INDIVIDUAL OPTIMIZATION OF THE KICK START POSITION RELATIVE TO KINEMATIC PARAMETERS

Ivan **MATÚŠ** [ABCDEF], Róbert **KANDRÁČ** [ABCDEF], Pavel **RUŽBARSKÝ** [ADEF], Bibiana **VADAŠOVÁ** [ADEF], Pavol **ČECH** [ADEF]

Faculty of Sports, University of Presov, Presov, Slovakia

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Abstract:

The purpose of the study was to assess individual kinematic differences during particular phases of the swim start from the preferred starting position at various positions of the OSB12 kick plate and basic starting positions, aiming to optimize the individual execution of the kick start. The sample included 2 non-randomly recruited performance-level swimmers whose average age, body height, and body weight was 17.0 years, 182.2±1.4 cm and 81±1.1 kg, respectively. To measure the kinematic parameters, we used the SwimPro camera system and DartFish software. The results of our study indicate ascending (front knee angle) and descending (rear knee angle) knee angle values depending on the basic starting position and the positon of the OSB12 kick plate. These positions affected other post-takeoff parameters. The takeoff angle and entry angle parameters were similar and ascending depending on the position of the OSB12 kick plate and basic starting position. Our study shows that the swimmer's preferred starting position is not always optimal for each swimmer. Therefore, we recommend individual assessment and optimization of swim starts.

INTRODUCTION

Since 2009 swimmers at world-class swimming events in Slovakia and abroad have been using the new Omega OSB11 starting block, which has an adjustable rear footrest. This rear footrest or the so-called kick plate may be set to 5 different positions in the anteroposterior direction. The footrest angle is 30° (90° rear knee angle), which facilitates the takeoff from the starting block [Omega 2016]. Since that year the swim starts improved in parameters as takeoff velocity, force impulse, shorter time to distances of 5 m and 15 m [Biel et al. 2010; Nomura et al. 2010; Beretic et al. 2012]. These findings indicate the efficiency of OSB11 for swim starts, especially in the sprint races. Studies on the swim starts from the OSB starting block [Slawson et al. 2011; Takeda et al. 2012; Honda et al. 2012] dealt with the various dynamic and kinematic parameters that determine the efficiency of swim start. However, the studies did not focus on all five footrest positions but only 3 positions (+- position from the preferred position). There is lack of findings [Honda et al., 2012; Barlow et al., 2014; Kibele et al., 2014] on various changes in the basic starting position, affecting the

kinematic parameters of the kick start and the swim start performance to a certain extent. The complex assessment in terms of kinematic characteristics requires comprehensive evaluation of the swim start. The assessment should include not only duration of particular phases of the start but also angular changes in either basic starting position or following phases of the start. Some studies [Nomura et al. 2010] show significant differences in rear knee angles caused by various adjustments of the rear kick plate. Other studies [Slawson et al. 2012] indicate the relationship between dynamic and kinematic parameters of the kick start. However, none of the studies focused on all OSB11 kick plate positions together with various changes in the basic starting position.

The purpose of the study was to assess individual kinematic differences during particular phases of the swim start from the preferred starting position at various positions of the OSB12 kick plate and basic starting positions, aiming to optimize the individual execution of the kick start.

MATERIAL AND METHODOLOGY

Participants

The sample included 2 non-randomly recruited performance-level swimmers whose average age, body height, and body weight was 17.0 years, 182.2±1.4 cm and 81±1.1 kg, respectively. The swimmers participated regularly in the Slovak regional swimming championships and Slovak swimming championship, having competed in particular in sprint races and freestyle races. When tested, all swimmers were healthy and did not report any health problems before the testing. Each tested person read an information leaflet about testing and gave his or her written consent.

