PERFORMANCE GAINS IN RELAY SWIMMING (PART II) – THE MOTIVATION GAINS COMPONENT

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The purpose of this study was to test whether swimmers become further motivated by swimming in a relay team compared to swimming on their own, which results in increased performance. Particularly, we assume that this increased motivation results in a performance that even exceeds their best performance achieved in individual competitions (their personal best). However, because the often-observed performance gains in relay swimming are the sum of relay start benefits and increased motivation caused by teamwork it is necessary to determine the advantage that is caused by a relay start (Fischer, 2017; Qiu et al., 2021) to accurately evaluate relay versus individual performances. But to date, the proportion of these two components remains unclear. The results of the current research show that most of the fastest swimmers from the last 20 years swam faster in a relay race. Thus, they exceeded their personal best (from an individual race) in a relay race due to the social influences of the team membership. Furthermore, the share of the performance that is due to increased motivation is markedly larger than that of the relay start benefit. This study is the first quantifying the motivation gains component in relay swimming.

KEYWORDS: relay swimming, motivation gains, relay start benefit.

INTRODUCTION: Previous studies frequently showed performance gains of swimmers in relay races (Hüffmeier et al., 2011, 2012, 2017, 2020; Braun et al., 2021). Those gains are commonly explained by increased motivation due to the membership in a team. According to Self-Determination Theory (SDT, Deci & Ryan, 1985) intrinsic motivation should be increased by this membership as the basic psychological need of *relatedness* is satisfied more strongly when acting in a team. Furthermore, a team membership leads to perceived responsibilities towards the fellow members, which result in increased effort expenditure (Hüffmeier et al., 2020; Johnson & Johnson, 2009). Therefore, this study investigates whether even the fastest 100-m-freestyle performances ever swum by male swimmers in an individual race were exceeded by them in a corresponding relay race.
However, performance gains for the section in the water (excluding the part on the starting block) are not only the result of increased motivation by the swimmers. They are also composed of benefits caused by the "flying start" of second to fourth positioned swimmers within their relay team. There is evidence that such relay starts can lead to a faster start performance due to the possibility of higher center of mass acceleration (McLean et al., 2000; Kibele & Fischer, 2018). However, the share of such starting benefits in the general performance gain has not yet been quantified. Therefore, the second aim of this study was to specify the share of the often-observed performance gains that is due to the start in relay swimming.

METHODS: In this study, we infer changes in athlete motivation from behavioural indicators like it was done in previous studies (for an overview see Hüffmeier & Hertel, 2020), as it is not possible to directly measure athlete motivation when analysing archival data. Therefore, the 50 fastest male 100 m freestyle swimmers (individual race) between the years 2000 and 2019 (from Olympic Games or World Championships) were selected in this study. We collected their fastest performance times as well as their corresponding reaction times from the results archives of www.fina.org. In addition, the fastest relay split times of the same swimmers swum

in a 4 x 100 m freestyle event as well as the corresponding reaction times (time from start signal to swimmers' toe-off from the starting block) and change-over times (time between the wall contact of the incoming swimmer and the toe-off of the outgoing swimmer) were collected from this website, respectively. To account for the different starting procedures between individual races and relay races all performance times/relay split times were corrected for the respective reaction or change-over times. For individual races and the first starter of the relay ("gun start"), reaction times were subtracted from the performance times. For the relay swimmers at positions two to four ("flying start"), the corresponding change over times were subtracted from the relay split times. To analyse differences between the individual swim time and the relay swim time, a paired *t*-test was conducted.
To quantify the relay start benefit (i.e., faster 15-m-times in relay races due to relay start techniques), video footage of freestyle performances from 62 male swimmers from the European Short Course Swimming Championships in Glasgow (2019) and the European Junior Swimming Championships in Kazan (2019) were analysed in a pilot study. Start performance was defined as time from toe-off until the head passes the 15-m-mark (15-m-time). The relay start benefit was calculated by subtracting the 15-m-times of the relay race of second to fourth relay swimmers from their 15-m-times of the individual race (for more details of this study see abstract of Qiu et al. for this congress) and was related to the relay start techniques no-step-start and step-start. A linear mixed modelling (LMM) analysis was conducted to account for multiple appearances of swimmers in different events or the analysed competitions. Relay start technique (no-step start, step start) was defined as fixed effect while event (mixed, gender-homogeneous) and competition (Glasgow, Kazan) were defined as repeated variables.

