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Lane Bias in Elite-level Swimming Competition

Christopher Brammer[1], Andrew Cornett[1,2], Joel Stager[1]

[1] Counsilman Center for the Science of Swimming
Indiana University
1025 E 7th St.
Bloomington, IN 47405
USA
812.855.1637

[2] Eastern Michigan University
School of Health Promotion and Human Performance
319L Porter
Ypsilanti, MI 48197
USA
734.487.2810

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Corresponding Author: Chris Brammer
1025 E 7th St.
Bloomington, IN 47405
(812) 855-1637
brammerc@indiana.edu

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Keywords: analytics, performance, sport, water current, competition

Abstract

Performance outcomes at the 2013 World Swimming Championship were previously shown to be biased based on the lane to which a swimmer was assigned. The purpose of this study was to determine if this kind of bias was unique, and if not, if the bias was related to the temporary or permanent nature of the pool. The effect of lane on the average odd-length split minus the preceding even-length split in the 800- and 1500-meter freestyle events, and on the relative change from qualifying to preliminary performance in the 50-meter events, was determined for 16 other elite-level competitions. In five competitions, swimmers were shown to be faster in a majority of lanes in one direction as compared to the other during the distance freestyle events. Analysis of the 50-meter events at these five competitions indicate that preliminary performances were significantly affected in a manner consistent with the direction effect shown to exist during the distance freestyle events. Further, evidence suggests that these lane biases occur more often in temporary pools than in permanent pools, with water currents as the most plausible cause. The prevalence of lane bias at elite level swimming competition highlights the need for the implementation of policies and procedures to prevent such bias from occurring again in the future.

Keywords: analytics, performance, sport, water current, competition

Introduction

A recent analysis of performance data from the 2013 World Swimming Championship provided evidence of a “lane bias” occurring during the competition (Cornett, Brammer, & Stager, 2015). The times for the 50-meter splits obtained from the 1500-meter freestyle were dependent on the lane to which the swimmer was assigned and the direction the swimmer was moving. The nature of the bias was such that on one side of the pool the swimmers were consistently faster when swimming toward the finishing end as compared to swimming away from it, and on the other side of the pool consistently slower when swimming toward the finishing end as compared to away from it. This was especially problematic for the 50-meter events during which swimmers complete a single length of the pool, and thus swim in only one direction for the entire race. Consistent with the effects observed for the 1500-meter event, on one side of the pool 50-meter event performances were facilitated while on the other side of the pool they were inhibited. As a result, swimmers were either advantaged or disadvantaged in all 50-meter events dependent upon lane assignment, with the effect being greater as the swimmers' lane assignment moved away from the centre of the pool. Whether or not the lane bias at the 2013 championships was an isolated occurrence remains unknown because analyses of elite-level performances at comparable swim competitions have not been conducted. The possibility exists, however, that lane biases are not rare in competitive swimming and that other competitions may have presented similar (but previously undetected) biases.

Cornett, Brammer, and Stager (2015) concluded that the lane bias at the 2013 World Swimming Championship was consistent with a circular current in the pool that favoured athletes in some lanes over others. However, while the analytic results support the existence of a pool current, direct scientific measurement of the physical properties of the pool was not possible as the 2013 championship was held in a temporary tank—immediately deconstructed following the competition's completion. Whether or not the inherent design of this temporary pool was flawed or its installation was causal to the bias is now impossible to determine. The possibility exists that permanent facilities are just as prone to lane biases as temporary venues. Either way, additional analyses of performances at elite competitions appears warranted.

Thus, the primary purpose of the present study was to analyse swim performance data as a means to determine if there is additional evidence of lane biases at past elite-level swim competitions. The working hypothesis was that there is no reason to suppose that the observed lane bias was an isolated case and that similar biases would be confirmed during other competitions. Secondarily, in the event that lane biases were prevalent, the issue of whether or not pool type (i.e., temporary vs. permanent) is associated with a greater or lesser incidence of lane bias would be addressed. If so, these findings would force additional dialog in order to formulate appropriate regulatory policies preventing lane biases from influencing competitive outcomes in the future.