Test protocol

The testing session took place in the morning at the swimming pool facilities of the Faculty of Sports, University of Presov, Presov, Slovakia. Each of the swimmers was informed about the testing conditions. Swimmers first had to determine their regularly used starting position on the OSB starting block. This was followed by a standard warm-up protocol and swimming over the course of 400 meters. After the warm-up, eleven waterproof adhesive markers were applied on swimmers' bodies: (1) lateral margin of the left transverse tarsal joint, (2) lateral left and right malleolus, (3) lateral left and right knee condyle, (4) left and right greater trochanter, (5) lateral margin of the left and right scapular spine, (6) lateral left and right elbow epicondyle, (7) ulnar styloid process of the left and right wrist, (8) medial side of the 5th metacarpal–phalanx joint. After that swimmers performed three trial kick starts from the OSB12 starting block to become familiar with the three basic starting positions: front-weighted, neutral-weighted, and rear-weighted.

To determine the starting position, we placed a 2-cm thick bar perpendicularly to the front edge of the starting block. The body position in the basic position on the starting block was determined according to the spot marked on the scapular spine. When this spot was located in front of the bar, the starting position was front-weighted. When the spot overlapped with the bar, the starting position was neutral-weighted. When the spot was located behind the bar, the starting position was rear-weighted. Swimmers took their marks and responded to a sound signal and a LED light signal at the same time. The swimmers started from starting positions and adjusted the kick plate to positions 1 through 5. Each of the swimmers performed 3 starts from all three positions (front-, neutral-, and rear-weighted). The rest period between starts and the change in the OSB12 kick plate position was 30 seconds and 2 minutes, respectively. Each swimmer performed a total of 45 jumps.

To measure the velocity parameters, we used the SwimPro camera system. The first camera was perpendicular to the starting block in the 0 m distance from the edge of the pool and 1.5 m above the water surface. The second camera was 1.6 m from the edge of the pool and 1.5 m under the water surface. The third camera was 1.6 m from the edge of the pool and 1.7 meters below the water surface. The fourth camera was 5 m away from the edge of the pool and 1.7 m below the water surface. To increase the level of lighting, we used halogen and additional LED lights. The camera system was operating at 60 frames per second and the shutter speed was set at 1/1000s- The video recording was subsequently assessed using the Dartfish© software (Dartfish ProSuite4.0, 2005; Switzerland). This software meets the validity and reliability criteria for the assessment of kinematic parameters using the 2D analysis in swimming [Seifert et al. 2010; Norris, Olson 2011].

RESULTS

The results for the kick start from the OSB12 starting block from various basic starting positions show that the starting position of the swimmer corresponds with his preferred starting position. When the swimmer used the neutral-weighted start from the kick plate in position 3, the block time was 1.617 and velocity to 5-meter distance was 3.092 m/s. Despite the fact that the time to 5 meter was the shortest, the swimmer reacted the fastest when using the front-weighted kick start and setting the OSB12 kick plate to position 3. The second shortest time to 5 meters (1.666 s) was found for the same kick plate position but for the rear-weighted start. The difference between the shortest and second shortest time was 0.049 s, which equals 0.091 m/s (Tab. 1).

As far as the knee angles in the basic starting position are concerned, the front-weighted and neutral-weighted starts produced lower front knee angles than the rear-weighted start. The greatest angle of 134.70° was found for the rear-weighted start when the OSB12 kick plate was in position 3, which yielded the second shortest time. When the swimmer started from the basic starting position, the front knee angle of 131.30° produced the shortest time to 5 meters.

Contrary findings were found for the rear knee angles. The rear knee angle was greater for the front-weighted start than for the rear-weighted start. The rear knee angle of 81.40° produced the shortest time to 5 meters. The trunk angle in the basic starting position also increased, being greater for the front-weighted start than for the rear-weighted start. The trunk angle of 46.70° produced the shortest time to 5 meters. Lower values of takeoff angles were recorded for the front-weighted and neutral-weighted start than for the rear-weighted start. The takeoff angle for the start with the shortest time to 5 meters was 38.80°. Findings about the entry angle were similar to those for takeoff angle. Lower entry angles were found for the front- and neutral-weighted starts than for the rear-weighted start.

