PERFORMANCE GAINS IN RELAY SWIMMING (PART I): THE RELAY START BENEFIT COMPONENT

Xiao Qiu, Claudia Braun, Sebastian Fischer, Armin Kibele

Institute for Sports and Sport Science, University of Kassel, Kassel, Germany

The present study aimed to detect statistical differences in the start performance between relay and individual races accounting for gender and relay start techniques. Race data of relay races and corresponding individual races from European Championships (2019) were analysed. Linear mixed models for repeated measures were applied to compare the differences in the 15 m start times (after toe-off) between relay and individual races accounting for gender and relay start techniques. The results revealed a small time benefit for step-starts over no-step starts in the freestyle races. Furthermore, depending on techniques, male butterfly swimmers showed more pronounced differences in their start performance as compared to female swimmers. However, no statistical differences were found in breaststroke races for either gender or relay start technique. The findings of the present study may improve coaches' and swimmers' understanding of the downsides and benefits of different relay starts. Based on results, we suggest that, at least for freestyle relays, a step-start should be the relay start technique of choice.

KEYWORDS: swimming, relay start, performance analysis.

INTRODUCTION: Previous studies have consistently shown performance gains in relay swimming over individual swimming (e.g., Hüffmeier & Hertel 2011; Hüffmeier et al., 2020). From a biomechanical perspective, swimming relay races differ from individual races, for the most part, through the start behaviour of relay swimmers in the second to fourth team position (Kibele & Fischer, 2018). Instead of starting after an acoustic signal, the second to fourth relay swimmers can initiate their starting movements at any time as long as both or one of their feet are still in contact with the starting block when the incoming swimmer touches the wall. Although, possible motivational advantages in relay swimming compared to individual swimming were previously investigated (Braun et al., 2021; Hüffmeier et al., 2020) existing knowledge about possible benefits in the relay start technique over the individual start technique is still limited. One might expect that, owing to the introductory movement (including steps and arm movements) on the block enabling relay swimmers to extend their acceleration pathway and increase velocities at take-off (Kibele & Fischer, 2018), a relay start should prove to be more effective than an individual start. In turn, previous studies have focussed, in this respect, on differences in the aerial phase highlighting spatiotemporal parameters (Qiu et al., 2021a) or entry and underwater performance (Atkison, 2018; Qiu et al., 2021b). While in the past two decades, various relay start techniques have been developed, e.g., no step with a circular arm swing, single-step or double-step techniques (McLean et al., 2000; Qiu et al., 2021c; Takeda et al., 2010), no studies have been conducted, so far, to examine differences between start performance in relays versus individual swimming based on race data in international competitions. Therefore, the goal of the present study was to analyse real competitions in order to compare the start performance times between relay and individual races accounting for gender and relay start techniques.

METHODS: The following race data were collected: 4 × 100 m relay races (freestyle/medley/mixed) and corresponding individual races of the European Junior Swimming Championships 2019 in Kazan (long course) as well as 4 × 50 m relay races (freestyle/medley/mixed) and corresponding individual races of the European Short Course Swimming Championships 2019 in Glasgow. Swimmers (age: 20 ± 4.38 yrs) who participated in relay and the corresponding individual events were sampled as participants. Data from disqualified swimmers and first relay swimmers were excluded from the statistical analysis as first relay swimmers commonly performed the same start technique as compared to an individual race. Overall, a total of 217 swimmers (2 genders × 3 strokes) were included in the

statistical analyses. Video footages were provided by the championship organisation sampling at 50 Hz (HD). Each lane was covered by a tracked camera located at the pool's public stands to record the swimmer's entire race performance, enabling the analysis of the start phase of both events.

Linear mixed models (LMM) analyses were conducted to examine the differences between relay and individual races in start performance times. Differences in the 15 m start time (time from swimmer's toes take-off from the start block to head passing the 15 m mark) between relay and individual races were defined as the dependent variable. The time differences were calculated as: 15 m start time in individual races minus 15 m start time in relay races, meaning that a positive value represents a faster start performance in the relay race and a negative value represents a slower start performance in the relay race. The fixed effects were defined by gender and swimmers' relay start techniques. Mainly, three types of relay start techniques were observed during races: no step-kick start (NS-KS), no step-with arm swing (NS-WA), and step-start (SS, both single-step and double-step starts were defined as step-start due to the small number of double-step starts). Bonferroni post-hoc tests were adopted to verify localised differences. Effects size (ES) was calculated by Cohen's d and categorised as the following thresholds: 0.2, trivial; 0.6, small; 1.2, moderate; 2.0, large; 4.0, very large; and $\geqslant$ 4.0, extreme large (Hopkins et al., 2009). All statistical analyses were conducted using SPSS (version 25.0, IBM), and significance was set at $p < 0.05$.

RESULTS: The LMM revealed a significant effect of relay start technique in freestyle races, $F(2, 72.55) = 3.87$, $p = .025$. A post-hoc Bonferroni test indicated a faster start performance ($p = .02$, $d = 0.58$) for freestyle relay swimmers SS technique ($M = 0.06$ s, $SD = 0.09$ s) compared to NS-KS techniques ($M = 0.007$ s, $SD = 0.09$ s). Furthermore, the LMM revealed a gender difference in the start performance between the relay and the individual races for butterfly events depending on relay start techniques, $F(1, 24.48) = 7.35$, $p = .012$, $d = 0.97$. However, no significant differences for the breaststroke races, neither for the fixed effect gender nor relay start techniques were observed. Figure 1 shows the mean start performance loss/gain between relay and individual races across all strokes.

