# IS LATERAL ENTRY BENEFICIAL TO ELITE SWIMMERS? A PRELIMINARY STUDY

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The purpose of this study was to improve performance of elite swimmers during the starting phase, by analysing whether the lateral entry technique is beneficial to athletes' starting. Participants' (N=12) motion data were obtained from a 3D Performance Analysis System (Kistler 9691A1) with three cameras. Extracted 14 parameters were analysed using paired samples *t*-test. Differences contributing to the lateral entry performance included decrease of both entry angle and maximum depth by 1° and 0.42 m respectively ($p<.01$), and increase of push force by 0.08 of body weight ($p<.01$). The preliminary results show that the lateral technique provides a 0.06 s reduction in time to reaching the first 5 m ($p<.05$) compared to ordinary entry, suggesting performance improvements at start times.

**KEYWORDS**: swimming, track start, 3D force platform, performance improvement

**INTRODUCTION:** In elite-level swimming, improving any segment of the race may lead to victory. The starting phase of swimming is reported as contributing from 0.8 to 26.1% of the total event duration depending on the race distance (Cossor & Mason, 2001); the shorter the distance, the higher the contribution of the starting stage. Peterson Silveira et al. (2018) compared two different ordinary entry styles: the flat style has a quick entry into the water using a flatter body position and earlier stroking. The pike style creates a smaller hole for water entry with higher velocity due to the influence of gravity. The new lateral entry technique proposed in this study is distinguishable by rotating the body during the process of leaving the start block so that a swimmer enters the water sideways (≤ 90°). The inspiration for the lateral entry technique comes from a study on Fosbury-flop high jump, showing the body rotation during take-off is conducive to more power from the take-off leg, thus increasing the height of take-off (Dapena J., 2002). We hypothesise that in contrast to ordinary entry, the lateral entry technique will allow faster times to reach the initial 5-metre distance, considering projection area in the direction of motion with a smaller gradual displacement over time hence reducing the resistance and speed lost when entering the water. The purpose of this study is aimed to improve performance of elite swimmers during the starting phase.

**METHODS**: Twelve elite swimmers (6 female, 6 male) volunteered to participate in the study (age: 21.6 ±2.42 years; height: 177.33 ±8.37 cm; weight: 70.66 ±9.42 kg; performance level: 93 ±3% of the world record in their best event). Procedures were fully explained to the participants, who were informed of the risks involved in the experiments and provided written consent to participate in the study before starting the data collection. Tests for both the ordinary and lateral entry techniques (Figure 1) were conducted after all participants reported they were accustomed to track start over 8-week lateral entry technique familiarisation. Each swimmer performed in a randomised order, resting until they were fully recovered from the previous tests, with an interval lasting at least 5 minutes between tests. The 3D Performance Analysis

System (Kistler 9691A1, Switzerland) for swimming was adopted for the test evaluations. The first two cameras were positioned at 1.5 m recording the block to entry phases of the swimming start. The third camera was located at 5 m underwater. Figure 1 shows two different entry techniques.

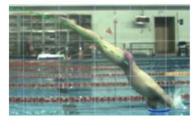
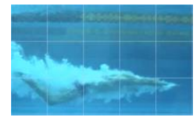
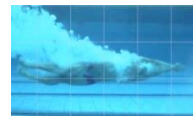
| Phase / Technique | Block Phase | Off-Block Phase | Flight Phase | Entry Phase | Glide Phase |
|---|---|---|---|---|---|
| Ordinary entry |  |  |  |  |  |
| Lateral entry |  |  |  |  |  |

**Figure 1. Comparisons of two different entry techniques during five starting phases**

For temporal data assessment, the 3D force platform and videos were synchronised with the starting signal, enabling assessment of the kinematic parameters described in Table 1.

**Table 1. Definition of the parameters accessed to characterise starting performance**

| Parameter | Definition |
|---|---|
| Block phase duration (s) | Time between the starting signal and the take-off |
| Take-off angle (°) | Take-off angle of athlete's Centre of Gravity (CoG) |
| Horizontal take-off velocity (m/s) | Horizontal velocity of the centre of mass at take-off |
| Flight distance (m) | Horizontal distance between the point of the hands' entry into the water and the starting wall |
| Entry angle (°) | Slope of path of athlete's CoG calculated at water level |
| Entry range (m) | On the water surface, the range from the entry point of the hand to the entry point of the foot |
| Entry velocity (m/s) | Entry velocity of the centre of the head at the water level |
| Maximum depth (m) | The maximum vertical distance from the centre of athlete's head to the horizontal axis of water level after entry phase |
| Time to 5 m (s) | Time between the starting signal and the hand reaching the 5 m mark |
| Power (W/Kg) | Average power from starting signal to take-off |
| Horizontal force (BW) | The resultant force on the horizontal direction of the front and rear platforms (corrected according to the jump angle), plus the horizontal direction force of the handle |
| Vertical force (BW) | The resultant force on the vertical direction of the front and rear platforms (corrected according to the jump angle), minus the vertical direction force of the handle |
| Rear kick force (BW) | The force acting on the rear plate of the platform |
| Push force (BW) | The force acting on the handle of the platform |

Note: BW = Body Weight

The video (aerial and underwater, 100fps) and force plate were frame-by-frame synchronised by data acquisition system of Kistler. Multimodal motion data analysis (total data samples =

334) was conducted by using PAS-S (Kistler ver. 9691A1) for force vectors and time calculations from videos. Mean (±SD) computations for descriptive analysis were obtained for all variables (normal distribution of the data was confirmed with Shapiro-Wilk's test). The difference between the related variables to the ordinary entry technique and the lateral entry technique was tested using a paired samples *t*-test. Statistical analyses were performed using SPSS (ver. 26.0) and the level of statistical significance was set at $p<.050$.

