Analysis of recent swim performances at the 2013 FINA World Championship: initial confirmation of the rumored 'current'.

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The affiliates of the Counsilman Center at Indiana University are uniquely positioned within the swimming community as both researchers and practitioners. Center faculty and students conduct research on swimming and about swimmers; sponsor and administrate a USA Swimming affiliated club; and coach age group and high school swim teams. Part of the mission of the Counsilman Center is to provide empirical data to help resolve controversy and or establish regulations and safety mandates. What follows is one example of the 'problem solving' that we feel contributes to the swimming community:

We recently heard rumors originating from the pool deck of the 2013 FINA World Swimming Championships regarding a possible 'current' in the competition pool *while competition was taking place*. The current was rumored to be such that lanes 7 and 8 were at a disadvantage when swimming away from the finishing end of the pool and at an advantage when swimming towards the finishing end. Lanes 1 and 2 were also rumored to be impacted by this current but in the exact opposite direction. These two lanes on the opposing side of the pool were supposedly at an advantage when swimming away from the finishing end and at a disadvantage when swimming towards the finishing

end. After being forwarded a request from an athlete participating in this competition, we decided that there were several approaches that could be initiated that might help verify or refute this rumor. We readily admit that the analyses we performed were limited to the 'human performance' aspects, as that is our expertise as exercise physiologists. The description of an actual current, or any other unique mechanical or hydrodynamic characteristic related to pool design, will await further analysis by qualified professionals in this field.

We initially reasoned that, if a current was indeed present during the competition, evidence would exist within the meet results. This assumes, of course, that the effect was large enough to influence the swimmers' performances. We decided that an initial method for testing this hypothesis involved comparing 50-meter splits from the 1500-meter Freestyle. In this event, the athletes typically attempt to maintain a fairly even pace throughout most of the race. If there is any truth to the rumors, the odd 50-meter split times from the 1500-meter Freestyle for lanes 1 and 2 should be faster than the even splits. And, for lanes 7 and 8, the even 50-meter split times should be faster than the odd 50-meter splits.

So, for each 1500-meter performance at the 2013 World Championships, we took the average of the odd 50-meter splits and the even 50-meter splits. We did not include the 50-meter splits from the first or last 100 meters of the races as a means of eliminating the impact of the start and the tactical aspect of the finish. Thus, for each 1500-meter performance, we had an average of 13 times from the odd 50-meter splits and 13 times from the even 50-meter splits. During the competition, 17 swimmers competed in the 1500-meter Freestyle in lanes 1 and 2 and 15 swimmers in lanes 7 and 8.

We analyzed the data by conducting a 2x2 Mixed ANOVA and found there to be a significant interaction between the lane grouping and the split times ($F = 99.95$, $p < .001$). When we analyzed this interaction effect, we found the average time for the odd 50-meter splits in lanes 1 and 2 (31.77 s) is significantly faster than the even 50-meter splits (32.26 s) for these same lanes (see Table 1). The opposite was found to be true for lanes 7 and 8. The mean for the even 50-meter splits (31.87 s) were significantly faster than the odd 50-meter splits (32.23 s) (see Table 1) in these two lanes.

Table 1. The mean split time for the odd and even 50-meter splits for lanes 1-2 and 7-8 for the 1500-meter Freestyle for the past five FINA World Swimming Championships.

Lanes	50-m Split	2005	2007	2009	2011	2013
1 and 2	Odd	32.13	32.26	32.11	31.71	31.77
	Even	32.25	32.45	32.16	31.72	32.26
7 and 8	Odd	32.34	32.33	32.22	31.90	32.23
	Even	32.62	32.93	32.21	31.85	31.87

Note: The 50-meter splits from the first and last 100 meters of the race was not included in the analysis to remove any possible effect of the start and finish.

We considered this to be strong, initial evidence in support of the rumors of a current in the pool at the 2013 FINA World Swimming Championships and that this effect was present on both sides of the pool. At this point, though, we realized it was important to analyze results from previous World Championship swim competitions to determine whether or not the split times from the 2013 competition followed a similar pattern as previous World Championship competitions. Perhaps this is the way elite swimmers typically perform in this race and 2013 was not necessarily an anomaly? We analyzed the data using the same analysis that we used for the 2013 (i.e., a 2x2 Mixed ANOVA). We found that the results from the 2005, 2007, 2009 and 2011 meets were inconsistent with those in 2013 (see Table 1) and in sharp contrast. The 2013 Championship was *the only competition* where swimmers performed better on the odd 50-meter splits on one side of the pool and better on the even 50-meter splits on the other side of the pool.

