SWIM START STANDPOINTS ON THE OSB11 STARTING BLOCK

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Systematic variations of the preferred stance positions of 17 elite swimmers on the OSB11 were analyzed in regard to block time, swim start times to 5 m, horizontal take-off velocities, and horizontal vs. vertical peak force values. The variations encompassed changes of the front leg (left vs. right), the centre of mass (CM) height (low vs. high), the stance width (narrow vs. wide), and a rear vs. a front weighted stance. For half of the subjects, at least one stance alter-native provided a better swim start time than the preferred stance with an average gain of 0,06s and extreme improvements of up to 0,14s. The majority of the improvements were associated with a change to the front weighted stance, a narrow foot displacement, and an elevated CM position.

KEY WORDS: swim start, OSB11, stance position.

INTRODUCTION: Although clear advantages have been reported for the new OSB11 as compared to the old OSB9 starting block model (e.g. Honda et al., 2010; Biel et al., 2010) there is a dearth of research about the optimal stance position on the OSB11 with respect to the swimmers' leg preference, the stance width, and the CM position. While, for the old OSB9, the rear-weighted track start has been shown to offer advantages over the front-weighted track start (Welcher et al. (2008) it remains unclear whether this virtue is maintained with the use of the OSB11 and its new foot plate and a slightly longer and more inclined start block surface. While swim start positions on the new block have been examined regarding leg preference and stance width already (e.g., Slawson et al., 2011; Takeda et al., 2012; Barlow et al. 2014), only limited knowledge is available about the optimal position of the centre of mass (CM) as this measure has been shown earlier to influence block time as a major prerequisite of swim start performance (Hay & Guimaraes, 1983; Fischer, 2013).
A comparative study was conducted to analyze systematic variations of the preferred stance position in the track start of 5 female and 12 male elite swimmers on the OSB11. Variations of the individually preferred stance were examined regarding the front leg (left vs. right), the CM height (low vs. high), the stance width (narrow vs. wide), and a weighted stance (rear vs. front) estimated by the horizontal distance of the hip joint to the front edge of the block. The size of the variations was expressed relative to the individual leg length. Kinematic and kinetic measures were analyzed to evaluate the swim start performance. In addition, a cluster analysis on joint angles (shoulder, elbow, hip, knee, and foot) was conducted to identify the most typical strategies in the preferred stance condition.

METHODS:

Subjects: 17 elite swimmers (5 females: 24,8 ±2,7y age; 1,74 ±0,02m height, 63,8 ±5,09kg body mass; 12 males: 23 ±1,5y age; 1,88 ±0,07m height, 83,6 ±11,7kg body mass) participated in the study. All subjects reported crawl to be their preferred swimming style except for one male and one female with a preference on butterfly swimming.

Instrumentation: For the kinematic data analysis, 2 video cameras (Sony DCR-TRV900E Pal operated at 50Hz) were placed vertically at a height of 1,35 m above the water level and horizontally in parallel to the front edge of the block, and at 5m after the block. While the first camera was used to analyze the take-off behaviour on the block, the second camera was utilized to capture the time between the starting signal and the head passage at 5m. A 2D-strain gauge equipped starting block (Kibele, 2004) with an OSB11 surface measured the horizontal and vertical ground reaction forces.

