement Studies*, 36.

Kilani, H. & Statieh, S. (2006). “SHOULD We Change the Stroke length for Jordanian Swimmers?”. XXIIIed ISBS, Salzburg. Austria,

Maglischo, E .W. (1999).*Unpublished Observations of the Forward Velocity of Breaststroke Swimmers Based on both Center of Mass and Velocity Meter Tracings*. Lecture presented at maglischo coaching seminar , June 25-26,Washington , d.c.

Maglischo, E. W. (2003). *Swimming Fastest*. Revision edition of: Swimming Even Faster, copyright 1993. Human Kinetics Publisher, USA.

Psycharakis, S.G, Sanders, R. & Mill, F.(2005). A calibration frame for 3D swimming analysis. In Q.Wang (Ed.) *Proceedings of the XVII International Symposium on Biomechanics in Sports*, Beijing, China: The China Institute of Sports Science, pp.901-905.

Sanders, R.H., J.M. Cappaert, and R.K. Devlin. (1995). Wave characteristics of butterfly swimming. *Journal of Biomechanics*, 28 (1) 9-16.