Methods

The performance data for this study represent the official outcomes of international and US national swim competitions between the years 2000 and 2013 (N = 17 competitions), and were downloaded from the publically accessible websites of Omega Timing (www.omegatiming.com) and USA Swimming (www.usaswimming.org). Because the data were in the public domain, informed consent was not required from the athletes for use of this information. All Olympic Games and World Championship competitions since the year 2000 were included in the data set, with the only exception being the 2001 World Championships whose results were unavailable. In addition, the US national and Olympic trial competitions from the third and fourth year of each Olympic quadrennial since 2000 were included. These additional competitions were selected in an attempt to balance the number of temporary and permanent pools and the level of competition among the championship events included within the data set. All competitions met official Federation Internationale de Natation Amateur (FINA) accreditation requirements for 50-meter competitions, with the finishing end being the same as the starting end for all events except the 50-meter events. Thus, for the sake of clarity, description of the swimmers' motion is made relative to the finish end (i.e., swimming toward or away from the finish end).

In an effort to address the prevalence of lane bias, we first conducted an analysis of the 800-meter and 1500-meter freestyle (distance freestyle) events to determine if 50-meter splits were faster in one direction versus the other. If significant direction effects (i.e., swimmers were faster in one direction versus the other) were evident during the distance freestyle events, two additional analyses were planned. The first of the two additional analyses was designed to determine whether or not performance outcomes in the 50-meter events were affected in a manner consistent with the direction effect observed in the distance freestyle events. The second additional analysis addressed the question of whether or not the occurrence of affected lanes was different between temporary and permanent venues. These analyses are detailed in the following paragraphs. An alpha level of 0.05 was used to determine significance for all statistical tests.

The 50-meter splits were analysed for all of the 800-meter and 1500-meter freestyle performances for each of the seventeen swim competitions. For each performance, competition name, competition date, swimmer name, sex, event, lane, each 50-meter split, and total performance time were recorded. In many cases the same swimmer appears more than once, either within a competition, between competitions, or for some swimmers, both within and between competitions. However, because our sample size for a given lane within a given competition was limited, and the focus of this study was to assess the effect of lane assignment on measures of performance, we chose to ignore individual subject variation both between and within competitions. This approach is likely conservative given that some of the distance freestyle split variability might be accounted for by considering intra-individual variation.

Sample size for each lane ranged from 6 to 12, 12 to 30, and 12 to 36 for the Olympic Games, World Championships, and US National & Olympic Trials competitions, respectively.

Data pre-processing was needed to eliminate the impact of the start and the finish; thus, the 50-meter splits from the first and last 100 meters of the 800-meter and 1500-meter races were not included. In addition, it is expected that athletes will change their speed throughout the race depending on factors such as strategy and fatigue. Therefore, for each performance, any systematic trend in distance freestyle splits was accounted for by fitting a lowess curve with the width of the sliding window equal to four 50-meter splits ($\alpha = 0.15$ for 1500-meter & $\alpha = 0.33$ for 800-meter; Cleveland, 1979). Essentially, the lowess procedure calculates a weighted least-squares regression equation within a window containing the nearest four split times at each value along the abscissa. Since the local regressions only involve the data points that fall within the window, the estimated slopes (and hence, the fitted values) change to follow the contours of the data, thus accounting for the systematic change in performance within the event. Next, the residuals from the lowess curve fit were calculated for each distance freestyle performance.