Procedures: Systematic variations of the preferred stance position accounting for the CM heights and distances relative to the front edge of the block, as well as the stance width, were related to the standard deviations (SD) found in a preceding pilot study (Experiment 1 in Kibele, Biel, & Fischer, 2013) with six male and seven female elite swimmers (females: 22,1 ±4,0y age; 1,78 ±0,06m height, 65,2 ±5,4kg body mass; males: 23,8 ±2,3y age; 1,90 ±0,03m height, 85,8 ±5,4kg body mass). Here, the means and SDs in the above measures were expressed relative to the individual leg lengths of the male and female swimmers separately. For the present study, these SDs were reconverted to metres for male and females separately according to the leg length of each subject. These measures were then added or subtracted to the preferred stance configurations (Fig. 1 left side). Thus, in addition to the preferred stance, 8 configurations were possible for each leg: CM height (low vs. high) x CM distance (rear vs. front weighted stance), and stance width (narrow vs. wide). However, because of motor coordination demands, for each leg, only four of the eight possible configurations could be eventually maintained on the block. The configurations consisted of: a narrow stance with CM position high-front (No.1), a wide stance with CM position high-back (No.2), a wide stance with CM position low-front (No.3), and a wide stance with CM position low-back (No.4). Hence, aside from the preferred stance, a total of eight swim start variations were analyzed. Three trials were used for each configuration. Prior to the various trials, the subjects performed starts in their preferred stance conditions. Subsequently, the variations of the stance configuration were analyzed in random order and across three non-consecutive days. For simplicity reasons, the hip-joint landmark was used as an estimate of the CM location. For the stance width of a male subject, for example, the SD 0,66 from the pilot study was multiplied with the given leg length of a subject and the result was added to the preferred stance width (wide) or subtracted (narrow). Then, the closest footplate position was used for the swim start trial. A video display was used to control the required stance configurations. Here, an overlay reference grid (Fig. 1 right side) was used to indicate the various hip joint positions.

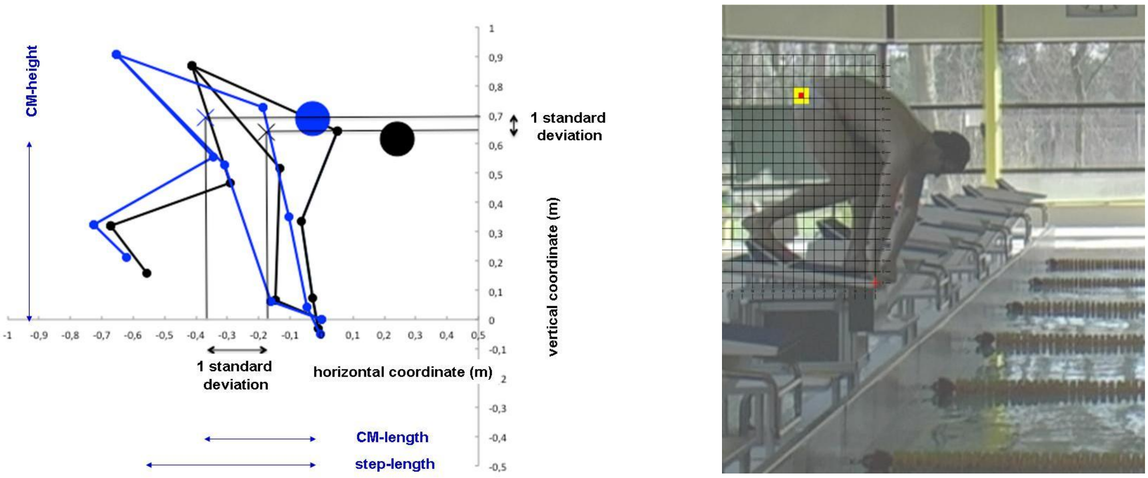

Fig. 1 left side: stance parameters: CM-length (rear weighted vs. front weighted start), CM-height (high vs. low), and step length (narrow vs. wide), right side: video display to control for the required CM location.

Parameters: For each subject, the mean values across valid trials were evaluated for the following kinematic take-off parameters: block time, horizontal take-off velocity (mean velocity across the first three images in the flight phase), take-off angle (inclination of CM trajectory during the first 3 images in the flight phase), flight distance (between front end of the block and the point of hip entry) relative to the body height, entry angle (inclination of the CM-hand interconnection), and hip angle at entry (angle between shoulder, hip, and knee joint at hand entry). For the take-off dynamics, the vertical and horizontal peak forces were evaluated across the valid trials. Swim start performance was evaluated by the time between the starting signal and the head passage at 5m

Statistics: For the statistical data evaluation, an analysis on variance for repeated measures was conducted with the stance configurations and preferred vs. non-preferred leg as factors. For the cluster analysis, the Ward-Method was adopted.

