THE EFFECT OF STARTING POSITION ON ELITE SWIM START PERFORMANCE USING AN ANGLED KICK PLATE

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The addition of a new start block in competitive swimming, the OSB11 with incline (kick) plate, has led to the development of a new starting technique, the kick start. Although some swimmers have limited access to these blocks, their approach to using it may determine their level of success. The purpose of this study was to a) determine the effect of kick plate position on the performance of the start and b) determine the effect on start performance of changing the swimmers position on the block prior to the start signal. Eighteen elite swimmers completed 30 'dive and glide' starts using the kick start in three different kick plate positions along with three variations in their weight. There was no effect of kick plate position on time. Leaning further towards the rear of the block resulted in higher velocity off the block however no significant difference in time to 7.5 m was seen.

KEY WORDS: swimming start, biomechanics, kick start, OSB11.

INTRODUCTION: In 2008 a newly designed start block by Omega (OSB11, Corgémont, Switzerland) gained approval from the international governing body for swimming (FINA), for use in international competition. The OSB11 starting block has been developed with the addition of a kick plate fixed at an angle of 30° to the surface of the block and can move between five different locations along the length of the starting platform (Figure 1). The kick start is a new start technique developed with the use of the kick plate on the OSB11. The kick start is essentially a modified track start that allows the rear foot to be raised off the platform and placed upon a kick plate. Honda et al. (2010) showed the kick start to be a significantly faster start than the traditional track start, producing an increased horizontal force on the block and therefore an increase in horizontal velocity leaving the block. The optimal set up position using the OSB11 however needs to be determined, including the location of the kick plate and the position of the athletes' centre of mass.

Only one published study to date has examined the effect of different kick plate positions and movement of the swimmers weight prior to the start signal on performance (Takeda et al., 2011). Takeda et al. did not use the OSB11 block or its dimensions. Rather, they used their own modified blocks and found that moving the kick plate forward from an initial position of 59 cm behind the front edge of the block to 29 cm, significantly reduced velocity off the block and correspondingly increased time to 5 m. Their study took no account of the swimmers' preferred plate position. Further a 30 cm change in kick plate position was far greater than the 20 cm range allowed by the actual OSB11 block (Figure 1), which is the starting block currently used in international competition.

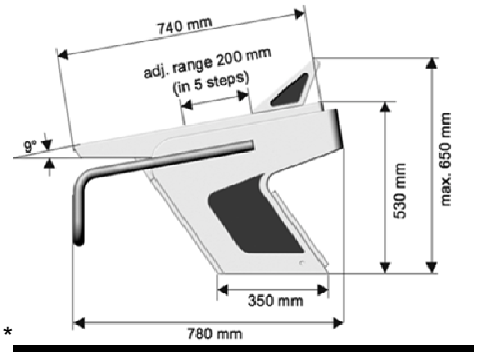

Figure 1: The OBS11 starting block

The aims of the present study were to determine the performance effects of moving the kick plate and changing the swimmers' preparatory position prior to the start signal. It was hypothesised that their preferred block spacing would be the most beneficial to performance and that positioning their weight further back would increase the total time, generate a higher horizontal impulse, and thus create a higher horizontal velocity off the block.

METHODS: Eighteen elite swimmers participated in this study (nine male age; 20.8 ± 3.0 years, nine female age; 21.4 ± 2.8 years). All participants were members of the Australian Institute of Sport (AIS) Swim Team and had personal best times which attained a minimum of 850 FINA points (Federation Internationale de Natation, 2009). This standard equated to a 100 m freestyle swim time of 50.21 s or better for male swimmers and 56.42 s or better for the female swimmers.

The participants undertook four 30-minute familiarisation sessions in the two weeks prior to testing. These familiarisation sessions were used to become accustomed with the new starting techniques, and to determine the swimmers preferred kick plate position. There were three variations in the position of the swimmer's weight in three different block positions examined during this study. In the front-weighted kick start the swimmers were instructed to lean their shoulders forward in front of their hands, moving the centre of mass forward toward the front of the block. The neutral-weighted kick start required the swimmers to have their shoulders directly above their hands. In the rear-weighted kick start the swimmers were instructed to lean back with their shoulders behind their hands.

The three different kick plate positions were based around the swimmers' preferred position. Position 0 was their preferred kick plate position, the position they found to be the most beneficial during the familiarisation period. The other two had the plate located one position immediately behind (position +1) and one immediately in front (position -1) of their preferred position on the OSB11 starting platform. This resulted in the kick plate being positioned 4 cm on either side of their preferred position.

