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Minimum Water Depth Rules for Competitive Swim Starts

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The majority of research on competitive swim start safety has focused on the maximum head depth (MHD) attained during execution of the start and the head velocity at that depth. But when assessing start safety as a means of stratifying risk, the horizontal distance from the start wall at MHD (DIST) must be considered as well. USA Swimming and the Fédération Internationale de Natation (FINA) require that minimum water depth for executing competitive starts be maintained for distances of 5 and 6 m from the wall, respectively. The purpose of the present analysis was to evaluate if these distances are appropriate. To do so, we reexamined data from studies that reported DIST for competitive swimmers executing starts. We found that 16.5% and 2.9% of the 715 starts had DIST in excess of 5 and 6 m, respectively. Since MHDs during starts have been observed at distances exceeding the mandated distance at which minimum water depth is to be maintained, swim start rules must be revised such that minimum depth is measured at a greater distance from the wall.

Keywords: competitive swimming, safety, diving, injury

The potential for catastrophic head and neck injury exists during the execution of the competitive swim start if and when an athlete collides with the pool bottom due to a dive that is too deep and/or a pool that is too shallow. Although such an injury is rare, when it does occur, it is tragic and enduring to the athletes, families, and teams involved. In an effort to reduce the frequency of such accidents, governing bodies in the sport of swimming mandate and enforce rules pertaining to the minimum allowable water depth for the execution of competitive swim starts. Currently, USA Swimming, the national governing body of swimming in the United States, enforces a minimum water depth for the execution of competitive swim starts; their rule says that the minimum water depth for racing starts from a standard starting block during practice and competition is 1.22 m and “shall be measured for

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a distance 3 feet 3.5 inches (1.0 meter) to 16 feet 5 inches (5 meters) from the end wall” (USA Swimming, 2014). The Fédération Internationale de Natation (FINA), the international governing body of swimming, also has a minimum water depth requirement that is stated as “1.35 metres, extending from 1.0 metre to at least 6.0 metres from the end wall, is required for pools with starting blocks” (FINA, 2014). Both of the governing bodies (1) provide a minimum water depth and (2) indicate how far from the starting wall the minimum depth needs to be maintained.

The first part of the rules above, the minimum water depth, has been the subject of reasonably extensive debate within the swimming and scientific communities (Welch & Owens, 1986; Counsilman, Nomura, Endo, & Counsilman, 1988; Blanksby, Wearne, & Elliott, 1996; Gehlsen & Wingfield, 1998; Blitvich, McElroy, Blanksby, & Douglas, 1999; Blitvich, McElroy, Blanksby, Clothier, & Pearson, 2000a; and Blitvich, McElroy, & Blanksby, 2000b; Cornett, White, Wright, Willmott, & Stager, 2010, 2011a, 2011b, 2011c, 2011d, 2012a; Cornett, White, Wright, & Stager, 2012b, 2014; Cornett, Naganobori, & Stager, 2012c; White, Cornett, Wright, Willmott, & Stager, 2011; Stager, Cornett, & Naganobori, 2013). The second aspect of the rules, the distance from the wall for which the minimum water depth must be maintained, has not received much discussion.

It seems logical to suggest that minimum water depth should at least be maintained for a distance beyond where swimmers reach their maximum head depth (MHD). It is not clear, however, whether current rules are supported by existent empirical evidence. Thus, the purpose of the present analysis was to evaluate, based upon empirical observation and existent published data, whether USA Swimming and FINA minimum water depth rules are appropriate with regard to the distance from the starting wall for which minimum water depth must be maintained. A secondary purpose of the project was to reexamine previously published data to assess the level of risk associated with increasing distances from the wall at MHD (DIST).

Method

We located previous studies that measured DIST for competitive swimmers executing racing starts from standard starting heights (Blitvich et al. 1999; Cornett et al., 2010, 2011a, 2011b). Then, we compared the maximum DIST for each group to the distance from the wall for which minimum water depth is to be maintained by USA Swimming and FINA rules (5 and 6 m, respectively). We focused our attention on the maximum values for the groups because extreme maximum values are more important than group means in regards to safety considerations for the competitive swim start. Cases of head and neck injury due to pool bottom collisions are rare, and thus, it makes little sense to use measures of central tendency (such as the mean or median), which describe the typical case, in evaluating the appropriateness of the minimum water depth rules.

Because maximum DIST from the different studies exceeded the distance at which minimum water depth must be maintained by USA Swimming and FINA rules, we reevaluated the relationship between MHD and DIST during the competitive swim start. We used data from previous studies of competitive swimmers executing racing starts during actual competitions and in controlled environments (Cornett et al., 2010, 2011a, 2011b). Complete and detailed methodological information regarding the data collection procedures is found in these three articles.

In particular, we verified the relationship between MHD and DIST, a relationship first documented by Blitvich et al. (1999) when studying a group of 95 first-year university students, by calculating Pearson correlation coefficients. And finally, we determined whether any of the observed racing starts had MHDs deeper *and* DIST farther than the mandated depths and distances under USA Swimming and FINA rules.