RESULTS: Performance gains: Seventy percent of the swimmers swam faster in the relay race compared to their best performance in an individual race, $X^2(1) = 8.0$, $p = .005$.
A paired *t*-test revealed significantly faster mean relay split times ($M = 0.18$ s, $SD = 0.39$ s) compared to individual race times for the complete 100-m-distance, $t(49) = 3.24$, $p = .002$, $d = 0.46$. Furthermore, those performance gains were nearly equal for both legs of the 100-m-distance, 0-50 m: $M = 0.09$ s, $t_{0\text{-}50}(49) = 1.96$, $p = .06$, $d = .28$; 50-100 m: $M = 0.09$ s, $t_{50\text{-}100}(49) = 2.21$, $p = .032$, $d = .31$ (see Figure 1).

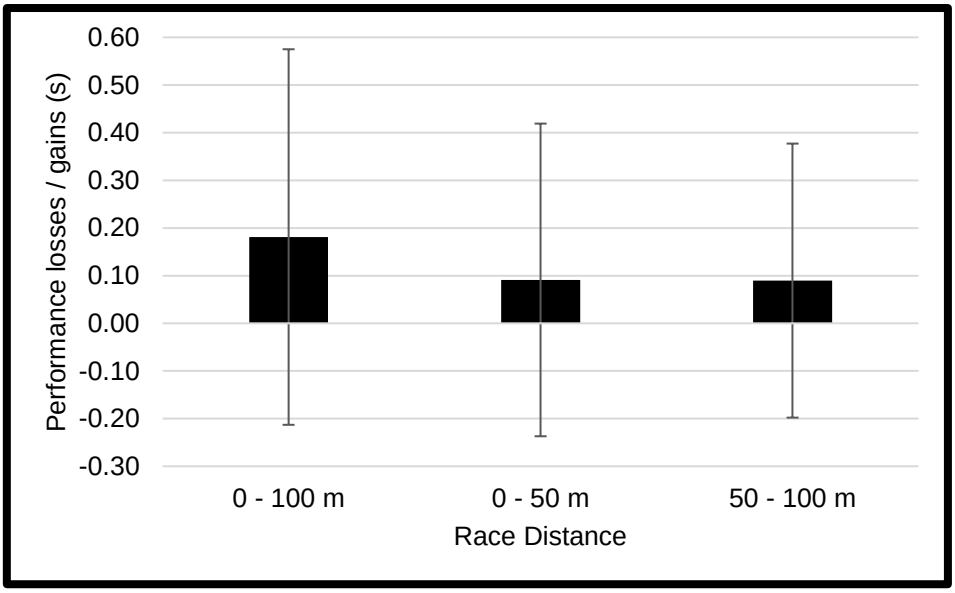

Figure 1: Mean performance gains for the complete 100-m-distance and both legs separately. Performance gains were calculated by subtracting the reaction or change-over time corrected relay split times from the reaction time corrected individual race times. Positive values depict faster swim times in the relay race whereas negative values depict faster swim times in the individual race.

Relay start benefit: A LMM analysis revealed no effect of relay start technique, $F(1, 60.2) = 1.87$, $p = .177$, indicating no differences in relay start benefits for step-starts ($M = 0.058$ s, $SD = 0.10$ s) compared to no-step starts ($M = 0.027$ s, $SD = 0.097$ s) (see Figure 2).