RESULTS: For the evaluation of typical strategies in the preferred stance, 3 clusters were identified: a) elevated CM height, large step size, rear-weighted CM position (N=3), b) intermediate CM height, large step size, front-weighted CM position (N=8), and c) low CM height, small step size, intermediate CM position (N=6). Across all stance variations, the deviations for the hip joint landmark from the target position were -0,049 ±0,039m in the vertical direction and -0,040m ±0,053m in the horizontal direction. To prevent overlapping in CM locations in the different stance configurations, trials were excluded from the statistical data analysis if their CM deviation from the target was larger than the smallest difference between the various target CM locations. Subsequently, 12% of all the trials were excluded.
For the valid trials, 9 of the 17 subjects showed swim start improvements for the stance alternatives better than the preferred stance position. However, for 6 swimmers, alterations of their preferred stance configuration caused a deteriorated swim start time. Across all subject, the mean improvements were found as large as 0,06s. The largest increase in the swim start time was 0,14s.
In the analysis of variance for repeated measures, a significant main effect for the front leg factor could not be found in any of the kinematic and dynamic variables, or in the swim start time. For the stance factor, swim start parameters with significant main effects are listed in Tab. 1. For the remaining variables the level of significance was missed.

Tab. 1 Significant main effects for the stance variations (1 = CM high-front narrow stance, 2 = CM high-back wide stance, 3 = CM low-front wide stance, 4 = CM low-back wide stance) with F-values and effect sizes (expressed as partial eta2-values) for the multivariate tests in the analysis of variance for repeated measures and post-hoc differences (* p < 0,05; ** p < 0,01).

repeated measures variables	*stance factor*	*stance differences*
block time	*32,2** : 0,92*	*1-2**, 1-4**, 2-3**, 3-4***
swim start time at 5m	*7,9* : 0,80*	*1-4**, 2-3*, 2-4*, 3-4***
horizontal take-off velocity	*6,1* : 0,70*	*2-3*, 3-4***
horizontal peak force	*11,6** : 0,81*	*1-2**, 1-4**, 2-3*, 2-4*, 3-4***
take-off angle	*6,5* : 0,71*	*2-3**, 3-4***

Shortest block times were found for the front-weighted CM positions (No. 1 and 3). No differences were observed between the preferred and non-preferred leg except for the high-front narrow stance (No. 1) with superior values for the non-preferred leg. Accordingly, an interaction effect was found between the front leg factor and the stance factor (F=5,2*; eta2 = 0,66). Best swim start times to 5m were found in for the front-weighted CM positions as well. No differences between the preferred and non-preferred leg were identified except for the high CM positions (No. 1 and 2). Here, best values were observed for the non-preferred leg. In contrast, the largest horizontal take-off velocities were found independent of the leg in the back CM positions. For the front-high CM position with narrow stance width a slightly smaller take-off velocity was found in the non-preferred leg. The largest horizontal peak forces were present for front CM positions. A significant difference between the preferred and the non-preferred leg was not observed.

DISCUSSION: The presented results indicate that for the majority of the elite swimmers the best swim start performance in other stance configurations than their preferred one. There was a clear tendency showing that a forward shift to high CM position with a narrow stance would provide best biomechanical conditions for a fast swim start to 5m. Here, subjects were able to produce large horizontal peak forces while block times remained small. These benefits were not counterbalanced by the smaller horizontal take-off velocities observed for the frontal stance positions. These advantages in the take-off velocity are based on the longer block times and acceleration pathways with lower forces amplitudes. A main objection towards of the presented results regards swimmers (33 percent) who have found their best stance positioning from the beginning. Variations in their stance configuration led to a deterioration of the swim start performance. In addition, it is unclear whether swim start performance is unambiguously evaluated by the time to the 5m mark.

CONCLUSION: The presented results show that swimmers looking for their best stance positioning a shift to the front with a high CM position and a narrow stance might offer the best chances to improve their swim start performance.

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