Results

Four published studies were located that presented maximum values for DIST for competitive swimmers executing racing starts from standard starting heights. Nine different groups of competitive swimmers were included in these studies, and two of the groups underwent more than one treatment condition. Table 1 provides the group mean, standard deviation, and maximum for DIST and the number and percentage of starts with DIST greater than 5 and 6 m for each group and/or treatment condition. When comparing the maximum DIST to the mandated distances for which minimum water depth is to be maintained by USA Swimming and FINA rules, we found that 11 out of 12 of the groups or treatment conditions had a maximum DIST greater than 5 m from the wall and 8 out of 12 of the groups or treatment conditions had maximum DIST greater than 6 m.

There was a statistically significant correlation between MHD and DIST for the data collected by Cornett et al. (2010; $R = -0.61$, $p < .001$) and Cornett et al. (2011a; $R = -0.55$, $p < .001$). There was also a statistically significant correlation between MHD and DIST for two of the three conditions tested by Cornett et al. (2011b). When the swimmers executed starts in 1.52 m and 3.66 m water depths, the relationship was significant ($R = -0.67$, $p = .023$ and $R = -0.79$, $p = .004$, respectively), but the relationship was not significant when swimmers executed starts in a 2.13 m water depth ($R = -0.47$, $p = .147$).

Nine racing starts from Cornett et al. (2010, 2011a, and 2011b) were observed to have MHD deeper than 1.22 m and DIST in excess of 5 m. If 15 cm is added to MHD to get an estimate of the actual deepest part of the head (Blitvich et al., 2000a), then 17 starts are estimated to have had MHD deeper than 1.22 m and DIST greater than 5 m (see Figure 1). There were no racing starts observed with MHD deeper than 1.35 m and DIST in excess of 6 m. However, if we adjust the values for the starts, once again, to estimate the actual deepest part of the head, we find that five starts exceeded both of the thresholds (see Figure 1).

Discussion

Governing bodies within the sport of swimming enforce rules regarding racing starts as a means of ensuring the safety of the participating athletes. While the intention of the rules is certainly a worthwhile one, the rules are often based more on the opinions of a few individuals rather than on empirical data derived from swimmers executing racing starts. The purpose of this investigation was to determine whether USA Swimming and FINA minimum water depth rules were consistent with the experimental evidence regarding the distance from the wall at which maximum head depth is attained during the competitive swim start.

Table 1 Mean, Standard Deviation, and Maximum Values for Distance From the Starting Wall at Maximum Head Depth (DIST) for Competitive Swimmers of Different Ages Executing Racing Starts From Standard Starting Heights

Study	Participants	Age (yrs)	Water Depth (m)	DIST (m)			DIST > 5 m		DIST > 6 m	
				Mean (SD)	Maximum	#	%	#	%	
Blitvich et al. (2000a)	36 elite junior swimmers	15.3	1.2	4.72 (0.62)	6.30	NA	NA	NA	NA	NA
Cornett et al. (2010)	45 competitive swimmers	8 & U	2.0	5.01 (0.61)	6.33	NA	NA	NA	NA	NA
		9-10	1.22	3.07 (0.65)	5.08	1	2.2	0	0	0
		11-12		3.55 (0.65)	4.91	0	0	0	0	0
Cornett et al. (2011a)	115 competitive swimmers	11-12		3.93 (0.60)	6.07	3	1.9	1	0.6	0.6
		13-14		4.29 (0.59)	5.58	13	11.6	0	0	0
Cornett et al. (2011b)	112 competitive swimmers	15 & O	2.29	4.53 (0.53)	6.00	9	20.5	1	2.3	2.3
		10 & U		3.90 (0.82)	6.35	4	6.5	1	1.6	1.6
Cornett et al. (2011b)	149 competitive swimmers	15 & O		4.87 (0.77)	6.57	62	41.6	14	9.4	9.4
		20.1 swimmers		5.34 (0.66)	5.48	7	63.6	1	9.1	9.1
			2.13	5.27 (0.61)	5.49	9	81.8	1	9.1	9.1
			3.66	5.55 (0.45)	6.67	10	90.9	2	18.2	18.2

Notes. U = under; O = over.