These results led us to ask two additional questions: (1) were lanes other than 1, 2, 7, and 8 also affected by this apparent lane bias and (2) if so, was there evidence that there was an impact on the final race results?

In regard to the first question, if a current existed, one that affected performance in lanes 1, 2, 7, and 8, it seems possible, if not likely, that the effect would be evident in other lanes as well. To investigate this, we calculated the difference between the odd and even 50-meter splits for each lane during the 1500-meter Freestyle. Figure 1 shows the mean difference between the odd and even 50-meter splits by lane for the 1500-meter Freestyle.

We analyzed this data by statistically comparing the mean difference for *each lane* to the overall mean difference between odd and even 50-meter splits from the 1500-meter Freestyle (-.07 s). In doing so, we found that the mean difference for each of the eight lanes was significantly different ($p < .05$) from the overall mean difference for all lanes. As is shown in Figure 1, the odd 50-meter splits in lanes 1-4 were faster than the even splits and the even 50-meter splits in lanes 5-8 were faster than the odd splits. Thus, the swimmers competing in one half of the pool (lanes 1-4) appear to be at an advantage when swimming away from the finishing wall and a disadvantage when swimming towards it. Conversely, the swimmers on the other half of the pool (lanes 5-8) are at a disadvantage when swimming away from the finish wall and at an advantage when swimming towards it.

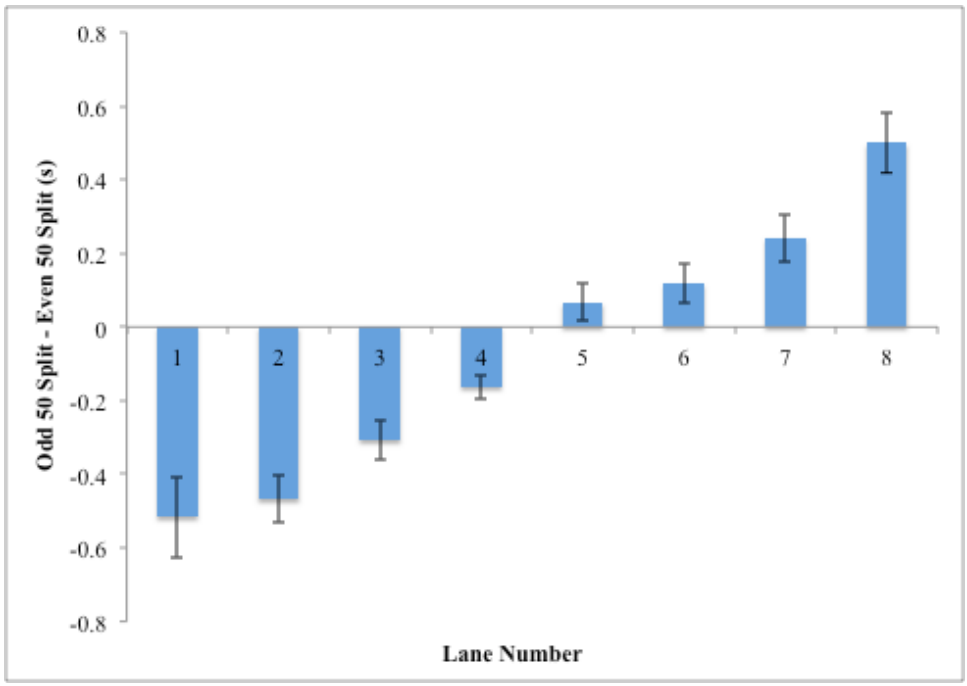

Figure 1. The mean difference between the odd 50-meter splits and the even 50-meter splits from the 1500-meter Freestyle at the 2013 FINA World Swimming Championships by lane. The mean value *for each lane* was significantly different ($p < .05$) from the overall mean difference between the odd and even 50-meter splits for all lanes together. Note: Error bars = SEM.