Table 1 Kinematic parameters of the kick start according to kick plate positions: Swimmer 1

	Front knee angle	Rear knee angle	Trunk angle	Block time	Take-off angle	Entry angle	Time to 5m	
	°	°	°	s	°	°	s	m/s
1F	127.20	88.60	47.50	0.833	32.00	34.10	1.800	2.778
1N	129.40	85.60	43.50	0.870	36.70	35.00	1.760	2.841
1R	131.10	77.40	42.80	0.851	37.50	35.60	1.754	2.851
2F	126.70	91.70	44.60	0.826	36.70	34.20	1.743	2.869
2N	128.80	82.30	43.90	0.836	37.00	34.70	1.732	2.887
2R	131.20	75.50	41.50	0.840	38.50	36.70	1.722	2.904
3F	127.60	91.00	47.80	0.733	35.70	35.30	1.783	2.804
3N*	131.30	81.40	46.70	0.800	38.80	36.90	**1.617**	3.092
3R	134.70	79.50	43.00	0.833	38.80	39.60	**1.666**	3.001
4F	126.40	95.40	46.90	0.766	34.80	36.70	1.817	2.752
4N	128.00	85.00	46.70	0.773	35.60	38.70	1.757	2.846
4R	132.50	79.20	41.20	0.850	41.50	38.50	1.699	2.943
5F	127.40	94.50	47.20	0.850	34.30	35.00	1.816	2.753
5N	129.90	84.70	42.40	0.856	36.90	39.70	1.790	2.793
5R	131.00	80.60	42.10	0.856	38.50	40.90	1.777	2.814

Note. 1-5 kick plate position; F - front; N - neutral; R – rear; * - preferred kick plate position

As regards the shortest time in the kick start from OSB12 starting block, the second swimmer showed a kick plate position different from the preferred one. The rear-weighted start produced the shortest block time of 1.734 s and the highest velocity of 2.884 m/s. The difference between the shortest time and time when the swimmer set the kick plate to the preferred position was 0.082 s (0.132 m/s). Similarly, just as the first swimmer the second swimmer, despite the shortest time to 5 meters, showed the fastest start reaction (0.816 s) when using the front-weighted start and OSB12 kick plate in position 3. The second fastest time to 5 meters (1.766 s) was produced by the swimmer when using the same starting position and the kick plate in position 3. The difference between the fastest time and second fastest time was 0.05 s, which equals 0.09 m/s (Tab. 2).

The front knee angles in the basic starting position were lower for the front- and neutral-weighted starts than for the rear-weighted start. The greatest angle of 133.30° was found when the OSB12 kick plate was set to position 5 and the swimmer used the rear-weighted start. In the basic starting position, the shortest time to 5 meters was produced when the front knee angle equaled 129.60°.

Contrary findings were found for the rear knee angles. Greater values of rear knee angles were found for the front-weighted start and lower for the rear-weighted start. The rear knee angle of 79.90° produced the shortest time to 5 meters. The values of trunk angles in the basic starting position increased. The trunk angles for the front-weighted start were greater than for the rear-weighted start. The trunk angle of 42.30° produced the shortest time to 5 meters. The swimmer showed lower values of the takeoff angle when using the front- and neutral-weighted starts. When the takeoff angles equaled 39.80°, the time to 5 meter was the shortest. The findings for the takeoff angle and entry angle were similar. When the rear- and neutral-weighted starts were used, the entry angle was lower. The angle of 37.20° produced the fastest time to 5 meters.