On the testing days the participants completed a warm up based around their pre-race routine. Normal competitive starting procedures were used to conduct each trial. The participants were instructed to exert a maximal effort 'dive and glide', whilst not kicking or swimming, until their forward momentum ceased. Prescribing these dives prevented individual swimming speed from contributing towards the measured times. The participants completed a total of 30 trials; 15 per day over two testing sessions, on two non-consecutive days. There were a total of ten start variations and three trials of each variation completed by each swimmer. The conditions included nine variations of the kick start, with three block positions and the three different variations of their weight, along with a track start.

Forces applied to the surface of the block were measured w an instrumented start block incorporating a Kistler force platform. Vertical grab force was measured via two Kistler tri-axial transducers (9601A) placed in a bar at the front of the start block. The contribution of the rear foot was measured on a second instrumented incline plate by 4 Kistler tri-axial transducers (9251A) developed to specifications of the OSB11. A series of calibrated high speed digital cameras (Pulnix, TMC-6740GE), one above water and three underwater, gave vision from 0 m to 15 m. Times to 5 m and 7.5 m were assessed using analogue video cameras (Samsung, SCC-C4301P) located out of the water, perpendicular to the plane of motion, at 0 m, 5 m and 7.5 m.

Three-way analysis of variance with repeated measures was used to assess the main effects of Kick Plate Placement (preferred position, preferred position -1, and preferred position +1), Weighting (front, neutral and rear) and Trial Number (one to three). When the assumption of homogenous variance was violated, significance was adjusted using the Greenhouse-Geisser procedure.

RESULTS and DISCUSSION: The results for the comparison of kick plate position are presented in Table 1, while results for the weighting comparison are in Table 2. Male subjects recorded faster times, higher velocities and applied larger forces to the blocks than did female subjects, however there were no significant interactions between gender and the kick plate placement or between gender and weighting for any of the variables. Consequently, the results for gender and trial have been pooled in Tables 1 and 2.

Table 1: Comparison of performance variables between three kick plate positions. Mean ± Standard Error.

Variables	Preferred Kick Plate Position -1	Preferred Kick Plate Position	Preferred Kick Plate Position +1	Significance Level
Reaction Time (s)	0.14 ± 0.01	0.14 ± 0.01	0.14 ± 0.01	0.265
Time on Block (s)	0.77 ± 0.01	0.77 ± 0.01	0.77 ± 0.01	0.089
Time to 5m (s)	1.63 ± 0.02	1.62 ± 0.01	1.63 ± 0.02	0.275
Time to 7.5m (s)	2.72 ± 0.02	2.71 ± 0.02	2.72 ± 0.02	0.428
Take-off Horizontal Velocity (m/s)	4.50± 0.04	4.50± 0.04	4.51± 0.04	0.026* ^~
Average Velocity between 5m & 7.5m (m/s)	2.34± 0.03	2.35± 0.03	2.33± 0.03	0.223
Average Horizontal Force (BW)	0.73 ± 0.02	0.74 ± 0.02	0.74 ± 0.02	0.014* ^
Peak Kick Plate Resultant Force (BW)	1.39± 0.04	1.42 ± 0.05	1.44 ± 0.05	0.000* #^~
Peak Kick Plate Horizontal Force (BW)	1.01 ± 0.03	1.04 ± 0.04	1.08 ± 0.03	0.000* #^~
Peak Kick Plate Vertical Force (BW)	1.01 ± 0.03	1.01 ± 0.03	1.00 ± 0.03	0.243
Peak Vertical Grab Force (BW)	0.86 ± 0.04	0.85 ± 0.04	0.84 ± 0.04	0.008* ^
Flight Distance (m)	2.74 ± 0.03	2.74 ± 0.03	2.74 ± 0.03	0.330

*** Significant difference between Kick Plate Position, $p < 0.05$**
 # Significant difference between Preferred Kick Plate Position -1 & Preferred Kick Plate Position, $p < 0.05$
^ Significant difference between Preferred Kick Plate Position -1 & Preferred Kick Plate Position +1, $p < 0.05$
~ Significant difference between Preferred Kick Plate Position & Preferred Kick Plate Position +1, $p < 0.05$

Abbreviation: **BW = Body Weights**

Table 2: Comparison of performance variables between three initial weighting positions. Mean ± Standard Error.