To us, the analyses on the 1500-meter Freestyle provided clear evidence that some factor was causing swimmers in lanes 1-4 to have faster splits when swimming away from the finishing end of the pool than when swimming towards it. And, this factor seemed to cause swimmers in lanes 5-8 to have faster splits when swimming towards the finishing end of the pool than when swimming toward it. With this said, the question becomes, did this factor have an impact on other events and results of the meet?

Logically, it would seem that for most races any advantage a swimmer received from swimming in one direction would be counteracted by a disadvantage when swimming in the opposite direction. The reason for this is that the majority of races have an even number of lengths and thus for every 50-meter length that a swimmer completes with an advantage, there is another 50-meter length that the swimmer must complete in which they are disadvantaged. There are, however, events in which this is not the case.

There are eight events at FINA World Championship competitions that are 50 meters in length: Men's and Women's 50-meter Butterfly, Backstroke, Breaststroke, and Freestyle. These events are different from the other events at the competition in that they consist of a single length of the competition pool. Because of this, the swimmers begin the 50-meter races at the opposite end of the pool from where they finish. Since the swimmers only perform one length of the pool, the presence of a current in the pool could have a major impact on the event results.

Based on our initial analyses of 1500-meter Freestyle splits, we hypothesized that the swimmers in lanes 5-8 would be at an advantage in the 50-meter events and the swimmers in lanes 1-4 would be at a disadvantage. To test whether or not this apparent lane bias affected the performances in the 50-meter events, the percent change in prelim to semi-final performance time, and the percent change in semi-final to final performance time was calculated for the top-16 swimmers in each event. The total sample was (8 events x 16 semi-finalists) + (8 events x 8 finalists) = 192 observations. Each observation was labeled as being in one of four groups, depending on the lanes the swimmer was in for each pair of swims (see Table 2). Again, from our previous analyses, we hypothesized that group 2 (first swim in lanes1-4 and second swim in lanes 5-8) would show the greatest improvement in performance and group 3 (first swim in lanes 5-8 and second swim in lanes 1-4) would show the least improvement in performance.

Table 2. Categorization of observations based on the lane in which the swimmer swam for each pair of swims.

Group	First swim (lane)	Second swim (lane)
1	1-4	1-4
2	1-4	5-8
3	5-8	1-4
4	5-8	5-8

First swim: prelim or semi-final
Second swim: semi-final or final

We tested our hypothesis statistically by conducting a One-Way ANOVA and found a significant effect for group, $F(3,186) = 31.26$, $p < 0.001$. Post hoc analyses indicated that when swimmers went from lanes 1-4 for their first swim to lanes 5-8 for their second (group 2) they improved approximately 1%, which was a significantly greater improvement than any other group (see Figure 2). Further, when swimmers were in lanes 5-8 for their first swim and 1-4 for their second (group 3), they were slower by about 0.5%, which was a significantly worse result than the three other scenarios. When the swimmers did not change lanes, performances improved slightly, but these groups (1 and 4) were not different from each other.