To answer the question of whether or not swimmers in a particular lane or competition swam faster in one direction versus the other, the residual from each odd-length 50-meter split was paired with the residual from the previous even-length 50-meter split. The mean of the difference between each odd-length and even-length residual pair for each individual distance freestyle performance was calculated, a value we refer to as the odd minus even split difference (OMESD). OMESD is a value that can be thought of as the time difference between consecutive 50-meter splits, excluding any systematic changes in swim speed. To determine if swimmers swam slower when moving toward the finishing end in a given lane (i.e., slower on even-length 50-meter splits), a binomial analysis compared the percentage of swimmers whose average

OMESD's were below zero to the expected value of 50%. Alternately, to determine if swimmers swam faster when moving toward the finishing end (i.e., faster on even-length 50-meter splits), the percentage of swimmers whose average OMESD's were above zero was compared to the expected value of 50%. Because this study was concerned with the lane effect at a particular competition and not the effects of sex or event within or between competitions, these statistics were collated across event and sex for each competition. That is, the percentage of swimmers whose average OMESD's were above or below zero represented the proportion of *all* swimmers who swam in a particular lane at a given competition. Coupled with the binomial analysis, the magnitude of differences between odd and even length splits for each lane at each competition was quantified as the mean OMESD of all swimmers within a given lane divided by the between-swimmer standard deviation. This standardized mean effect was evaluated as trivial (0–0.19), small (0.20–0.59), moderate (0.60–1.19), large (1.20–1.99), and very large (2.00-3.99) according to Hopkins and colleagues (2009).

Next, if freestyle splits in the distance events were shown to be affected by the swimmer's direction in the majority of lanes at a given competition, then the results of the 50-meter events at that competition were analysed to determine if performance outcomes were affected in a manner consistent with the direction effect seen in the distance freestyle events. For these competitions, the percent change between the log of qualifying time and the log of preliminary performance was calculated for each 50-meter event competitor such that positive values reflected an improvement in performance. In an effort to remove outliers, percent change values that were more than 1.5 × the fourth spread above or below the upper fourth and lower fourth, respectively, were eliminated (Hoaglin, Mosteller, & Tukey, 1983). Then, each lane was categorized into one of three Lane Groups based on the results of the distance freestyle analyses:

50-meter splits were slower towards the finishing end than away from it (a moderate or greater negative direction effect), 50-meter splits were not dependent on the direction the swimmer was moving (a trivial or small direction effect), or 50-meter splits were faster towards the finishing end than away from it (a moderate or greater positive direction effect). For each competition, a one-way ANOVA was used to compare the percent change in 50-meter performance between each Lane Group. Pairwise comparisons were made using Tukey's post hoc test for all significant F-ratios.

Finally, in the event that significant direction effects were detected in the distance freestyle events, chi square tests of independence were performed to test whether or not the existence of a direction effect in a lane was related to pool type (i.e., temporary or permanent competition pool) and whether or not the nature of the direction effect (i.e., faster or slower towards the finishing end) was associated with pool type.

Results

With the exception of the 2004 Olympic Games, the remaining 16 competitions analysed had at least one lane in which the average OMESD was either above or below zero for significantly more than half the distance freestyle swimmers in that lane (Table 1). Swimmers' 50-meter splits were 0.16 seconds (95% CI, -0.18 to -0.13 seconds) *slower* when swimming toward the finishing end than away from it (a negative direction effect) in 53 of the analysed lanes across the 16 competitions. The mean magnitude of the negative direction effect for these lanes was -1.00 (-1.15 to -0.84). On the other hand, swimmers were 0.16 seconds (0.11 to 0.21 seconds) *faster* swimming toward the finishing end than away from it (a positive direction effect) in 17 lanes across 6 competitions. The mean magnitude of the positive direction effect for these lanes was 1.04 (0.71 to 1.37). There were 74 lanes in which there was no direction effect, with a mean split difference of zero seconds (-0.01 to 0.01 seconds) and mean effect size of 0.03 (0.05 to 0.11). Tables 1 and 2 detail the magnitudes of the direction effects and the 95% confidence limits of the mean OMESD for each lane at each competition, respectively.

