ELECTROMYOGRAPHIC ANALYSIS OF THE FLIP TURN TECHNIQUE

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The purpose of this study was to assess the electric potential of the muscles *vastus lateralis* (VA), *gastrocnemius* (GM), *tibialis anterior* (TA) and *biceps femoris* (BF) during the front crawl flip turn technique. The subject was an elite male front crawl/backstroke swimmer. Surface active electrodes were used and EMG signals were transmitted by 25m long cables to the main amplifier. BF and TA showed higher participation in the beginning of the "rotation", implying that its action is fundamental to a higher rotation velocity. In the "wall contact", TA and GM muscles seemed to be in co-activation. VL presented a significant activation during the "impulse". In the beginning of the "gliding", all the studied muscles presented low EMG signals. These new methodology procedures seem to be valid and reliable to assess the muscular function during the flip turn.

KEY WORDS: EMG, swimming, front crawl, flip turn.

INTRODUCTION:

Swimming turns are complex movements and are hard to analyze without proper technology. This fact is due to the aquatic environment, namely the resistance, refraction and pressure of the water, but also to the simultaneous movements of the several body segments which are performed in different plans and axis. This evidence seems to explain why, considering all swimming techniques, turns seem to be the less investigated. Furthermore, turns are the only swimming technique that imposes a contra- movement action.
From the four conventional swimming techniques, front crawl has been the most studied one, which might be associated to the fact of being the fastest stroke, and the one with the higher number of events in official competitions. During the front crawl events the flip turn technique is often used. This referred technique is the product of a long evolution process of the turning techniques used in front crawl events, probably starting with the open turn, and is also used, since recently, in backstroke events. Flip turn can be divided into five phases: (i) approach to the wall; (ii) rotation; (iii) wall contact; (iv) glide and (v) stroke preparation (Haljand, 1998; Lyttle & Benjanuvatra, 2006).
Complementarily, electromyography (EMG) applied to swimming could express the dynamic evolvement of the specific muscles responsible of the propulsion of the body through the water (Clarys, (1983). EMG is accomplished by the direct assessment of the electric potential of the working muscles, and provides valuable information to better understand the swimming actions. EMG studies that have examined swimming have been performed mainly taking stroking techniques as research object. Therefore, EMG profiles of turning techniques seem to be inexistent, which clearly justify the pertinence of the purpose of this study: to assess the EMG muscular action of the lower limb segments during front crawl flip turn technique.

METHODS:

A case study was conducted with a male front crawl/backstroke swimmer from the Portuguese national swimming team (2007 World Championship participant). The test session took place in a 25 m indoor swimming pool, with a water temperature around 27.5ºC. Briefly, the subject performed three turning trials at maximal velocity. The selected turn technique was the one that the swimmer usually applies during training and competition. The trials started and finished from a mark placed at 12.5 meters from the turning wall. EMG analysis was conducted considering "rotation", "wall contact" and "glide" phases. The "glide phase" was considered to be ended at the first leg kick off the wall.

EMG surface active electrodes were placed at 20mm apart and parallel to the muscle fibers. The muscles analysed were *vastus lateralis* (VA), *gastrocnemius* (GM), *tibialis anterior* (TA) and *biceps femoris* (BF). The swimmer's skin was prepared, shaved and cleaned, according to European Recommendation for Surface Electromyography - SENIAN (1999). Electrodes were water-proofed using proper adhesives (Tegaderm3M®, Figure 1A) and silver tape (Figure 1B). The swimmer used a Fast Skin ® swimsuit (Speedo®), with an cable entrance opened in the medium-dorsal position (Figure 1C). Additionally, over the water, at a 2 m height, a steel cable was extended with a sheave (Figure 1D), to which the cables corresponding to each one of the four electrodes (joined in a single beam) were fixed. All these procedures were used in order to reduce the mobility of the electrodes and to increase the comfort of the swimmer, allowing all "natural" turning movements during the test (Figure 1E).

