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ARE LAND TESTS A GOOD PREDICTOR OF SWIM START PERFORMANCE?

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The purpose of this study was to determine if there were any relationships between land tests and starting performance in swimmers. Results on six British international level male swimmers were collected and analysed independently to ensure no bias. Pearson correlations showed significant relationships between peak vertical forces on land with peak vertical forces on both the main plate and wedge components of the OSB11 style starting block. Correlations were also found with maximum depth and entry distance for both jump height and peak force indicating that land tests can be used as an alternative to instrumented blocks for accurate assessments of starting performance.

KEY WORDS: swimming, starts, jumps, OSB11.

INTRODUCTION: Swimming starts are explosive movements designed to propel athletes through the air as quickly and as far as possible in order to take advantage of the decreased resistance compared with water. Strength and conditioning coaches regularly monitor land tests throughout the swimming season but the relevance of these to actual swiming performance has not been examined in great detail. The swimming start can be divided into a number of phases including the block, flight, underwater and free swimming phases of which the block phase is hypothesised to be closely related to land conditions. Within a competition environment, starts can comprise up to 26.1% of the overall race time in sprint events (Cossor and Mason, 2001) and have been shown to have an impact on performance in nearly all strokes and distances (Mason and Cossor, 2000). At the 2009 World Swimming Championships in Rome, the average difference between the gold and bronze medal in all of the 50m events was 0.19s. That difference could be made or lost in the start phase of the race to 15m and highlights the importance of skills in overall race performance. The three most common forms of start technique that have been used in swimming include the grab, track and swing starts. In a grab start the swimmer has both feet at the front of the block and the hands placed either between or outside the legs. For the track start technique, the swimmer places one foot at the front of the block and the other towards the rear of the block. A wedge has been introduced to the block design so that swimmers now have a fixed area to push against with their rear leg, similar to athletics track starts. Swing starts tend to be used in relay events where the arms swing in a backwards direction in order to generate momentum prior to the swimmer leaving the blocks. Traditionally, sprinters have tended to favour the track start technique with a mixed use between the grab and track starts for the other events. Observations at international competitions in 2010 suggest that most swimmers are now favouring the track start technique with the exception of some breaststrokers. Previous research has looked at the effect of land training on swimming starts (Arellano et al., 2005, Benjanuvatra et al., 2007, Breed & Young, 2003 and West et al., 2010) with no significant results, but none have analysed the new OSB11 wedge type blocks. The purpose of this study was to determine if there were any relationships between dry land jump tests and swimming start performance utilising the OSB11 block with either the left or right legs at the front of the block. While swimmers had a preferred foot in the forward position, tests were conducted with both the left and right foot forward as no scientific approach had previously been used to determine the best foot. In tests using land based athletes, Read and Bellamy (1990), found little difference between the preferred and non-preferred legs for strength and power measures. Hardt et al. (2009), used the revised Waterloo Footedness Questionnaire (Elias et al., 1998) to assess foot preference but found that there was no relationship between the results of the questionnaire and preferred foot used in swimming starts. The group also found that the most effective starts were those using the preferred technique and it was suggested that this was due to a practice effect.

METHODS: Elite male swimmers from the British Swimming team were asked to perform eighteen swimming starts from an instrumented starting block with equivalent geometry to the Omega OSB11 block. An audio signal was used to start the each of the six swimmers after the "take your marks" command was given to replicate racing conditions and participants were instructed to swim maximally past the 15m mark. Times to 15m were measured (average of 6.37s) but are not included due to the focus on the block and flight phases of the start in this research. Block time, peak horizontal and vertical forces and times were measured on both the main plate and the wedge component of the block with a sampling frequency of 100Hz. The SwimTrack software written by Sheffield Hallam University was used to determine position and velocity of the swimmers as they left the block and as their head entered the water. Details of the pool based testing set up are explained in Cossor et al. (2010). Three trials were performed in each of the land based tests on a single axis force platform capturing data at 200Hz. Counter movement jumps (CMJ) were performed with the hands on the hips as were the left and right foot forward jumps. Markers were placed on the force platform to indicate the maximum size of the starting block (50 x 53cm) as well as the centre position to better represent positions during a swimming start. Trials on both the land and in the water were randomised in order to minimise any effects of learning or muscular fatigue throughout the testing sessions.

RESULTS: Average information for each of the testing conditions was used for the analysis, see table 1 for results from the main plate and table 2 for results from the wedge. Data was subgrouped for left and right legs upon which comparisons were made. The peak vertical (Z) and horizontal (Y) forces and the time that they occurred after the starting signal can then be compared between the main plate and wedge platform. Vertical forces on the starting block could also be compared with vertical forces during the land jumping tests.