Based on the initial results of the distance freestyle analyses, five competitions were identified during which the 50-meter splits from the majority of lanes were shown to be dependent on the swim direction. These competitions included the 2000 Olympic Games, the 2007, 2011 & 2013 World Championships, and the 2012 US Olympic Trials. At each of these five competitions except the 2007 World Championships, the mean percent change from qualifying time to preliminary 50-meter event performance was significantly better for swimmers in the Lane Group in which there was a trivial or small direction effect compared to the Lane Group in which there was a moderate or greater negative direction effect (-0.24 vs -1.12, -0.28 vs -0.88, -0.44 vs -1.33, & -0.14 vs -0.88 %, respectively; Table 3). In addition, at both the 2013 World Championships and 2012 US Olympic Trials, preliminary 50-meter event performances were significantly better relative to qualifying times for swimmers in the Lane Group in which there was a moderate or greater positive direction effect than they were for the Lane Group in which there was a moderate or greater negative direction effect (-0.79 vs -1.33 & 0.39 vs -0.88 %, respectively). All lanes at the 2007 World Championship had a moderate or greater negative direction effect, and thus no Lane Group comparisons could be made. Table 3 displays the 95% confidence interval about the mean percent change from qualifying to preliminary performances in 50-meter events.

Chi square tests of independence revealed that pool type (i.e., temporary or permanent) was associated with a direction effect (χ^2 (1) = 17.62, $p < 0.001$) and whether or not swimmers were faster when swimming toward the finish end than away from it (χ^2 (1) = 21.82, $p < 0.001$).

Discussion

Athletes, coaches, and spectators expect competitive sport outcomes to be determined by factors such as training, technique, and race strategy, but not by veiled external variables. For this reason, concluding that the outcomes of the 2013 World Swimming Championship were likely impacted by something as seemingly trivial as lane assignment was disconcerting (Cornett, Brammer, & Stager, 2015). Analyses determined that swimmers were assisted when swimming in one direction and resisted when swimming in the opposite direction, and the magnitude and direction of the effect was dependent upon lane assignment. To add to this conundrum, the collective results of the present study provide strong evidence that the lane bias observed at the 2013 World Swimming Championship was not unique.

The analysis revealed that 50-meter splits from the distance events were indeed affected by direction in at least one lane at 16 of the 17 competitions analysed and in 70 (49%) out of all 144 lanes analysed (Table 1). Within the 70 lanes affected, 50-meter splits were slower toward the finishing end than away from it (a negative direction effect) in 53 (76%) of the lanes and faster toward the finishing end than away from it (a positive direction effect) in the 17 (24%) remaining lanes. The specific manner in which lanes were affected varied between competitions, with some competitions in which lanes on one side of the pool had a negative direction effect (e.g., the 2000 Olympic Games and 2011 World Championships), and others in which both a negative and positive direction effect occurred on opposite sides of the pool (e.g., the 2012 US Olympic Trials and 2013 World Championships). In the unique case of the 2007 World Championships, surprisingly, the analysis revealed that *all* lanes appeared to be affected. The prevalence of a direction effect in elite-level swimming competition is an obvious cause for concern, but because the performance outcomes of the distance freestyle events were not directly analysed, the presence of a positive or negative direction effect for a lane does not necessarily mean the swimmers in that lane had an unfair competitive advantage (or disadvantage). However, the results of the distance freestyle analyses did serve to illuminate the venues in which a direct analysis of 50-meter event outcomes could be used to additionally confirm the existence of these lane biases.