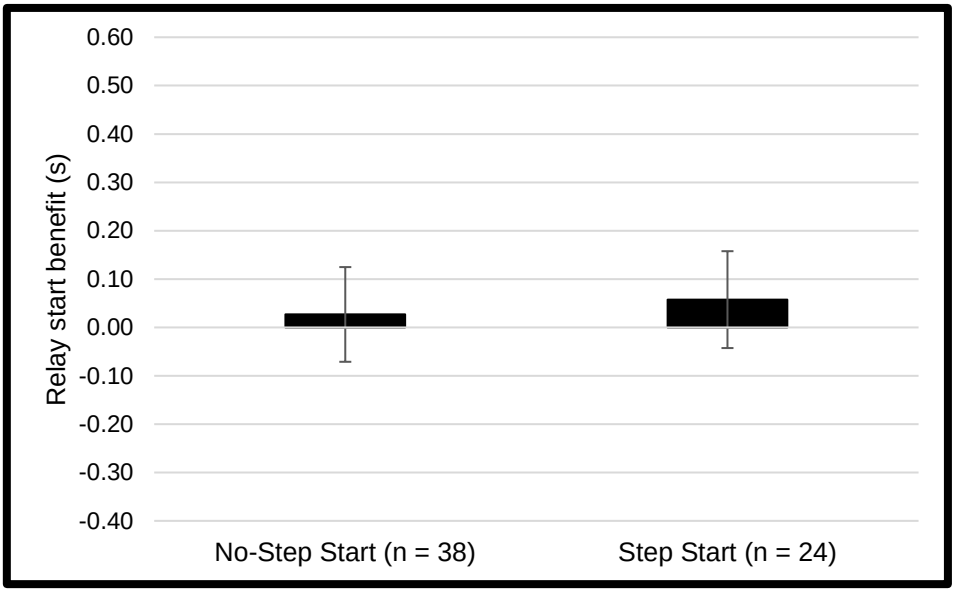

Figure 2: Mean relay start benefits of male swimmers. Relay start benefits were calculated by subtracting the 15-m-times from relay races from the 15-m-times of individual races for every swimmer. Positive values depict faster 15-m-times in the relay race whereas negative values depict faster 15-m-times in the individual race.

DISCUSSION: On average, most of the best swimmers in the world were able to significantly beat their personal best time - achieved in an individual race - in a relay race. Thus, the results of this study confirmed our hypothesis that the team situation further motivates the swimmers resulting in increased motivation compared to an individual race situation.

Performance gains were present in both legs of the 100-m distance. This result is in line with the findings of Braun et al. (2021) who could also show performance gains for both legs in 4 x 100 m freestyle relays for a much larger elite-class sample. This result is a strong indication for the motivational component of the often-observed performance gains because a possible swim start benefit cannot influence the second leg of a 100-m-split. Further evidence for the motivational component is derivable from the findings of the pilot study. Even though the start benefit is independent on the specific relay start technique with a somewhat larger benefit for step-techniques and slightly smaller benefit for no-step techniques, the mean relay start benefit is rather small ($M = 0.039$ s, $SD = 0.099$ s).

Based on these results, we can conclude that the motivational component of the performance gains in the main study is markedly larger than the relay start component. Here, it amounts to approximately 80% of the overall performance gain while the relay start represents approximately 20%. Thus, performance gains of relay swimmers are mainly driven by increased motivation among the team members.

Off note, the sample contains various (former) world record holders, i.e., who have already shown an exceptional performance in the individual competition that no one has been able to achieve before. In the relay competition, moreover, they were able to push the limits of their performance even further. These results underline the importance of mental states in achieving peak performances (Krane & Williams, 2010). Intrinsic motivation may be boosted through the membership in a relay and thus a stronger satisfaction of the basic psychological need relatedness (Deci & Ryan, 1985).

In addition to higher intrinsic motivation, the positive social interdependence among relay swimmers' goal attainments also probably plays a role: Relay swimmers know that they can only attain their own goals when their teammates attain their goals (Johnson & Johnson, 2009). The knowledge that one's performance affects the success of teammates seems to generate

perceptions of responsibility that increase one's efforts. The influence of such responsibility forces has been shown in previous studies analysing the influence of the swimmers' serial position in relay swimming (e.g., Hüffmeier & Hertel, 2011; Hüffmeier et al., 2020). These studies show increasing effort expenditure of relay swimmers with later starting position within the team. This finding is commonly explained by the increasing perception of social indispensability with later serial positions since the possibility for performance compensation by teammates wanes.

CONCLUSION: This study showed the effect of a team context on effort expenditure of the fastest swimmers in the world. As a relay member, most of them significantly exceeded their personal best performance of a 100-m-freestyle individual race. Those gains cannot solely be explained by benefits of a relay start technique as this study shows that this share of the observed performance gains is much smaller than the motivational component. Thus, the swimmers were potentially further motivated due to the membership in a cooperatively linked team, which maybe led to an increase of effort expenditure in their relay performance.

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