Variables	Front Weight	Neutral Weight	Rear Weight	Significance Level
Reaction Time (s)	0.16 ± 0.01	0.14 ± 0.01	0.13 ± 0.01	0.000* #^~
Time on Block (s)	0.75 ± 0.02	0.76 ± 0.01	0.79 ± 0.01	0.000* #^~
Time to 5m (s)	1.62 ± 0.02	1.62 ± 0.01	1.64 ± 0.01	0.012* ^~
Time to 7.5m (s)	2.73 ± 0.02	2.70 ± 0.02	2.71 ± 0.02	0.115
Take-off Horizontal Velocity (m/s)	4.45± 0.04	4.51± 0.04	4.55± 0.04	0.000* #^~
Average Velocity between 5m & 7.5m (m/s)	2.30± 0.03	2.35± 0.03	2.38± 0.03	0.000* #^~
Average Horizontal Force (BW)	0.77 ± 0.01	0.74 ± 0.01	0.70 ± 0.01	0.000*# ^~
Peak Kick Plate Resultant Force (BW)	1.51 ± 0.05	1.42 ± 0.05	1.31 ± 0.04	0.000* #^~
Peak Kick Plate Horizontal Force (BW)	1.13 ± 0.04	1.04 ± 0.03	0.95 ± 0.03	0.000* #^~
Peak Kick Plate Vertical Force (BW)	1.03 ± 0.04	1.01 ± 0.03	0.98 ± 0.03	0.023* ^~
Peak Vertical Grab Force (BW)	0.78 ± 0.04	0.85 ± 0.05	0.91 ± 0.04	0.000* #^~
Flight Distance (m)	2.71 ± 0.03	2.74 ± 0.03	2.76 ± 0.03	0.000* #^~

*** Significant difference between Weighting, $p < 0.05$**
 # Significant difference between Front & Neutral, $p < 0.05$
^ Significant difference between Front & Rear, $p < 0.05$
~ Significant difference between Neutral & Rear, $p < 0.05$

Abbreviation: **BW = Body Weights**

Consistent with the results of Takeda et al. (2011), moving the plate one position backward (+1) produced a significantly higher horizontal velocity off the block. An increase in the peak resultant and horizontal kick plate forces produced, as the kick plate was moved backwards, may have contributed to this increase in velocity. An emphasis on the horizontal drive backwards by the rear leg during training may further increase the force and velocity produced from the kick plate during the kick start. Contrary to Takeda et al., adjusting the position of the kick plate produced no significant change in the time the athletes spent on the block, or in the times to 5 m and 7.5 m.

Changing the athletes' initial weighting position produced a significant difference for many of the variables tested. The front-weighted kick start enabled an increase in force production not only on the kick plate but also through the entire block. The rear-weighted kick start, however, had a greater contribution from the upper body as vertical grab force was increased. Further, the rear-weighted kick start had an increased horizontal take-off velocity with an increased flight distance when compared to both the front-weighted and neutral-weighted kick start. This came at a cost as the time it took the swimmer to drive from the block was also significantly increased and resulted in an increased time to 5 m. The higher

velocity off the block and greater flight distance however, enabled a higher average horizontal velocity to be maintained between 5 m and 7.5 m, resulting in no time difference between positions at 7.5 m. This relationship between the variables of time on block and velocity off the block therefore offset one another, producing no significant difference in time to 7.5 m. It is possible, however, that future research may find a preference for rear-weighted starts if the higher velocity between 5 m and 7.5 m is able to produce shorter times to longer distances with normal racing starts and underwater kicking.
The kick start has been shown to be the faster start off the start platform when compared to the track start (Biel, Fischer and Kibele, 2010; Honda et al., 2010). These results indicate that swimmers could gain an advantage by using the inclined kick plate on the OSB11 and it is recommended that coaches and athletes spend time adapting to the new block and the required starting technique to optimise its use. Further testing of the kick start with an enhanced training period and the introduction of the kicking and swimming technique through to 15 m is needed to encompass the start as a whole and see if the difference between the three types of kick start is maintained beyond the 7.5 m distance. Further, the present results were based on only a limited training period of four sessions. While this small degree of familiarization is common for many swimmers competing with the new blocks, it is possible that different starting positions may produce better performance after extended training.

CONCLUSION: Changes to swimming technology and training procedures have afforded advantages to those swimmers best able to adapt to the new techniques. With the introduction of the OSB11 starting block, swimmers need to quickly develop techniques to take advantage of the rear kick plate with often limited access to the blocks during training. This study has shown that a neutral-weighted to slightly rear-weighted kick start on the swimmers' preferred kick plate setting allows for the best combination to produce the best all round performance gains after limited practice. While it is possible that other techniques may provide further improvements to performance after extensive training, the opportunities for extended training with the blocks are currently limited for most swimmers. Further research into the influence of the new block in competition may show a variation of the kick start to elicit a further increase in underwater velocity and a decrease in the overall start time.

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Acknowledgement: The authors gratefully acknowledge the support and assistance of AIS ATTRU for their contribution to the testing procedure, the AIS, Applied Sensors Division and the AIS, Technical Research Laboratory for their continued effort to produce world class equipment and the AIS, Swim team for their participation.