Table 2 Kinematic parameters of the kick start according to kick plate positions: Swimmer 2

	Front knee angle	Rear knee angle	Trunk angle	Block time	Take-off angle	Entry angle	Time to 5m	
	°	°	°	s	°	°	s	m/s
1F	125.10	88.50	46.40	0.912	32.70	33.20	1.899	2.633
1N	129.30	87.90	43.00	0.915	33.60	34.20	1.893	2.641
1R	132.30	79.00	42.00	0.933	38.30	35.70	1.866	2.680
2F	122.20	90.90	46.50	0.912	35.10	32.40	1.836	2.723
2N	127.10	83.60	43.00	0.916	39.70	35.20	1.801	2.776
2R	131.80	76.70	42.10	0.916	40.40	36.90	1.799	2.779
3F	127.80	89.60	49.30	0.816	37.10	33.30	1.849	2.704
3N*	130.20	79.20	46.20	0.916	38.00	34.10	1.816	2.753
3R	132.10	78.40	44.90	0.950	39.10	38.20	**1.766**	2.831
4F	124.40	93.50	47.50	0.820	35.00	35.50	1.830	2.732
4N	129.70	86.00	43.80	0.853	36.40	38.00	1.803	2.773
4R	129.60	79.90	42.30	0.900	39.80	37.20	**1.734**	2.884
5F	126.40	97.60	49.10	0.916	35.60	33.60	1.882	2.657
5N	131.10	85.70	44.70	0.900	36.00	36.80	1.864	2.682
5R	133.30	83.30	40.90	0.920	37.70	37.50	1.833	2.728

Note. 1-5 kick plate position; F - front; N - neutral; R – rear; * - preferred kick plate position

DISCUSSION

The studies by Nomura et al. (2010) and Honda et al. (2010) have confirmed that the OSB11 has more advantages than the traditional starting block despite the fact that no study dealt with the effect of knee angle on start performance. Nomura et al. (2010) found statistically significant differences in the rear knee angle due to the adjustment of the kick plate position. The kick plate inclination angle decreased from 97 to 84 degrees. However, there were not significant differences in takeoff velocity and flight distance. On the contrary, Honda et al. (2010) found a significantly higher takeoff velocity from OSB11 (4.48 m/s) than from OSB9 4.41 m/s. Slawson et al. (2012) reported a significant relationship between peak force values and rear knee angle (r= 0.701; -0.688). Swimmers performed better starts when they adopted a high front knee angle of 135° to 145° and rear knee angle of 75° to 85° at set-up. It is speculated that by opening the angle of the legs, muscles are in a more effective position for force production at the start signal. Their study suggests that, for the best starts, peak horizontal force production occurred with an obtuse knee angle of 100° to 110°. As reported by Barlow et al. (2014), neutral and rear-weighted positions produced faster times to the 15 m distances compared to the front-weighted position. This would suggest that the neutral and rear-weighted position allowed for critical improvements in take-off parameters that more than compensated for a longer block time. This implies that, regardless of any preference in starting position, a swimmer will perform better in the rear-weighted condition than the front-weighted condition.

The results of our study on individual optimization of the kick start relative to angular parameters are consistent with findings reported in other studies [Nomura et al. 2010; Slawson et al. 2012; Barlow et al. 201]. These studies showed changes in knee angles in the basic starting position on the starting block. Similarly, swimmers produced the fastest times to 5 meters when the front and rear knee angles ranged from 130° to 131° and 80° to 81°, respectively. The first swimmer's parameters corresponded with the preferred starting position, but the parameters of the second swimmer were different. Some studies focused in

particular on the entry angle after the takeoff from the starting block. The entry angles ranged from 35° to 42° [Beretic et al. 2012; Ozeki et al. 2012; Barlow et al. 2014], which is consistent with our findings. Our findings showed that the swimmers entered water under the angle between 33° and 41°. Both swimmers produced entry angles of 37°. Ozeki et al. [2012] dealt with the takeoff angle in the kick start and found that the takeoff angle was 32°. In our study, the takeoff angle ranged from 32° to 42° depending on the position of the OSB12 kick plate and the basic starting position. The optimal takeoff angles for the swimmers were 39° and 40°, respectively.