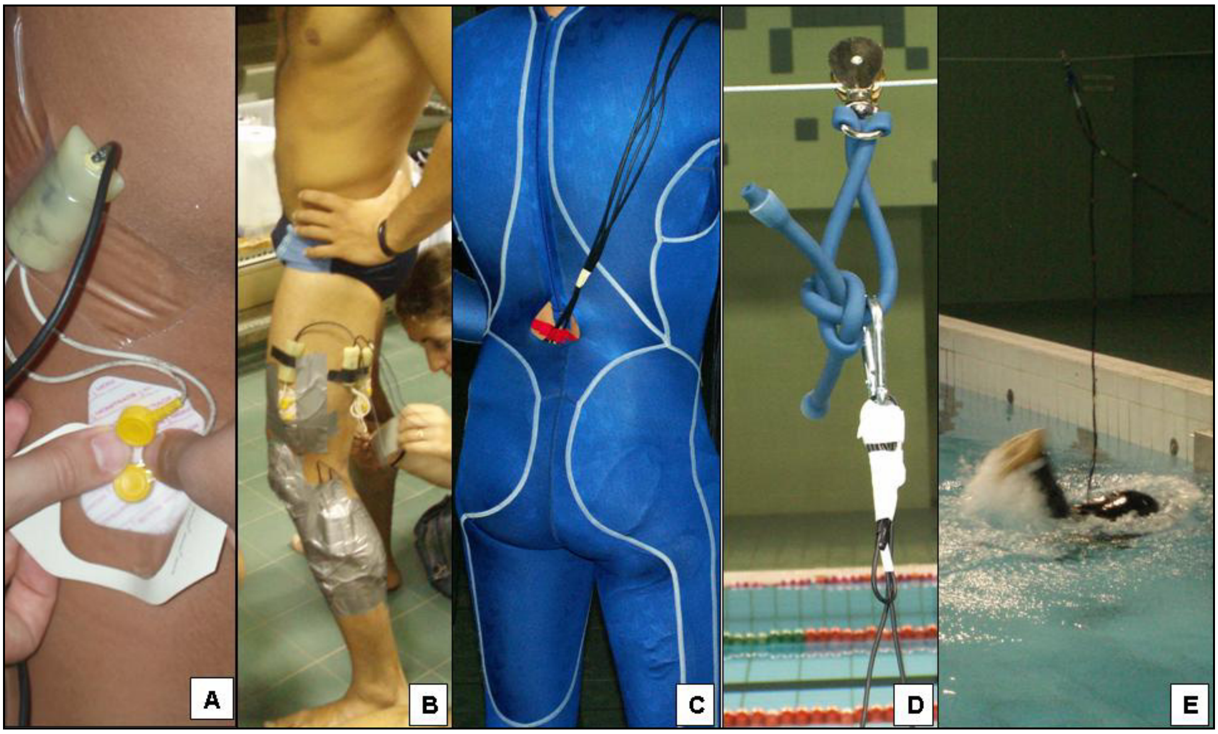

Figure 1: A-electrodes covered with water-proofed adhesives; B-electrodes recovered with silver tape; C-swimmer dressed with adapted Fast Skin®; D-system developed for sustentation of the cables; E-swimmer with the cables performing the flip turn.

The active electrodes used a pre-amplifier (AD621BN), with a 100 gain and the CMRR of 110 dB (Carvalho, Gonçalves, Sousa, Conceição, & Vilas-Boas, 1999). The registered and pre-amplified signals were transmitted by 25 meter cables to the main amplifier, where the signals were conditioned and amplified 11 times, in a total amplification of 1100 (Gonçalves, 2006). The isolation of the electronics of the active electrodes was carried out imbedding it in special glue (Araldit ®).

The signals were acquired by an A/D converter (BIOPAC Systems, Inc.) with one input voltage range of ± 10 volts and a sampling frequency of 1000 Hz, supplied by a 15 volts energy source. The converter allowed the ulterior acquisition of the signal by a PC, and its numerical treatment through Acqknowledge® 3.2.5 software (BIOPAC System, Inc.). The routines for the treatment of the EMG signal were: (i) digital filtering, pass-band of 35-450 Hz; (ii) removal of the common component (DC offset); (iii) full-wave rectification; (iv) linear envelope; (v) normalization of the signal for the maximum value of the dynamic action and (vi) integral of treated signal (iEMG).

RESULTS AND DISCUSSION:

In Figure 2 the EMG signals of the 4 studied muscles are presented for the “rotation”, “wall contact” and “glide” turning phases. After the “approach to the wall” and during the beginning of the “rotation” phase, it occurs a simultaneous action of the legs, observable in Figure 2 by an activation of BF and TA. This action results in a high position of the hips, with the legs near the surface, and the head and shoulder facing down. The TA muscle is responsible by the dorsiflexion of the feet, leading to a lower water resistance during the emersion of the legs. According to Lytlle e Banjanuvatra (2006), the flexion of the knees is a fundamental action of the “rotation” phase because it increases the velocity of rotation by reduction of the moment of inertia due to the more pronounced proximity of body mass to the axis of rotation. The main action of the BF in this phase of the turn is exactly the flexion of the legs, followed by an ulterior extension during the feet approach to the wall.

