THE CONTRIBUTION OF VELOCITY PARAMETERS TO 5-METER DISTANCE IN VARIOUS MODIFICATIONS OF THE KICK START

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Abstract:
The purpose of the study was to determine the percentage contribution of particular phases to various modifications of the kick start across all OSB12 kick plate positions to the 5-meter distance time. The participants were performance-level swimmers whose average age was 17.4±1.8 years. To collect and process the collected data, we used the SwimPro camera system and DartFish software, respectively. The results of our study show that the rear-weighted start produced the fastest times to 5 meters across all five positions of the OSB kick plate. The highest percentage contribution of velocity and time to 5-meter distance was found for the start reaction, which accounted for half of this time. We found that the flight phase and glide phase contributed to this time to a lesser extent. The results of our study support the findings of other studies in that performance-level swimmers should choose the neutral- or rear-weighted start from the OSB12 starting block. Coaches should pay more attention to both start response in the basic starting position and the flight and glide phases. This study was conducted within the VEGA research project no. 1/0793/18 entitled "The effect of basic position on the starting block on changes in kinematic parameters of track start in swimming".

INTRODUCTION

Starts in swimming are one of the essential factors determining the structure of sports performance that affect swimmer’s performance in sprint races. Sports performances of swimmers in these races are consistent. Therefore, the final standings are decided already at the start, which swimmers perform to begin a race. This finding has been confirmed by placements at world-class events, which confirm this significance. Start may be defined as the time between the sound of the staring signal and the moment when the swimmer’s head breaks the water surface [Ružbarský, Matúš 2017]. 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]. Using this technical innovation, swimmers may modify their basic starting position in the kick start, which consists in placing the rear foot against the kick plate of the starting block. The benefits of this starting block lie in shorter start reaction [Biel, Fischer, Kibele 2010; Honda et al. 2010; Ozeki et al. 2012], higher horizontal takeoff velocity [Biel et al. 2010; Honda et al. 2010; Ozeki et al.,2012], and shorter time to 5 meters [Honda et al. 2010], 7.5 meters [Biel et al. 2010; Honda et al. 2010], and 15 meters [Ozeki et al. 2012] compared with the previous or other techniques of swim starts or their modifications. The body weight on the OSB12 starting block may be over the front leg, evenly distributed over both legs or only over the rear leg. In their study, Honda et al. [2012] found that when swimmers performed the kick start using three different kick plate positions along with three variations in their weight, the rear-weighted kick start had an increased horizontal take-off velocity, increased flight distance and reaction time when compared to both the front-weighted and neutral-weighted kick start. There were no significant differences in time to 7.5 meters, and higher velocity between 5 meters and 7.5 meters was found for the rear-weighted kick start. Kibele et al. [2014] and Barlow et al. [2014] noted that when swimmers used the front-weighted kick start from the new starting block, the start reaction was shorter. On the other hand, when the swimmers used the rear-weighted kick start, the horizontal takeoff velocity increased. Despite these results, all three studies were different in terms of determining the basic starting position on the starting block.

The purpose of the study was to determine the percentage contribution of particular phases to various modifications of the kick start across all OSB12 kick plate positions to the 5-meter distance time.

MATERIAL AND METHODOLOGY

The participants were 5 performance-level swimmers aged 17.4±1.8 years, whose mean body height and body weight was 182.2±3.4 cm and 81±3.9 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 that swimmers performed six 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]. The velocity parameters assessed during the start from the OSB starting block included:

- start reaction (s) – time between the start signal and the takeoff from the starting block,
- flight time (s) – time between the water entry and distance to 5 meters, without any movement,
- time (s) to 5 meters, which is the time between the start signal and the moment when swimmer's head breaks the water surface at a specified distance,
- velocity (m/s) at 5 meters.

RESULTS

The phase of basic position

Table 1 shows that when the rear-weighted kick start was used, swimmers' start reactions were faster across all kick plate positions (0.804-0.908) compared with the neutral-weighted (0.861-0.903 s) or rear-weighted start (0.863-0.921 s). The swimmers produced the shortest reaction (0.804±0.048 s) when the kick plate was adjusted to position 3 and the front-weighted start was used.