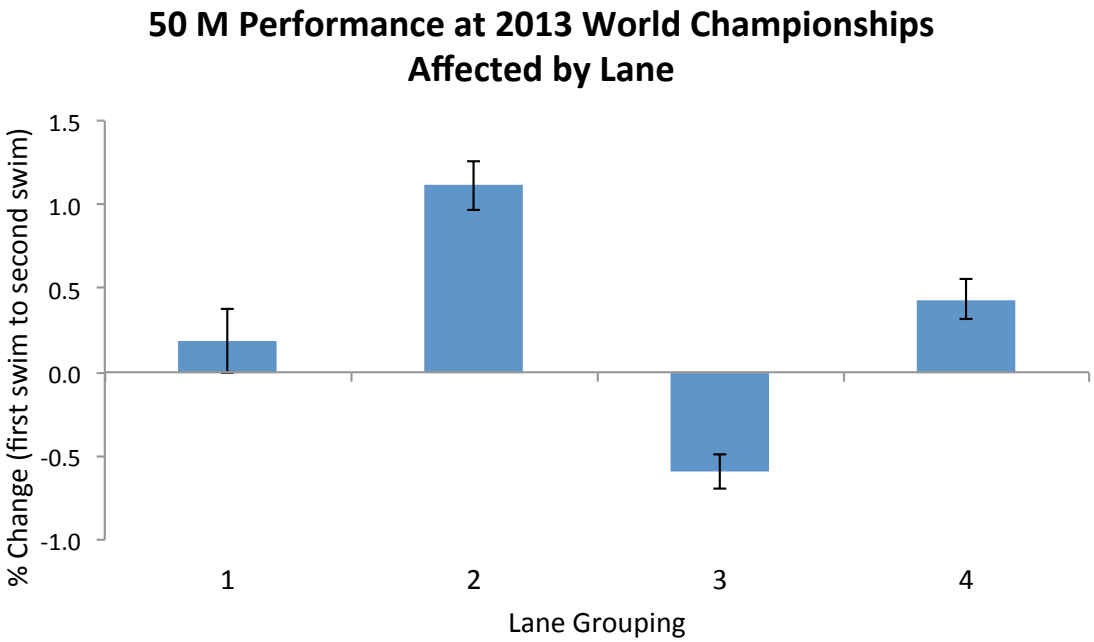

Figure 2. Average percent change in performance time from prelim to semi-final and semi-final to final for 50-meter events at the 2013 World Championships. Swimmers in group 2 (moved from lanes 1-4 to 5-8) improved by about 1%, which was significantly greater improvement than the other groups. Swimmers in group 3 (moved from lanes 5-8 to 1-4) were slower by about 0.5%, which was significantly worse result than the other groups. Error bars = SEM.

This result from analyses on the 50-meter events is consistent with the bias found in the 1500-meter Freestyle, which suggests that swimming speed in lanes 5-8 was facilitated when swimming towards the finishing end, while speed in lanes 1-4 was inhibited. Similarly, in the 50-meter events, the swimmers were significantly faster relative to themselves when moving from lanes 1-4 to 5-8. And, they were significantly slower relative to themselves when moving from lanes 5-8 to 1-4. Put in the context of the previous World Championship competitions, it is clear that the 50-meter events in 2013 were biased (Table 3). While there were occasions when performance improvement was different depending on the lanes in which the swimmer competed, *in no other case did swimmers, as a group, get significantly slower*. Comparing the percent change in performance time to zero, the only time swimmers were shown to be significantly slower was at the 2013 competition when swimmers went from lanes 5-8 in their first swim to 1-4 for their second (see Figure 3).

Table 3. Average ± standard deviation of percent change in performance time from prelim to semi-final and semi-final to final for 50 M events at each World Championships since 2005.

Group	1	2	3	4
2005	0.40 ± (0.77)	0.07 ± (0.85)	0.48 ± (0.84)**	-0.04 ± (0.96)
2007	0.29 ± (1.09)	0.50 ± (0.92)***	0.00 ± (0.78)	0.04 ± (0.97)
2009	0.55 ± (1.06)	0.47 ± (0.77)	0.00 ± (0.71)*	0.53 ± (0.73)
2011	0.46 ± (0.82)	0.36 ± (0.88)	0.06 ± (0.99)	0.07 ± (0.59)
2013	0.19 ± (1.13)	1.11 ± (0.98)*	-0.59 ± (0.79)*	0.43 ± (0.81)

* Significantly different change in performance than the other three groups.
** Significantly different change in performance than group 4.
*** Significantly difference change in performance than groups 3 and 4.