CONCLUSION

The results of our study indicate ascending (front knee angle) and descending (rear knee angle) knee angle values depending on the basic starting position and the positon of the OSB12 kick plate. These positions affected other post-takeoff parameters. The takeoff angle and entry angle parameters were similar and ascending depending on the position of the OSB12 kick plate and basic starting position. Our study shows that the swimmer's preferred starting position is not always optimal for each swimmer. Therefore, we recommend individual assessment and optimization of swim starts.

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REFERENCES

1. Barlow, H., Halaki, M., Stuelcken, M., Greene, A., Sinclair, H. (2014), *The effect of different kick start positions on OMEGA OSB11 blocks on free swimming time to 15m in developmental level swimmers*, „Human Movement Science", *34*, 178-186. doi: http:// dx.doi.org/10.1016/j.humov.2014.02.002
2. Beretic I., Durovic M., Okicic, T. (2012), *Influence of the back plate on kinematical starting parameter changes in elite male serbian swimmers. „Physical Education and Sport",* vol. 10, no. 2, pp. 135-140
3. Biel, K., Fischer, S., Kibele, A. (2010), *Kinematic analysis of take-off performance in elite swimmers: New OSB11 versus traditional starting block*. „XIth International Symposium Biomechanics and Medicine in Swimming", Oslo, Norway Norwegian school of sports sciences, pp.91.
4. Honda, K., Sinclair, P., Mason, B., Pease, D. (2012), *The effect of starting position on elite swim start performance using an angled kick plate*, „eProceedings of the 30th Annual Conference of the International Society of Biomechanics in Sports*",* pp. 72-75.
5. Kibele, A., Biel, K., Fischer, S. (2014), *Optimising individual stance position in the swim start on OSB11*, „XIIth International Symposium on Biomechanics and Medicine in Swimming", pp. 158- 163.
6. Nomura, T., Takeda, T., & Takagi, H. (2010), *Influences of the back plate on competitive swimming starting motion in particular projection skill*. „XIth International Symposium Biomechanics and Medicine in Swimming", pp. 135-137.
7. Norris, B. S., Olson, S. L. (2011), *Concurrent validity and reliability of two-dimensional video analysis of hip and knee joint motion during mechanical lifting*. „Physiotherapy Theory and Practice", 27, pp. 521–530.

8. Omega (2016), *OSB 11 – Swimming starting block*. Available from URL *https://www.swisstiming.com/.../DOCM_AQ_OSB11_StartingBlock_1015_EN.pdf*
9. Ozeki, K., Sakurai, S., Taguchi, M., Takise, S. (2012), *Kicking the back plate of the starting block improves start phase performance in competitive swimming*, „30th Annual Conference of the International Society of Biomechanics in Sports", pp. 373-376.
10. Seifert, L., Vantorre, J., Lemaitre, F., Chollet, D., Toussaint, H. M., Vilas-Boas, J. P. (2010), *Different profiles of the aerial start phase in front crawl*, „Journal of Strength and Conditioning Research", 24, 507–516.
11. Slawson S.E., Conway P.P., Cossor J., Chakravorti N., Le-Sage T., West A.A. (2011), *The effect of start block configuration and swimmer kinematics on starting performance* in elite swimmers using the Omega OSB11 block, *„Procedia Engineering",* vol. 13 ,pp. 141-147
12. Slawson, S.E., Conway, P.P., Cossor, J., West, A.A. (2012), *The effect of knee angle on force production, in swimming starts, using the OSB11 block,* „Procedia Engineering", 34, 801-806.
13. Takeda, T., Takagi, H., Tsubakimoto, S. (2012), *Effect of inclination and position of new swimming starting block´s back plate on trackstart performance*, „Sports Biomechanics", vol. 11, no. 3, 370-381.