KICKING THE BACK PLATE OF THE STARTING BLOCK IMPROVES START PHASE PERFORMANCE IN COMPETITIVE SWIMMING

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Kinematic characteristics and performance were evaluated during the start phase using two start techniques (kick start and track start) in 11 male elite collegiate swimmers. Trials were recorded using three synchronized video cameras shooting at 60 fps. Two-dimensional video analysis was performed in the sagittal plane. Paired t-test was used to compare variables between the two techniques. The block time (kick start 0.70 ±0.04 s, track start 0.74 ±0.04 s, $p < 0.01$) and 15-m time (kick start 6.78 ±0.33 s, track start 6.92 ±0.34 s, $p < 0.01$) for the kick start were significantly shorter than those for the track start. The horizontal velocity (kick start 4.41 ±0.18 m/s, track start 4.29 ±0.12 m/s, $p < 0.05$) and speed (kick start 4.58 ±0.26 m/s, track start 4.48 ±0.18 m/s, $p < 0.05$) at takeoff for the kick start were greater than those for the track start.

KEY WORDS: swimming start, kick start, track start, starting block, back plate.

INTRODUCTION: Starting skill is one of the most important factors for race performance in competitive swimming. The start phase (0–15 m) is divided into five sub phases: block, flight, entry, glide, and stroke. Kicking the starting block during the block phase is key to improving start performance in competitive swimming. The International Swimming Federation has recently approved a starting block equipped with a back plate for use in swimming competitions. Swimmers who utilize the track start technique have thus developed a new technique called the kick start (Honda, Sinclair, Mason & Pease, 2010; Figure. 1). In this technique, swimmers start races with one leg positioned on the back plate. Honda et al. (2010) reported shorter 5-m and 7.5-m times with the kick start technique compared to the track start technique. However, Takeda, Takagi, and Tsubakimoto (2009) reported no significant difference in performance between these two techniques. Thus, previous results have been inconsistent.

Factors cited as influencing start performance in competitive swimming include a high horizontal velocity of center of gravity at takeoff (Guimarase & Hay, 1985) and deceleration control on entering the water (Ozeki, Sakurai, Takahashi & Taguchi, 2010). The efficacy of different starting techniques can be established by comparing these kinetic variables. The kick start technique may improve start performance, but little is known about the biomechanical advantages of this technique compared to the track start technique. In this study, the kinematic characteristics and differences in performance were evaluated during the start phase using these two techniques.

Figure 1: (a) Kick start and (b) track start

METHODS: Eleven male elite collegiate swimmers participated in this study. Characteristics of the swimmers are shown in Table 1. Prior to the tests, the swimmers were given 3 months to practice their starts using starting blocks equipped with back plates. During the trials, swimmers executed the two start techniques in random order. Trials were recorded using three synchronized video cameras (DXC-990, Sony, Tokyo, Japan) equipped with charge-coupled devices and shooting at 60 fps (1/1000 s exposure). Two-dimensional video analysis was performed in the sagittal plane. Images from the video cameras were fed into a computer-assisted motion analysis system (FRAME-DIAS IV, DKH, Japan) to digitize the data. A two-dimensional analysis method was used to calculate the coordinates of the marked points on the bodies of the swimmers. A Butterworth digital filter was used on the coordinates and in image analysis for data smoothing. The digital filter cutoff frequency was set to 3–6 Hz (Winter, 1979). The block time and 15-m time were measured. During block phase, horizontal velocity, speed at take-off, angle of projection and attitude angle were calculated. Additionally, during, entry angle, attitude angle and angle of attack were computed (Figure. 2). Paired t-test was used to compare all variables between the two techniques by SPSS (PASW Statistics 20.0, IBM, Japan). Significance levels were set at $p < 0.05$. In addition, effect size (Field, 2005) was determined for all variables.

Table 1. Characteristics of subjects

Subject	Specialty	Best record (m:s.ms)		Age (years)	Height (cm)	Weight (kg)	Athletic career (years)
A	Freestyle	100 m	0:52.12	22	179	80	15
B	Freestyle	100 m	0:52.74	20	177	75	8
C	Freestyle	100 m	0:52.92	19	175	73	11
D	Freestyle	50 m	0:24.42	19	173	65	9
E	Freestyle	50 m	0:26.27	20	180	72	5
F	Butterfly	100 m	0:54.16	22	171	71	16
G	Butterfly	100 m	0:54.41	20	171	63	12
H	Butterfly	100 m	0:56.00	19	180	71	14
I	Butterfly	100 m	0:56.59	18	169	61	9
J	Backstroke	100 m	0:57.11	20	173	71	17
K	Breaststroke	200 m	2:18.12	19	166	61	8
Average				19.8	174.0	69.4	11.3
±SD				1.3	4.6	6.1	3.8