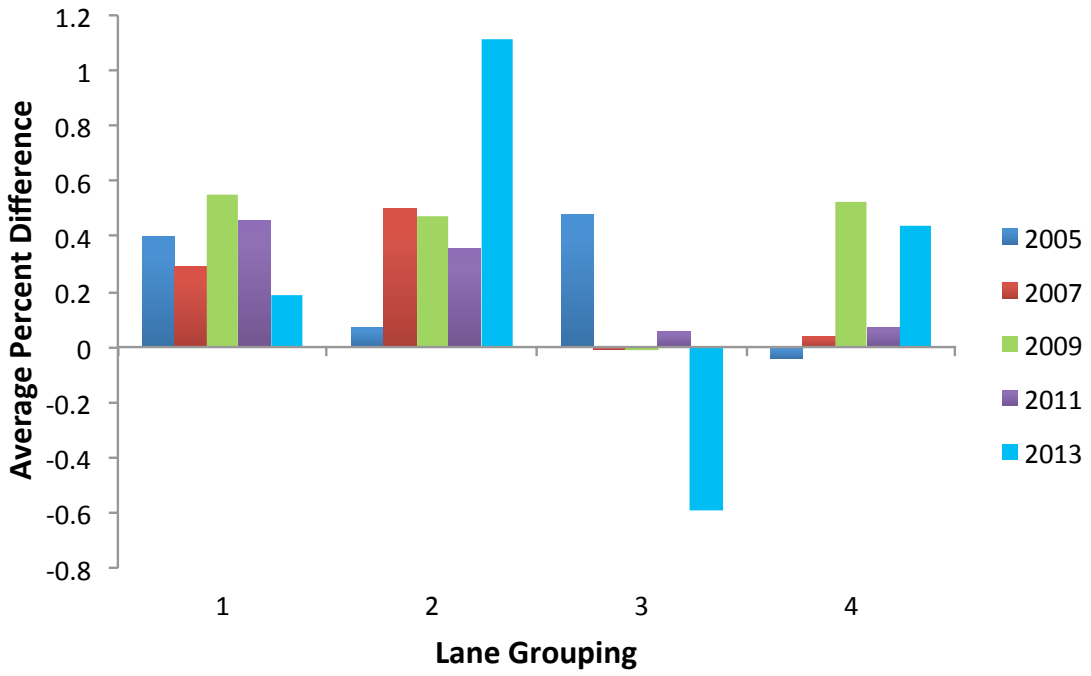

Figure 3. Average percent difference from first swim to second swim for each World Championships 2005-2013. Group 3 (first swim in lanes 5-8 and second swim in lanes 1-4) in 2013 was significantly slower than zero improvement.

The evidence here so far suggests that there was a lane bias during the 2013 World Swimming Championships and the bias had an effect on swim performances. This we show to be true within a swimmer's race as well as when races for a given swimmer were compared against each other. The last question then is: did the lane bias also impact the medal winners? The relevance of this is obvious. Given that many of these competitors are 'professional' swimmers, their careers and their income are dependent on

both the financial and publicity gains from a high-ranking championship performance. We cannot say with complete certainty that the 'bias' described here is causal to the presumably deviant outcomes but we can gain insight into this question by simply analyzing the number of medals won by swimmers in the different lanes (see Table 4) in the 50-meter events and compare this to what has taken place in the past.

Table 4. The number of medals won by swimmers in lanes 1-4 and 5-8 in the 50-meter events at the last five FINA World Swimming Championships.

Lanes	2005	2007	2009	2011	2013
1-4	16	13	15	13	7
5-8	8	11	9	11	17

We analyzed the medal winners for the lanes 1-4 and 5-8 from the past five World Championship meets using Pearson's Chi-Square Test. We found that the result was not statistically significant ($\chi^2 = 8.17$, $p = 0.086$). This means that we cannot rule out that the observed differences in medal count for lanes 1-4 and 5-8 were due to chance alone. But when we reconsidered what Figure 1 seemed to convey to us, that the effect was greatest on the outside lanes, we thought that perhaps the similarity in lane 4 and 5 might be masking an overall effect. When we eliminated lanes 4 and 5 from the analysis and focused only on the lanes where the effect appeared to be the strongest (i.e., lanes 1-3 and 6-8), we came to a very different conclusion (see Table 5). This analysis tells us that there is a statistically significant association between the lanes and the year of competition for the number of medals won ($\chi^2 = 10.11$, $p = 0.039$) and provided additional evidence that a lane bias affected the results at the 2013 FINA World Swimming Championships.

Table 5. The number of medals won by swimmers in lanes 1-3 and 6-8 in the 50-meter events at the last five FINA World Swimming Championships.

Lanes	2005	2007	2009	2011	2013
1-3	9	5	9	6	1
6-8	5	5	6	5	11

As none of these analyses involved direct testing of the physical properties of the facility, we recognize that we can only hypothesize the cause of these analytic results. As in previous work performed here at the Center, we are limited in what we can conclude: that an external 'bias' existed such that swimmers' performances were consistently affected depending upon which lane the swimmers were seeded. Our conclusion is based upon credible evidence in support of a significant 'lane' effect on the performances of the swimmers competing in the 2013 World Championship event. There may be other analytic approaches, and additional evidence from alternative swim events not analyzed here. Nevertheless, given that the outcomes of this competition include World record performances and there may be important monetary consequences to the athletes, coaches and teams, further consideration of this problem is warranted.