The percentage contribution of the start reaction to the time to 5 meters varied from 44% to 51% depending on the basic starting position on the OSB12 starting block. Higher percentage contribution of reaction speed was found for the rear-weighted kick start in most of the OSB kick plate positions (Table 2).

The phase of flight

As shown in Table 1, longer flight phase was recorded for all kick plate positions in the front-weighted (0.360-0.404 s) kick start than in the neutral-weighted (0.346-0.368 s) or rear-weighted start (0.330-0.358 s). The swimmers produced the shortest flight phase (0.330±0.036 s) when the kick plate was adjusted to position 1 and rear-weighted start was used.

The percentage contribution of the flight phase to the time to 5 meters varied from 18% to 22%. Higher percentage was recorded for the front-weighted and neutral-weighted kick starts in most of the OSB12 kick plate positions (Table 2).

The phase of gliding

The phase of water entry is followed by the phase of gliding. The glide phase was longer across all kick plate positions in the front-weighted kick start (0.569-0.615 s) than in the neutral-weighted (0.557-0.594 s) or rear-weighted kick start (0.532-0.591 s).

The percentage contribution of the glide phase to the time to 5 meters varied from 30% to 33%. Higher percentage was recorded for the front-weighted and neutral-weighted kick starts in most of the OSB12 kick plate positions (Table 2).

Resultant time at 5 m

Shorter reaction time and higher velocity at 5 meters across all OSB12 kick plate positions was found for the rear-weighted kick start (1.754-1.842 s; 2.855-2.719 m/s) than for the neutral-weighted kick start (1.788-1.864 s; 2.803-2.689 m/s) or the front-weighted kick start (1.810-1.894 s; 2.765-2.642 m/s).

Table 1 Mean values and standard deviations for variables in various weighted starts and OSB12 kick plate positions

		Block time	Flight time	Glide time	Time to 5m	
		s	s	s	s	m/s
1F	*M*	0.900	0.380	0.615	1.894	2.642
	SD	0.039	0.025	0.045	0.061	0.086
1N	*M*	0.902	0.368	0.594	1.864	2.689
	SD	0.032	0.030	0.054	0.104	0.156
1R	*M*	0.921	0.330	0.591	1.842	2.719
	SD	0.070	0.036	0.046	0.087	0.133
2F	*M*	0.908	0.360	0.569	1.837	2.724
	SD	0.032	0.025	0.030	0.049	0.073
2N	*M*	0.903	0.346	0.566	1.794	2.790
	SD	0.059	0.034	0.026	0.071	0.110
2R	*M*	0.909	0.340	0.537	1.786	2.801
	SD	0.047	0.015	0.027	0.042	0.067
3F	*M*	0.804	0.404	0.602	1.810	2.765
	SD	0.048	0.036	0.034	0.067	0.102
3N	*M*	0.865	0.366	0.557	1.788	2.803
	SD	0.043	0.029	0.056	0.101	0.169
3R	*M*	0.884	0.338	0.532	1.754	2.855
	SD	0.069	0.009	0.049	0.074	0.118
4F	*M*	0.862	0.390	0.600	1.853	2.700
	SD	0.084	0.052	0.062	0.043	0.062
4N	*M*	0.861	0.363	0.570	1.794	2.795
	SD	0.085	0.040	0.075	0.104	0.162
4R	*M*	0.863	0.358	0.542	1.763	2.837
	SD	0.040	0.027	0.059	0.048	0.078
5F	*M*	0.876	0.370	0.613	1.859	2.692
	SD	0.031	0.050	0.030	0.047	0.067
5N	*M*	0.903	0.356	0.574	1.833	2.731
	SD	0.056	0.042	0.028	0.069	0.102
5R	*M*	0.906	0.348	0.573	1.827	2.737
	SD	0.035	0.042	0.056	0.027	0.040

Note: 1-5 kick plate position; F- front-weighted, N- neutral-weighted, Z- rear-weighted

Table 2 Contribution of selected time parameters to the time at 5 meters

	Block time	Flight time	Glide time
1F	48%	20%	32%
1N	48%	20%	32%
1R	50%	18%	32%
2F	49%	20%	31%
2N	50%	19%	32%
2R	51%	19%	30%
3F	44%	22%	33%
3N	48%	20%	31%
3R	50%	19%	30%
4F	47%	21%	32%
4N	48%	20%	32%
4R	49%	20%	31%
5F	47%	20%	33%
5N	49%	19%	31%
5R	50%	19%	31%

Note: 1-5 kick plate position; F – front; N – neutral; R - rear

DISCUSSION

Start in swimming, especially in sprint races, is one the relevant factors that may affect the final placement in the race. The swim start consists of the start, flight phase, glide phase, and initial swimming movements.