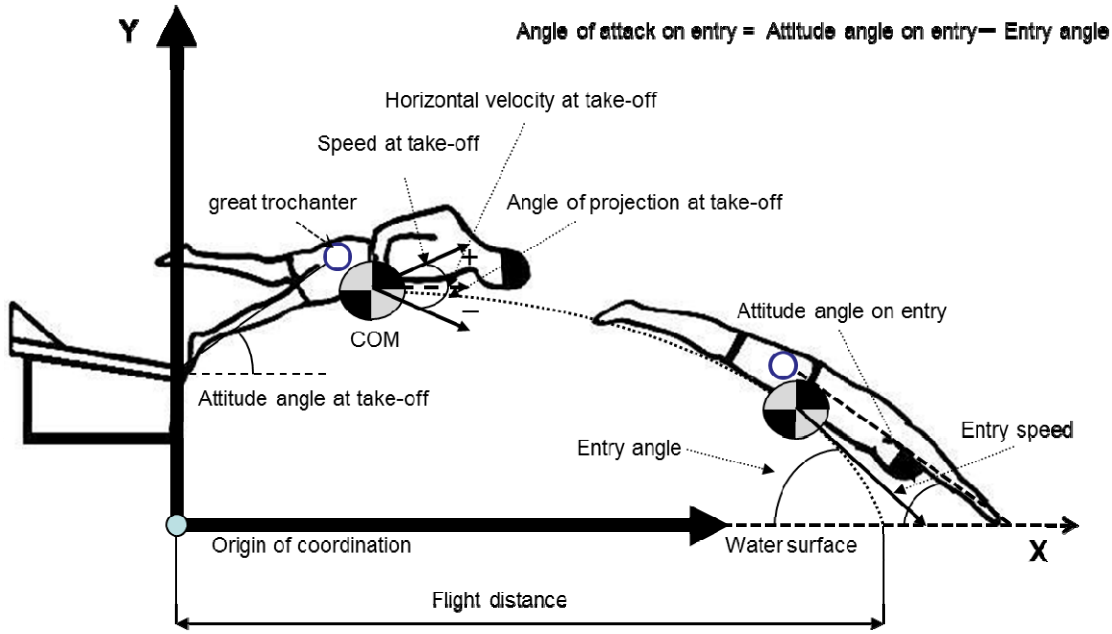

Figure 2: Definitions of kinematic variables

RESULTS: The block time and 15-m time for swimmers using the kick start technique were significantly shorter than those for swimmers using the track start technique ($p < 0.01$ for both variables; Table 2). Values for horizontal velocity and speed at takeoff for swimmers using the kick start technique were higher than those for swimmers using the track start technique ($p < 0.05$ for both variables; Table 2). No significant difference was observed between any other kinetic variables.

Table 2. Significant differences in start phase variables

Kinematic variables	Kick start (mean ±SD)	Track start (mean ±SD)	p	r
Horizontal velocity at take-off (m/s)	4.41 ±0.18*	4.29 ±0.12	p <0.05	0.71
Speed at take-off (m/s)	4.58 ±0.26*	4.48 ±0.18	p <0.05	0.63
Angle of projection at take-off (degree)	32.1 ±5.5	31.2 ±6.3	n.s	0.17
Attitude angle at take-off (degree)	−14.4 ±4.4	−15.9 ±5.9	n.s	0.40
Entry angle (degree)	39.9 ±5.7	41.2 ±6.5	n.s	0.40
Attitude angle on entry (degree)	38.5 ±2.4	39.3 ±2.2	n.s	0.29
Angle of attack on entry (degree)	1.4 ±6.4	1.9 ±7.1	n.s	0.10
Flight distance (m)	2.69 ±0.20	2.69 ±0.23	n.s	0.01
Block Time (s)	0.70 ±0.04**	0.74 ±0.04	p <0.01	0.92
15 m Time (s)	6.78 ±0.33**	6.92 ±0.34	p <0.01	0.83

DISCUSSION: The aim of this research was to investigate differences in start performance of male collegiate swimmers with and without a back plate in terms of several associated kinetic

variables. Speed at take-off and horizontal velocity was faster with the kick start technique than with the track start technique. In addition, block time and 15-m time were shorter with the kick start technique than with the track start technique. These results indicate that the kick start technique provides better start performance in the swimmers examined here (Table 2).

Faster movement of swimmers on the block may be responsible for the shorter block time with the kick start technique. In achieving this faster movement, the attached back plate may help swimmers to extend and push their rear legs and lean forward more quickly than with the track start technique.

Horizontal velocity at takeoff was significantly higher for the kick start technique than for the track start technique. Honda et al. (2010) reported significantly greater horizontal ground reaction force during the kick start technique compared to the track start technique. Horizontal ground reaction force can be improved using a back plate. The significant difference in speed at take-off indicates a difference in the total ground reaction force between the two techniques, including in the vertical direction. The results of this study are also supported by those of a previous study by Ozeki et al. (2010), who reported that its greater horizontal velocity at takeoff makes the kick start a better starting technique. Variables that indicate take-off technique (angle of projection and attitude angle at take-off) showed no significant difference between two different start techniques. Robert, Richard and Thomas (2008) reported a difference in Horizontal velocity at take-off and block time caused by difference between the stance (Front-or rear-weight) at the start. These studies show that there is a need to determine the best technique to takeoff using a back plate. In future, to measure the ground reaction force at the take-off could help to consider appropriate start technique.

CONCLUSION: Improving start performance is important to reduce overall time of race performance in competitive swimming. The kick start technique, which involves use of a back plate, improves start performance compared to the track start technique.

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