Table 1
Main force plate data in the vertical (Z) and horizontal (Y) directions for each leg

Front Leg	Block time (s)	Max Fz (N)	At time (s)	Max Fy (N)	At time (s)
Left	0.76 ± 0.06	813.39 ± 82.25	0.46 ± 0.03	380.12 ± 38.5	0.70 ± 0.01
Right	0.75 ± 0.06	833.83 ± 65.83	0.56 ± 0.05	407.76 ± 57.2	0.68 ± 0.01

Table 2
Wedge force plate data in the vertical (Z) and horizontal (Y) directions for each leg

Front Leg	Block time (s)	Max Fz (N)	At time (s)	Max Fy (N)	At time (s)
Left	0.66 ± 0.05	885.06 ± 111.8	0.50 ± 0.01	182.18 ± 22.0	0.56 ± 0.02
Right	0.64 ± 0.07	912.59 ± 99.3	0.46 ± 0.03	166.53 ± 38.1	0.55 ± 0.03

Table 3
Correlations between land and pool based tests

	Right Jump Height	Left Jump Height	Right Fz land	Left Fz land
Right Fz main			0.526	0.596
Left Fz main	-0.478	-0.515	0.647	0.636
Right Fz wedge			0.653	0.741
Left Fz wedge			0.792	0.830
Right dive depth			0.885	0.794
Left dive depth			0.765	0.771
Right entry distance				
Left entry distance	-0.694	-0.593	0.500	0.600

In order to determine any relationships between land and pool based tests, significant values reported at the alpha level of 0.05 and are presented in table 3.
Jump heights and peak vertical forces were measured for the left and right leg in the forward position. Peak forces on the main and wedge components as well as maximum depth and head entry distance with the left and right front in the forward position were used for the pool based measures. Results showed significant positive correlations for all swimming based variables with the peak vertical jump forces except for the entry distance with the right leg in the forward position. Vertical jump height was also negatively, significantly correlated with the peak vertical forces with the left foot in the forward position on the starting block as well as the horizontal entry distance in the same position.

DISCUSSION: The start itself can be divided into a number of phases but the focus of the current study was on the block and flight phases. Research has previously attempted to examine relationships between starting performance and land tests using a variety of methods, which included different types of starts – grab (Benjanuvatra et al., 2007), track (West et al., 2010) and swing (Breed & Young, 2003) with upper and lower body land tests (Arellano et al., 2005). The main aim of this research was to determine if there were any relationships between land tests and swimming starts using the new OSB11 style starting blocks. Traditionally swimmers have chosen their preferred foot forward based on feel rather than on scientific measures. Hardt et al. (2009), found that questionnaires showed no relation to start performance. The current study also attempted to look for differences between the left and right leg in the forward position. Galbraith et al. (2008), suggested that the strongest leg should be placed at the rear of the block while other swimming specific research suggested that it should be at the front (Blanksby et al., 2002 and Hardt et al., 2009). All subjects were required to perform tests in both positions (left and right leg forward) on the land and in the water without the researchers' knowledge of preferred foot in order to minimise bias of the results. Although the results showed little differences in timing for the left and right leg, there were differences noted in peak forces. Future studies would need to determine if there were any signficant differences between the left and right legs but with the small sample size in the current study it was felt that this would not be a true indicator. Strong positive correlations within the group were found between the peak forces measured during the land tests and the peak forces measured on both the main and wedge plates of the starting block suggesting that land tests can be used as an alternative to pool based tests for peak force. It is has been suggested that the horizontal velocity at take-off is linked to improved starting performances (Galbraith et al. 2008, Guimaraes & Hay, 1985 and Houel et al., 2010) but as the land tests were measured using a uni-directional force plate, it was felt that direct comparisons in the vertical component would be more beneficial. Future research may examine the relationship between the vertical and horizontal components on the starting block and this resultant measure compared with the vertical forces measured during simple jumping tests on land. The maximum depth that a swimmer travels after their dive can have an effect on velocity, drag and angle of ascent and this variable would also be strongly correlated to the peak forces measured on land. As the focus of this research was predominantly on the block and flight phases of the start, this relationship was not examined any further but it was interesting to note and will be explored further. Whilst there was no correlation between the starts with the right leg at the front of the block and peak vertical jump forces, there was for the left leg. Greater peak forces measured on land were significantly related to longer flight phases with the head entering further from the blocks compared with lower peak forces. Head entry distance is likely to be closely related to the horizontal forces measured on the starting block but were not examined in this instance due to time constraints. All of the peak jump forces were measured using a portable single axis force platform that is easy to locate in various venues making testing accessible to a large range of swimmers. Vertical height is another simple measure that showed significant negative correlations with the peak vertical forces on the main plate and the horizontal entry distance when the left leg was in the forward position. Interestingly there were no relationships with the right leg in the forward position for this group of elite male swimmers so further research will investigate the trends with a larger subject group.

CONCLUSION: The outcomes of this study show that simple jump tests measured on land do relate to swimming start performance and can be used by swimmers and coaches. Equipment used for the jumps on land was portable and would allow for testing to occur in a variety of locations including the poolside. Due to the ease of testing, these types of jumps could occur more frequently than testing with the inclusion of an instrumented starting block and at a fraction of the price. The jump height tests indicate that there may be a preference towards swimmers having the left leg at the front of the starting block but with the numbers quite small in the current study, this needs to be investigated further before conclusions can be made.

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