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Effects of different swimming race constraints on turning movements

Santiago Veiga [a,b,*], Javier Mallo [b], Archit Navandar [b], Enrique Navarro [b]

[a] Madrid Swimming Federation, C/ José Martinez Velasco, 3, 28007 Madrid, Spain
[b] Technical University of Madrid, Health and Human Performance Department, C/ Martín Fierro, 7, 28040 Madrid, Spain

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ABSTRACT

The aim of this study was to investigate the effects of different swimming race constraints on the evolution of turn parameters. One hundred and fifty-eight national and regional level 200-m (meters) male swimming performances were video-analyzed using the individualized-distance model in the *Open Comunidad de Madrid* tournament. Turn ($p < .001$, ES = 0.36) and underwater distances ($p < .001$, ES = 0.38) as well as turn velocity ($p < .001$, ES = 0.69) significantly dropped throughout the race, although stroke velocity and underwater velocity were maintained in the last lap of the race ($p > .05$). Higher expertise swimmers obtained faster average velocities and longer distances in all the turn phases ($p < .001$, ES = 0.59), except the approach distance. In addition, national level swimmers showed the ability to maintain most of the turn parameters throughout the race, which assisted them in improving average velocity at the end of races. Therefore, the variations in the turning movements of a swimming race were expertise-related and focused on optimizing average velocity. Turning skills should be included in the swimming race action plan.
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1. Introduction

In competitive swimming, both underwater and surface swimming techniques (Cohen, Cleary, & Mason, 2012) are employed by competitors to overcome the aquatic constraints that impose forward

* Corresponding author at: Madrid Swimming Federation, C/ José Martinez Velasco, 3, 28007 Madrid, Spain. Tel.: +34 616001953.
E-mail address: santi.veiga@fmn.es (S. Veiga).

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resistance (Toussaint & Beek, 1992; Toussaint, Roos, & Kolmogorov, 2004). Underwater swimming allows competitors to minimize their velocity loss after dives and turns (Connaboy, Coleman, Moir, & Sanders, 2010) as far as a maximum of 15-m from the starting or turning walls. In most cases, this is achieved by minimizing the resisted drag forces with a streamlined body position (Lyttle, Blanksby, Elliott, & Lloyd, 1998) and by maximizing propulsion with the swimmer's feet moving simultaneously in vertically-oriented motions (Von Loebbecke, Mittal, Mark, & Hahn, 2009), in an underwater undulatory stroke (Connaboy, Coleman, & Sanders, 2009). Compared to surface swimming, forward velocities during underwater swimming are greater (Vennell, Pease, & Wilson, 2006) whereas kinematics are significantly simpler (von Loebbecke, Mittal, Mark, et al., 2009). On the other hand, physical exertion is probably greater for the swimmer due to apnea conditions.

The analyses of swimmers' performances have traditionally examined spatio-temporal parameters representing the starting, stroking and turning segments in a swimming race (Arellano, Brown, Cappaert, & Nelson, 1994) but, somehow, have overlooked the role of underwater swimming techniques. Researchers and/or practitioners have measured partial times at 5, 10, 15 or 25-m intervals from the starting or turning walls and have evaluated how different swimming constraints, such as increasing fatigue, affect their evolution throughout races (de Jesus et al., 2012; Figueiredo, Rouard, Vilas-Boas, & Fernandes, 2013; Figueiredo, Zamparo, Sousa, Vilas-Boas, & Fernandes, 2011; Hellard et al., 2008; Suito et al., 2008; Toussaint, Carol, Kranenborg, & Truijens, 2006). However, temporal race parameters do not discriminate between submerged and surface techniques and it cannot be assumed that swimmers travel the same distances with starting, turning or stroking movements (Veiga, Cala, Mallo, & Navarro, 2013). In fact, the limitations of quantifying only traditional race parameters have been increasingly recognized in recent years (Psycharakis, Naemi, Connaboy, McCabe, & Sanders, 2010).

Underwater swimming techniques, such as the undulatory swimming or the breaststroke pullout with dolphin kick (McLean, Havriluk, & Brandt, 2008) are relatively new in competitive swimming (Arellano, Pardillo, & Gavilán, 2002; Von Loebbecke, Mittal, Fish, & Mark, 2009). However, at present, there is a growing research interest in these competitive techniques (Connaboy et al., 2010; Hochstein & Blickhan, 2011; Puel et al., 2012) as they are supposed to provide a competitive edge to swimmers (Atkinson, Dickey, Dragunas, & Nolte, 2014; von Loebbecke, Mittal, Fish, et al., 2009). Several factors have been reported to affect the effectiveness of underwater undulatory swimming, including the kick frequency (Cohen et al., 2012), amplitude (Houel, Elipot, André, & Hellard, 2013), symmetry (Atkinson et al., 2014) and swimmer morphology (von Loebbecke, Mittal, Fish, et al., 2009). Distances traveled with underwater movements have been found relevant to the starting and turning (Blanksby, Elliott, McElroy, & Simpson, 1998; Tourny-Chollet, Chollet, Hogie, & Papparodopoulos, 2002) competitive performances. However, it is unknown how swimmers organize the underwater or surface components during a swimming race or how various competitive swimming constraints (like the number of laps, gender, expertise or event stroke) could influence the underwater swimming parameters. Previous research studies have reported that skilled swimmers exhibited more stable stroking parameters and average velocities (Chollet, Pelayo, Delaplace, Tourny, & Sidney, 1997; Figueiredo et al., 2011; Hellard et al., 2008) in 100 and 200-m freestyle races, although there is still a lack of knowledge if this skill issue is also present during non-swimming segments.

Therefore, in the present study we employed the individualized-distance method to detect the underwater and surface components of swimming races. The main aim of the investigation was to examine the effects of different swimming race constraints (lap, stroke and swimmers expertise) on the evolution of individualized-distance turn parameters. It was hypothesized that the turning parameters might be related to the swimmer's ability.

2. Methods

2.1. Participants

One hundred and fifty-eight male swimming performances were video-analyzed in the 200-m final events of the *2008 Open Comunidad de Madrid*, an international competition organized by the Madrid

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