**RESULTS:** Data analysis for the 14 parameters is presented in Table 2. In comparisons between the ordinary entry and lateral entry techniques, five parameters show significant differences ($p<.050$). For the lateral entry technique, the participants showed a smaller **entry angle** (decrease 1°, $p=.039$), shallower **maximum depth** (decrease 0.42 m, $p<.001$), reduced **time at the 5 m** distance mark (decrease 0.06 s, $p\leqslant.01$) and greater **push force** (increase 0.08 BW, $p=.006$), although there was a decrease in **vertical force** of the lateral entry technique compared to the ordinary entry technique (decrease 0.08 BW, $p=.020$).

**Table 2. Results of paired samples *t*-test between ordinary entry and lateral entry techniques （N=12）**

| Parameter | Ordinary Entry | Lateral Entry | *r* | 95% Confidence Int. | | *t* | *p* |
|---|---|---|---|---|---|---|---|
| | | | | Lower Limit | Upper Limit | | |
| Block phase duration (s) | 0.78±0.06 | 0.76±0.08 | 0.925 | -0.01 | 0.03 | 1.383 | 0.194 |
| Take-off angle (°) | 18.33±3.55 | 16.83±3.79 | 0.559 | -0.69 | 3.69 | 1.506 | 0.160 |
| Horizontal take-off velocity (m/s) | 4.20±0.35 | 4.26±0.47 | 0.974 | -0.16 | 0.04 | -1.355 | 0.203 |
| Flight distance (m) | 3.01±0.2 | 3.13±0.42 | 0.957 | -0.27 | 0.03 | -1.776 | 0.103 |
| **Entry angle (°)** | 51±2.37 | 50±3.59 | 0.959 | 0.06 | 1.94 | 2.345 | **0.039** |
| Entry range (m) | 0.53±0.18 | 0.62±0.12 | 0.568 | -0.18 | 0.01 | -1.978 | 0.074 |
| Entry velocity (m/s) | 6.73±0.24 | 6.74±0.28 | 0.928 | -0.07 | 0.06 | -0.110 | 0.914 |
| **Maximum depth (m)** | -1.50±0.51 | -1.08±0.27 | 0.942 | 2.34 | 2.82 | 22.220 | **0.001** |
| **Time to 5 m (s)** | 1.77±0.2 | 1.71±0.2 | 0.951 | 0.02 | 0.10 | 3.108 | **0.010** |
| Power (W/Kg) | 59.17±15.61 | 58.5±13.94 | 0.961 | -2.17 | 3.50 | 0.518 | 0.615 |
| Horizontal force (BW) | 1.24±0.23 | 1.24±0.31 | 0.986 | -0.06 | 0.06 | 0.000 | 1.000 |
| **Vertical force (BW)** | 1.55±0.28 | 1.47±0.23 | 0.933 | 0.02 | 0.15 | 2.712 | **0.020** |
| Rear kick force (BW) | 0.88±0.22 | 0.89±0.28 | 0.989 | -0.06 | 0.04 | -0.303 | 0.767 |
| **Push force (BW)** | 0.65±0.2 | 0.73±0.23 | 0.938 | -0.13 | -0.03 | -3.361 | **0.006** |

Note: *r* = Correlation coefficient

**DISCUSSION:** The focus of this preliminary study was limited to performance improvement of elite swimmers during the starting phase as a practical attempt at immediate technique adaptation aimed to push the boundaries of Olympic results and swimming biomechanics for athletes and coaches. From the preliminary data set, push force and vertical force on the start block were significantly different as dynamic parameters between the two entry techniques (*p*<.050). The larger push force observed in the results may help to optimise the block phase and generate higher average acceleration as reported previously by Mason et al. (2006). In agreement with Vantorre et al. (2014), who reported that a smaller entry angle will cause less resistance, we also found that entry angle, maximum depth and time to 5 m was significantly different (*p*<.050). Follow-up research may consider the off-block phase of the lateral entry technique, as body rotation may also improve efficacy of the lower limbs during kicking and stretching to obtain a faster horizontal speed, thereby improving the initial water entry distance. Hence, the swimmer's task during the flight phase is not merely to go as far as possible, but also to generate enough angular momentum to make a clean entry into the water. The above data should be interpreted with caution, preferably allowing even more than 8 weeks of adaptation. Since elite athletes have their own technical preferences, the proposed technique change may not necessarily benefit all athletes.

**CONCLUSION:** This study proposed the lateral entry technique to improve the performance of elite swimmers during the starting phase. As hypothesised, the lateral entry technique was significantly faster than the ordinary entry technique, resulting in 0.06 s (3.39%) time decrease for swimmers at the 5 m distance mark (*p*<.050). Considering the preliminary results from 12 elite-level swimmers, it appears that the lateral entry technique is advantageous over the ordinary entry technique. It is therefore suggested that swimmers consider adopting or continue to perfect their own lateral entry technique when performing track starts. The use of the lateral entry technique may help to decrease a swimmer's overall race time and improve their ranking in competition. Currently, follow-up work includes an updated data collection protocol with additional parameters aimed to capture a larger dataset to further investigate general technique nuances and adaptation to individual swimmers' idiosyncrasies.

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**ACKNOWLEDGEMENTS:** The authors would like to acknowledge Beijing Sport University and the Chinese swimming team for participating and jointly providing the testing equipment.