Because the 50-meter events consist of swimming a single length of the pool, we reasoned that 50-meter performances in any particular lane would be affected in a manner consistent with the direction effect that was identified in the distance freestyle analysis. If, in fact, the results of the 50-meter analysis agree with those derived from the distance freestyle analyses, then together they would act to strengthen the evidence pertaining to the existence of biased outcomes. We focused upon the five competitions in which distance freestyle split times were dependent on the direction of travel in a majority of lanes because in these competitions there was clear evidence of a systematic trend. At the 2000 Olympic Games, the 2011 & 2013 World Championships, and the 2012 US Olympic Trials, in the lanes where there was a moderate or greater negative direction effect in the distance freestyle events, the 50-meter event preliminary performances were significantly worse relative to qualifying times as compared to the lanes in which there was either a positive direction effect or no direction effect (Table 3). Although 50-meter performances within the lanes in which there was a significant positive direction effect were not shown to be better than those in the lanes with no direction effect, the overall findings still support the conclusion that some swimmers were unfairly disadvantaged based on lane assignment in these four competitions.

Although the factor(s) responsible for contributing to both the alternating pattern of speeding up and slowing down during distance freestyle events and the negatively affected 50-

meter event performances remain unknown, statistical evidence that lane biases are associated with pool type is given by the results of the chi square tests of independence. Lanes were more likely to have significant direction effects in the distance freestyle events in temporary swimming pools than in permanent ones. Of the lanes analysed in temporary pools, 42 of 60 lanes (70%) were shown to have a direction effect during distance freestyle events, while half that percentage (35%) were shown to be biased in permanent pools. More importantly, the 50-meter splits in the distance freestyle events were more likely to be faster towards the finishing end than away from it in temporary pools than in permanent pools; this occurred in 16 (27%) of the 60 lanes in temporary pools and in 1 (1%) of the 84 lanes in permanent pools. While the association between the categorical variables here does not establish causality, it does provide strong statistical evidence that lane biases at elite-level swim competitions are associated with the type of pool in which the competition takes place.

However, at the present, it is only possible to speculate as to why lane bias might depend on pool type. Personal communications with pool design experts suggests a pool's hydraulic design specific to how water is returned upon filtering and sanitizing may contribute to the production of currents in pools (Counsilman-Hunsaker, 2015). For example, total flow through the main circulatory pump, the proximity of inlets to the main pump, pipe diameter serving inlets, the number and locations of inlets, and direction of flow into the main basin can all contribute to generation of currents. While this is true for any pool design, temporary pools have traditionally limited the location of water return inlets to the pool's side and end walls, excluding the entire pool floor. These inlet locations, combined with a reduction of inlet quantity, can result in an increased flow of water through each inlet, thus potentially leading to stronger surface currents. Unfortunately, as the temporary pools are deconstructed immediately following competitions, it is no longer possible to measure the effects of their designs on the biased outcomes presented herein. Regardless of the cause of lane biases, the greater prevalence of lane bias in temporary versus permanent pools concerns not only the competitive fairness within a competition, but also the ability to compare athlete performances between competitions.

According to our analyses, the 2007 World Championships were unique in that swimmers in *all* lanes were shown to have been negatively affected (Table 1), a result that may threaten competitive fairness between competitions. If one assumes a water current existed during competition, then theoretically, in the distance events, the time lost swimming against the current would have been greater than the time gained swimming with the current. This should have resulted in a worsening of performance outcomes for each lane. The analogue for this is the effect of wind on 100-meter running times in which analytic models agree that the time lost when running against a headwind is greater than the time gained when running with an equal magnitude tailwind (Dapena & Feltner, 1987). Relevant to the current study, perhaps, is the precedent within Track and Field, whereby a maximum allowable wind velocity of 2 m/s is agreed upon as the threshold ensuring that record-setting performances were not wind aided. Further studies are needed in order to set maximum allowable water currents and the accurate procedures necessary to measure them as a means to not only ensure fairness within competitions, but also among competitions.

