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Effect of fatigue on the intra-cycle acceleration in front crawl swimming: A time–frequency analysis

V. Tella[a], J.L. Toca-Herrera[b,*], J.E. Gallach[a], J. Benavent[a], L.M. González[a], R. Arellano[c]

[a]*Departamento de Educación Física, Universidad de Valencia, Spain*
[b]*Biosurfaces Unit, CIC BiomaGUNE, Paseo Miramón 182, 20009 San Sebastian, Spain*
[c]*Departamento de Educación Física, Universidad de Granada, Spain*

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Abstract

The present study analyzes the changes in acceleration produced by swimmers before and after fatiguing effort. The subjects ($n = 15$) performed a 25-m crawl series at maximum speed without fatigue, and a second series with fatigue. The data were registered with a synchronized system that consisted of a position transducer (1 kHz) and a video photogrametry (50 Hz). The acceleration ($\mathrm{m\,s^{-2}}$) was obtained by the derivative analysis of the variation of the position with time. The amplitude in the time domain was calculated with the root mean square (RMS); while the peak power (PP), the peak power frequency (PPF) and the spectrum area (SA) were calculated in the frequency domain with Fourier analysis.

On the one hand, the results of the temporal domain show that the RMS change percentage between series was 67.5% ($p < 0.001$). On the other hand, PP, PPF, and SA show significant changes ($p < 0.001$). PP and SA were reduced by 63.1% and 59.5%, respectively. Our results show that the acceleration analysis of the swimmer with Fourier analysis permits a more precise understanding of which propulsive forces contribute to the swimmer performance before and after fatigue appears.
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Keywords: Swimming; Acceleration; Fatigue; Frequency analysis

1. Introduction

Swimming displacement is the result of the application of a propulsive force to overcome the body drag (Maglischo et al., 1987; Costill et al., 1987; Chengalur and Brown, 1992). In this sense, the acceleration that a swimmer achieves while moving will be the result of the interaction between the aforementioned forces and the water. Indeed, a right body position and adequate both arm and leg movements will influence a more efficient front crawl technique (Schleihauf et al., 1986; Maglischo et al., 1988; Toussaint et al., 1988; Chatard et al., 1990). Some recent theoretical models (Bixler and Riewald, 2002; Rouboa et al., 2006) show the importance of making accelerated propulsive movements to increase drag forces. Conversely, if acceleration lessens while the propulsive movements are being made, the magnitude of the produced drag force diminishes (Bixler, 2005).

Specifically, front crawl swimmers carry out three underwater phases with their arms (*Downsweep*, *insweep* and *upsweep*) as well as a series of leg movements to generate propulsion. The most frequent leg-arm coordination is that which includes six kicks per cycle (Maglischo, 1993). As in the aforementioned theoretical models, in Schleihauf et al. (1983) had already shown that the various arm propulsive phases made by top swimmers were done so in an accelerated fashion.

In contrast, specific movements that are characteristic of the front crawl style, such as body roll, how the hands enter the water, breathing and the depth that certain parts of the body reach, may bring about decelerations if they are performed incorrectly. On the other hand, when rolling is synchronized with the propulsive movements that the arms and legs perform, such movements are more efficient and produce greater accelerations (Toussaint and Beek, 1992; Yanai, 2001).

*Corresponding author. Tel.: +34 943 00 53 13; fax: +34 943 00 53 14.
E-mail address: jltocaherrera@cicbiomagune.es (J.L. Toca-Herrera).

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