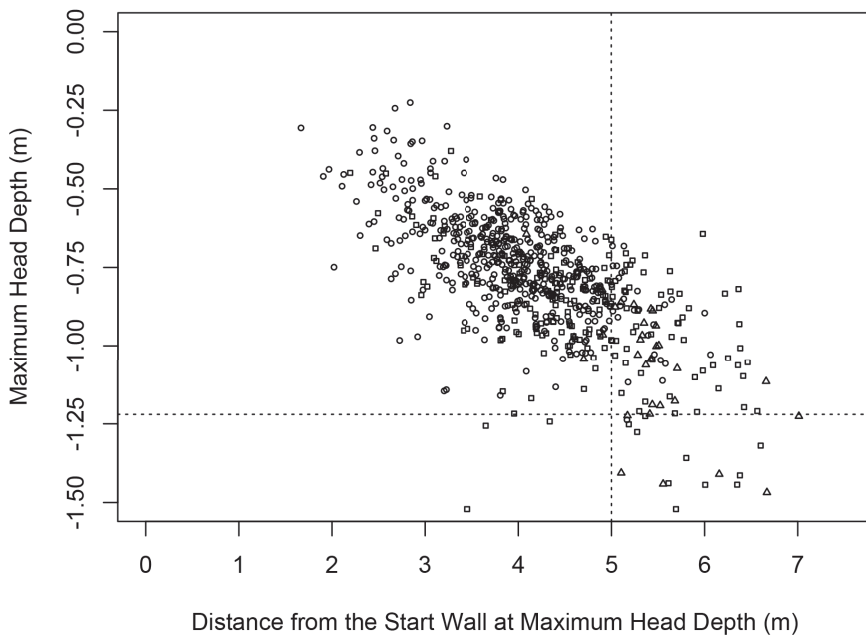


Figure 1 — Maximum depth of the deepest part of the head (m) as a function of the distance from the wall at maximum head depth (m). The maximum depth of the deepest part of the head was estimated by adding 0.15 m to the maximum depth of the center of the head (Blitvich et al., 2000a). The data are from Cornett et al. (2010; circles), Cornett et al. (2011a; squares), and Cornett et al. (2011b; triangles). The dotted lines represent the USA Swimming minimum water depth of 1.22 m (horizontal line) and the distance at which minimum water depth must be maintained (i.e., 5 m; vertical line).

The primary finding of this investigation is that, at times, swimmers reach their MHD during the swim start at distances from the wall greater than 5 and even 6 m. The conclusion to be drawn from this finding is that USA Swimming and FINA rules are not sufficient with respect to the mandated distance from the wall that minimum water depth is to be maintained.

USA Swimming requires that pools are at least 1.22 m for a distance of 1–5 m from the starting wall if swim starts are to be performed (USA Swimming, 2014). This rule seems to be inadequate, or rather, inappropriate, as group *means* are presented in the existent literature for DIST that are greater than 5 m (to say nothing of the maximums). For these groups, then, approximately half, or in some cases far more than half, of the swimmers are reaching their MHD beyond 5 m!

FINA rules state that water depth must be at least 1.35 m, and this depth must be maintained for a distance of 1 m to 6 m from the starting wall (FINA, 2014). Considerably fewer swimmers have DIST values greater than 6 m from the wall than 5 m from the wall, as expected. There still were instances in the studies we analyzed of swimmers reaching their maximum depth beyond this distance. Of the starts reviewed from Cornett et al. (2010, 2011a, and 2011b), DIST was greater than 6 m for 21, or 2.9%, of the 715. So while this distance appears to be an improvement on the rule

enforced by USA Swimming, the data suggest that the rule mandating 6 m is still inadequate.

The reality is, extending the distance for which minimum water depth must be maintained would not have an effect on many competitive swimming venues. Most pools that are deep enough for the execution of competitive starts maintain that depth well beyond the 5 or 6 m mandated by USA Swimming and FINA rules. There are certain pool designs where this would not necessarily be the case, though. Some swimming pools have deep ends where starts are permitted and the pool then slopes steeply from the deep end up toward the shallower end of the pool. It is particularly important that steps be taken to ensure that swimming pools with this design meet the minimum depth requirements for distances from the wall beyond what is currently mandated by USA Swimming and FINA. Otherwise, these pools provide a substantial safety risk when swimmers execute racing starts into them.

The starts with the greatest DIST also tend to be the starts with the deepest MHD. Our reanalysis of previously published data indicated a significant relationship between MHD and DIST. This finding was consistent with a finding by Blitvich et al. (1999) that DIST was a significant predictor of MHD. This means that starts with DIST greater than 5 and 6 m are potentially dangerous, particularly if minimum water depth is not maintained at 5 or 6 m. Figure 1 shows the observed starts with the estimated deepest part of the head deeper than 1.22 m and DIST greater than 5 m. The swimmers in these cases would be at serious risk of contacting the pool bottom if starting in a pool with a minimum water depth that is only maintained for 5 m.

This analysis has demonstrated that USA Swimming and FINA competitive swim start rules are not consistent with empirical observation. These rules mandate that minimum water depth be maintained for a distance of 5 m (USA Swimming) or 6 m (FINA) from the starting wall. Since swimmers, on occasion, reach MHD at distances from the wall beyond 6 m, these rules need to be revised. Using current data, however, we are unable to identify an exact distance from the wall for which minimum water depth should be maintained from the information herein.

The difficulty in pinpointing a specific distance has to do with the subject populations used in collecting the available data. Many of the starts were executed by young and/or relatively inexperienced competitive swimmers. And previous research has shown that young, inexperienced swimmers tend to perform starts that are shallower, slower, and closer to the wall at maximum head depth than their older, more experience counterparts (Cornett et al., 2010, 2011a; White et al., 2011). As a result, more research is needed on older, highly experienced swimmers executing racing starts before appropriate, evidence-based water depth rules can be established. Because the greatest observed DIST was 7.01 m, we can recommend that competitive venue requirements be revised such that minimum depth is measured at and maintained for a distance of *greater than 7 m* from the starting wall.

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