Within competitive swimming, and also of relevance here, is the precedent of limiting technology when it can be shown to bias competitive performance. The “high-tech” suits that were introduced in 2000, and subsequently became nearly ubiquitous, were shown to cause a dramatic improvement in elite-level swim performance (specifically in 2008 and 2009), with estimated mean performance gains of 0.3-1.2% (Berthelot, Hellard, Len, Tafflet, & Toussaint, 2010). These and other authors suggest that the rate of improvement in the performances of the top-ten swimmers decreases from year to year and does so at a predictable rate. When the world's best performers through this time span were swimming significantly faster than an analytic model predicted for the majority of events, researchers concluded that newly introduced swim suit technology biased elite swim performance (Brammer, Stager, & Tanner, 2012). Access, availability, and legal issues pertaining to sponsorship, in part, resulted in restrictions by the sport's governing bodies in 2010. Policies regarding the physical properties of the material used in making the suits and the extent to which this material could cover the swimmer were introduced and subsequently enforced. Importantly, within the current study's findings, hindrances of 0.5-0.9% were observed for 50-meter events (in some lanes relative to those lanes in which no direction effect was observed), which are of similar magnitude to the estimated effects on performance by suit technology. Additional competition regulations need to be introduced that address this issue as a means to eliminate a correctible bias. Presently the only mention of water currents exists within FINA rule FR2.11, in which it is stated, "inflow and outflow is permissible as long as no appreciable current or turbulence is created."

Summary & Conclusion

Prior analysis of performance data from the 2013 World Swimming Championship revealed that the swimmers' performances were affected by their lane assignment (Cornett, Brammer, & Stager, 2015). To extend these findings, the purpose of the present study was to determine whether or not there is evidence to suggest that other elite-level swim competitions were similarly affected. In five of the 17 competitions analysed, evidence is provided showing that swimmers were faster in a majority of lanes in one direction as compared to the other during the

800-meter and 1500-meter freestyle events. Further analysis of the 50-meter events at these five competitions indicate that these performances were affected in a manner consistent with the direction effect shown to exist during the 800-meter and 1500-meter events. Specifically, in these competitions, when swimmers were determined to be slower when swimming toward the finishing end in the distance freestyle events, 50-meter performances were similarly inhibited. The most plausible explanation for these findings is that water currents are present in the pools during the competitions.

In many cases, because the pools were built specifically for the competition and then taken apart immediately afterwards, it is impossible and/or unrealistic to test the swimming pools for water currents. Evidence generated from competition results, however, suggests that lane biases at elite-level swim competitions occur more often in temporary pools than in permanent pools. Critical details of pool design, such as water inlets, gutter design, water depth, or other aspects of temporary pool construction will have to be carefully scrutinized in order to eliminate water currents as a factor in the competitive outcomes. In the short term, it would appear that it is the responsibility of the various sport governing bodies to (1) identify an accurate and valid means of measuring water currents and (2) specify a maximal water current threshold above which a competition cannot be considered unbiased or valid. An analogous precedent exists within Track & Field whereby wind velocity is measured during competition and record performances are only certified (or not) depending upon established wind velocity thresholds. We suggest that the data herein provide the necessary evidence to force the establishment and implementation of these standards immediately.

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Table 1. Standardized mean effect of swimmers' direction on distance freestyle 50-meter splits (800 and 1500-meter freestyle). Values were calculated as the mean of swimmers' odd minus even length split differences divided by the standard deviation of those differences. An asterisk (*) indicates either significantly more than half of the swimmers in a lane were faster (positive values) or slower (negative values) when swimming toward the finishing end than away from it. Pool type refers to either permanent (P) or temporary (T).