Multiple studies have shown that the basic starting position and the swimmer's movement on the starting block affect performance in the following phases of the swim start. It is, therefore, vital that swimmers assume an optimal basic position on the starting block [Biel, Fischer, Kibele 2010; Honda et al. 2010; Slawson et al. 2012; Barlow et al. 2014; Matúš 2016; Ružbarský, Matúš 2017].

The first phase is defined as the time from the starting signal and the swimmer's initial movements on the starting block until the takeoff when the feet leave the starting block. According to Tor et al. [2014], the percentage time contribution of start reaction for 15-meter distance is 11%, 20 to 22% for 10-meter distance, and 34 to 36% for 7.5-meter distance [Matúš 2012]. In our study, the percentage time contribution of start reaction to 5-meter distance varied from 44% to 50%. Greater percentage contribution was found for the rear-weighted kick start across most of the OSB12 kick plate positions. These findings show that the shorter the distance measured, the higher the percentage of the start reaction to the resultant time. The results about the start reaction are consistent with the results reported by Honda et al. [2012] and Barlow et al. [2014], who found that swimmers reacted faster when the front-weighted kick start was used. According to Torr et al. [2014], the percentage time contribution flight phase to the resultant time at 15 meters was 5%. According to our findings, the percentage time contribution of the flight phase to the resultant time at 5 meters varied from 18% to 20%.

In this phase, swimmers have to jump into the water as far as possible at the highest velocity and under an optimal angle [Vantorre et al. 2010; Vantorre et al. 2011]. It is necessary to maintain the velocity after the water entry and use it for the first swimming movements. In our study, the percentage time contribution of the glide phase varied from 30% to 33%. As reported by Torr et al. [2014], glide phase and underwater phase contribute at the rate of 56% to the time at 15 meters. This phase is particularly influenced by the position of arms, hips, and legs at the water entry, which determines the loss of swimmer's velocity under water. The glide phase should fall within the range from 5.5 to 6.5 m [Ruschel et al. 2007; Elipot et al. 2009; Elipot et al. 2010]. Therefore, in our study, we selected the distance to 5 meters in order to determine the efficiency of takeoff from particular OSB kick plate positions and using various weighted starts. The findings on the resultant time to 5 meters are consistent with the results reported by Barlow et al. [2014], who found that the shortest time to 5 meters was recorded when the swimmers used the rear-weighted kick start. In the study by Honda et al. [2012], there were no significant differences in the time to 7.5 m between particular kick starts from the OSB12 starting block. However, mean velocity between 5 and 7.5 was higher for the rear-weighted start than for the front-weighted and neutral-weighted start.

CONCLUSION

The results of our study show various levels of velocity parameters for the takeoffs from the OSB12 kick plate positions and weighted starts. We found that velocity parameters assessed above the water surface are not always optimal for the assessment of swim starts because the swim start (kick plate position 3 and front-weighted kick start) in which the start reaction was fastest did not produce the shortest time after water entry. Swimmers produced the shortest time to 5 meters when the kick plate was adjusted to position 3 and the rear-weighted position was used. As regards the OSB12 kick plate positions, we may conclude that swimmers produced the highest velocity at 5 meters under the water surface when they used the neutral-weighted kick start. The highest percentage time contribution to the time to 5 meters was found for the starting position, glide time, and flight time. When evaluating swim starts, both coaches and swimmers should focus in particular on the complex of kinematic parameters, not on start reaction only, or on the times over short distances above water. We assume that the swim start efficiency manifests itself after the entry into water. According to the results of the present study, performance-level swimmers should use the rear-weighted kick start from the OSB12 starting block.

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