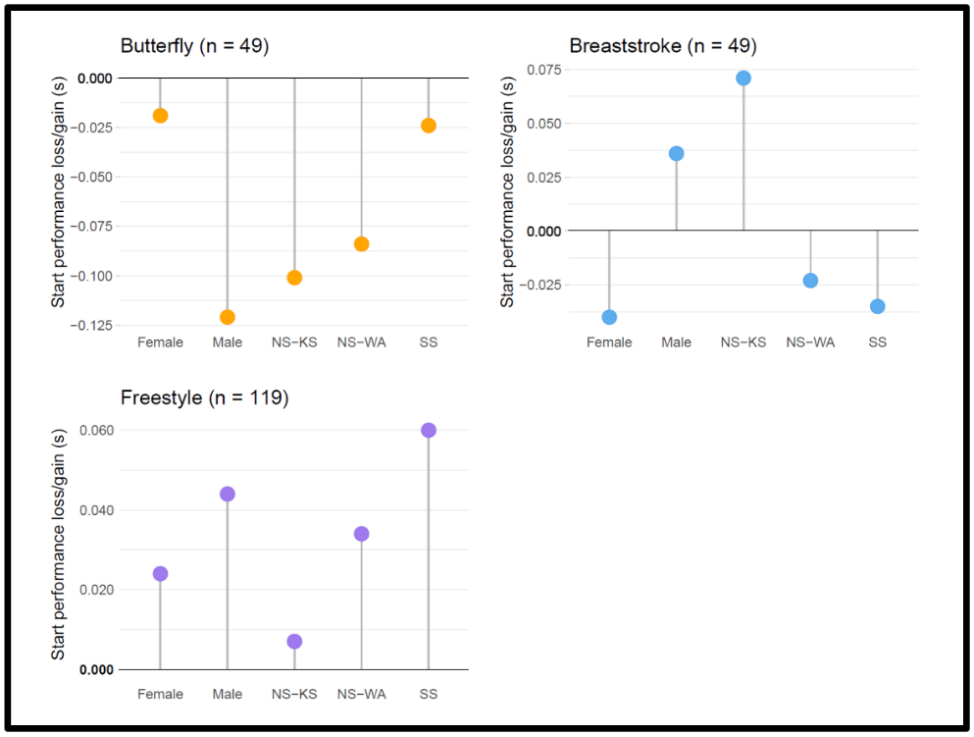

Figure 1: Mean start performance loss/gain between relay and individual races across all strokes.

DISCUSSION: The present study aimed to identify relay start benefits as a component of performance gains in relay swimming. Therefore, we compared start performance times between relay and individual races accounting for gender and relay start techniques for three different strokes. The main finding of our study was that step techniques provide an advantage over no-step kick start techniques in freestyle races. The results for breaststroke and butterfly races don't match to the results found in the freestyle data. For these strokes, no clear advantage for either start technique is provided. As a consequence, performance differences between relay and individual swimming in these strokes may not be related to the relay start. However, our results may be influenced by a lack of power owing to small subgroup sizes.

This study is the first study to investigate the effect of different relay start techniques on differences between relay and individual performance in international competitions (e.g., two European Championships in 2019). Three mainly used relay start techniques were analysed. The substantial differences between the three relay start techniques analysed were found for freestyle races with a time benefit for step-starts over no-step starts (Figure 1). This finding is consistent with previous results in an experimental setup (Qiu et al., 2021c), demonstrating a trend for shorter start performance times for the step start techniques compared to no-step start techniques. As a possible cause, preparatory steps and arm movements on the start block may enable swimmers to extend their acceleration pathway and, thus, further affect performance in the following start phases (Kibele & Fischer, 2018).

Moreover, for butterfly races, both genders exhibited slower relay start performances versus their individual start performances (negative values), and male swimmers exhibited a significantly larger time difference than female swimmers. Potentially lower entry and underwater performances in relay starts than individual starts (Atkinson, 2018; Qiu et al., 2021b) might lead to increased drag forces thereby affecting performance times, resulting in slower start times for both genders in relay races. However, our study did not investigate underwater data; thus, studies are needed to address underwater time differences between relay and individual races taking into account gender and different relay start techniques.

Our results provide a basis for some practical recommendations to coaches. To enhance performance times in relay races, step starts should be preferred for training and competition. However, owing to a more extended action on the block, a different timing pattern may be required when matching the motor actions on the block with the approach of the incoming swimmer. In addition, more research is needed to further analyse relay starts in butterfly and breaststroke events. Our sample may have been too small to provide conclusive evidence on the most beneficial relay start technique for these strokes. Further, our data indicates a trend for start performance losses in medley relays for those strokes. Future studies should verify this trend and analyse possible causes.

CONCLUSION: The present study aimed to quantify the beneficial effect of relay start techniques on performance gains in relay races. Time differences in the 15 m start performance between relay and individual races in two European Championships (2019) were analysed. We found relay start benefits in freestyle races with step techniques. The findings of our study suggest that (at least freestyle) swimmers should use and thus train step techniques to enhance their relay performances.

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