	Pool Type	Year	Lane 0	1	2	3	4	5	6	7	8	9
Olympic Games	P	2000	NA	-1.10*	-1.03*	-1.24*	-1.08*	-0.89*	0.05	0.52	0.39	NA
	P	2004	NA	-0.07	-0.66	-0.27	0.05	-0.22	-0.41	-0.15	-0.02	NA
	P	2008	NA	0.42	-0.17	-0.45*	-0.46	0.29	-0.85*	-0.60	0.18	NA
	P	2012	NA	-1.23*	-1.34*	-0.72	0.14	0.19	-0.16	-1.39*	-0.58	NA
World Championships	T	2003	NA	-0.21	0.11*	0.71*	0.70*	0.41	-0.06	-0.22	-0.45*	NA
	P	2005	NA	0.58	-0.22*	-0.48*	-0.29*	-0.20	-0.07	0.19	0.25	NA
	T	2007	NA	-0.86*	-1.40*	-2.37*	-1.63*	-0.69*	-1.21*	-1.31*	-1.65*	NA
	P	2009	-0.55	-0.35	-1.16*	-0.57	-0.49*	-0.63*	0.15	-0.53*	-0.33	-1.35*
	T	2011	NA	0.10	-0.89*	-0.45*	-0.68*	-1.04*	-0.95*	-0.48	-0.12	NA
	T	2013	-1.66*	-1.75*	-2.14*	-2.44*	-1.26*	0.56	0.72*	1.48*	3.05*	2.21*
US National & Olympic Trials	P	2000	NA	-0.52	0.11	0.12	-0.05	0.06	-0.23*	0.30	0.51	NA
	P	2003	NA	-0.21	-0.40*	-0.67*	-0.34	-0.51*	-0.17	-0.01	-0.62*	NA
	T	2004	NA	0.17	0.86	1.49*	0.24	0.04	0.74*	-0.15	-1.39*	NA
	P	2007	NA	-0.67*	-0.30*	-0.21	-0.08	-0.26*	-0.52	-0.25	-0.15	NA
	T	2008	NA	0.21	-0.39*	0.11	-0.35*	0.27	0.55*	0.88*	0.20	NA
	P	2011	0.84	-0.18	-0.23	-0.07	0.05	-0.51*	0.35	-0.20	0.64*	-0.60*
	T	2012	1.23*	0.70*	0.90*	0.82*	0.75*	-0.02	-0.16	-1.28*	-1.57*	-2.17*

Table 2. 95% confidence interval for the mean odd minus even 50-meter split difference during the distance freestyle events (800 and 1500-meter freestyles). Data were collapsed across event and sex such that the interval was representative of *all* swimmers in a given lane at a given competition. Negative values indicate swimmers were slower when swimming toward the finishing end than away from it. Mean sample size for each lane was 10, 22, and 21 for Olympic Games, World Championships, and US National & Olympic Trials, respectively.

		Lane									
	Year	0	1	2	3	4	5	6	7	8	9
Olympic Games	2000	NA	-0.26 to -0.17	-0.24 to -0.15	-0.26 to -0.16	-0.12 to -0.05	-0.16 to -0.08	-0.01 to 0.09	0.08 to 0.19	-0.01 to 0.09	NA
	2004	NA	-0.09 to 0.03	-0.21 to -0.09	-0.05 to 0.04	-0.02 to 0.07	-0.04 to 0.05	-0.08 to 0.01	-0.04 to 0.07	-0.05 to 0.05	NA
	2008	NA	-0.02 to 0.10	-0.04 to 0.04	-0.12 to -0.05	-0.08 to 0.00	0.02 to 0.10	-0.19 to -0.08	-0.09 to 0.00	-0.03 to 0.06	NA
	2012	NA	-0.24 to -0.14	-0.19 to -0.11	-0.13 to -0.04	-0.01 to 0.09	-0.02 to 0.07	-0.12 to 0.00	-0.20 to -0.12	-0.15 to -0.05	NA
World Championships	2003	NA	-0.08 to -0.01	-0.02 to 0.05	0.03 to 0.09	0.08 to 0.15	0.02 to 0.10	-0.03 to 0.04	-0.12 to -0.03	-0.09 to -0.02	NA
	2005	NA	0.07 to 0.14	-0.07 to 0.01	-0.12 to -0.04	-0.12 to -0.05	-0.09 to -0.02	-0.06 to 0.01	-0.01 to 0.09	-0.02 to 0.10	NA
	2007	NA	-0.20 to -0.12	-0.27 to -0.20	-0.36 to -0.29	-0.28 to -0.21	-0.26 to -0.18	-0.23 to -0.15	-0.26 to -0.19	-0.31 to -0.24	NA
	2009	-0.12 to -0.01	-0.09 to -0.02	-0.26 to -0.18	-0.13 to -0.06	-0.09 to -0.02	-0.12 to -0.05	-0.04 to 0.03	-0.11 to -0.04	-0.10 to -0.02	-0.30 to -0.19
	2011	NA	-0.02 to 0.07	-0.21 to -0.14	-0.13 to -0.06	-0.13 to -0.06	-0.21 to -0.13	-0.14 to -0.08	-0.14 to -0.06	-0.02 to 0.06	NA
	2013	-0.34 to -0.21	-0.40 to -0.31	-0.45 to -0.38	-0.35 to -0.29	-0.21 to -0.14	0.05 to 0.12	0.09 to 0.17	0.23 to 0.32	0.37 to 0.44	0.34 to 0.43
US National & Olympic Trials	2000	NA	-0.08 to 0.00	0.00 to 0.08	-0.01 to 0.07	-0.04 to 0.03	-0.02 to 0.05	-0.10 to -0.02	0.00 to 0.07	0.04 to 0.12	NA
	2003	NA	-0.06 to 0.01	-0.10 to -0.04	-0.14 to -0.07	-0.09 to -0.03	-0.09 to -0.03	-0.04 to 0.01	-0.06 to 0.00	-0.13 to -0.06	NA
	2004	NA	-0.01 to 0.11	0.12 to 0.22	0.12 to 0.22	-0.03 to 0.06	-0.05 to 0.05	0.09 to 0.19	-0.11 to 0.01	-0.33 to -0.20	NA
	2007	NA	-0.16 to -0.09	-0.06 to 0.00	-0.04 to 0.02	-0.07 to 0.00	-0.06 to 0.00	-0.10 to -0.04	-0.05 to 0.01	-0.02 to 0.05	NA
	2008	NA	0.03 to 0.13	-0.12 to -0.03	-0.04 to 0.04	-0.06 to 0.00	0.01 to 0.10	0.00 to 0.08	0.14 to 0.22	-0.02 to 0.07	NA
	2011	0.10 to 0.19	-0.03 to 0.04	-0.04 to 0.04	-0.05 to 0.03	-0.04 to 0.04	-0.11 to -0.03	0.02 to 0.10	-0.06 to 0.01	0.09 to 0.17	-0.16 to -0.06
	2012	0.19 to 0.27	0.06 to 0.15	0.12 to 0.20	0.08 to 0.15	0.06 to 0.13	-0.04 to 0.04	-0.10 to -0.02	-0.20 to -0.12	-0.24 to -0.17	-0.37 to -0.29

Table 3. Percent change from qualifying time to preliminary performance for 50-meter events (data represent mean and 95% confidence interval). Negative values indicate preliminary performances were slower than qualifying times. A given lane's performances were categorized into Lane Groups based on the effect of direction of distance freestyle splits (see Table 1), with inclusion criteria defined as follows: the lane had a moderate or greater negative direction effect, the lane had a small or trivial direction effect (No effect), or the lane had a moderate or greater positive direction effect during the distance freestyle events.

		Lane Group					
	Year	Negative Effect	n	No effect	n	Positive effect	n
Olympic Games	2000	-1.48 to -0.77	86	-0.76 to 0.27[1]	50		
World Championships	2007	-1.04 to -0.78	833				
World Championships	2011	-1.08 to -0.67	272	-0.55 to 0.00[1]	160		
US Olympic Trials	2012	-1.60 to -1.06	95	-0.73 to -0.15[1]	64	-0.99 to -0.60[1]	161
World Championships	2013	-1.08 to -0.68	258	-0.45 to 0.18[1]	57	0.18 to 0.60[1]	204

[1] significantly greater than the negative effect Lane Group ($p < 0.05$).