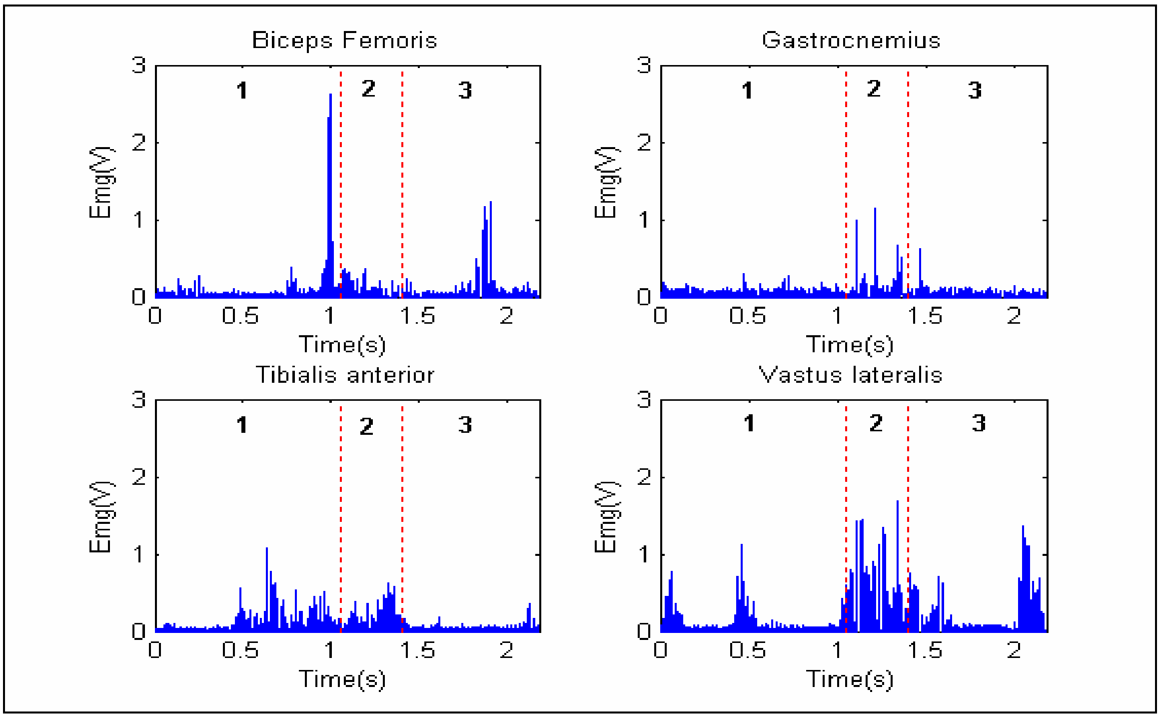

Figure 2: full wave rectified EMG signals of the 4 studied muscles (BF, GM, TA and VA) in the “rotation” (1), “wall contact” (2) and “glide” (3) turning phases of the freestyle flip turn.

Afterwards, immediately before the “wall contact” phase, there is a pre-activation of the lower limb muscles, with a 100 ms duration, to prepare them to the impact (Komi, (1987). This pre-activation is observable in our results in the GM and BF muscles. During the phase 2 (“wall contact”), the VL EMG signal is visible when the feet touch the wall. This precise moment is the one where VL action is more pronounced during the all turn. In Figure 2 it is also possible to see that TA and GM muscles seem to be in co-activation immediately after the “wall contact”, this is, during the “impulse” action.

In the beginning of the “gliding”, all the studied muscles present low EMG signals until the first action of the legs occurs. In this precise instant in time, BF is responsible for the flexion of the legs, and VL for the subsequent extension, corresponding to the down sweep of the legs.

The quantitative results presented in Table 1 complement the data of Figure 2. The BF values seem to indicate that there was a fast and intense muscle contraction in the preparation of the turn. This fact was again observable during the first leg kick in the beginning of the “stroke preparation” phase.

Complementarily, GM, TA and VL presented values corresponding to intense but continuous contractions during the phase 2 (“wall contact”), namely during the “impulse”.

Table 1 Mean, standard deviation and IEMG during the 3 turning phases. Gray highlights correspond to the more intense EMG activity in each muscle during the entire turn.

TURNING PHASES / MUSCLES		1 	2 	3 	**Total**
Bíceps Femoris	**Mean**	0.18002	0.17141	0.15951	0.17207
	Std	0.19439	0.08864	0.12996	0.16968
	IEMG	0.18068	0.05914	0.12695	0.36678
Gastrocnemius	**Mean**	0.25341	0.51016	0.23498	0.28559
	Std	0.15916	0.20826	0.10348	0.19635
	IEMG	0.25257	0.17871	0.17734	0.60863
Tibialis Anterior	**Mean**	0.35399	0.41487	0.14226	0.28522
	Std	0.24906	0.22019	0.09991	0.23651
	IEMG	0.35147	0.14409	0.11205	0.60762
Vastus Lateralis	**Mean**	0.18235	0.53823	0.23360	0.25716
	Std	0.16714	0.16753	0.21623	0.23407
	IEMG	0.18423	0.18269	0.18219	0.54892

CONCLUSION:

VL (TA and GM) presented a significant EMG activation during the “impulse” action of the flip turn technique. This fact is in accordance to literature, which refers that the force applied during the impulse, together with small contact time, are major influencing parameters of the flip turn (Pereira et al., 2006). BF showed higher participation in the “rotation” phase, seeming that its action is fundamental to a higher rotation velocity.

The new methodology procedures used in the present study seem to be valid to the assessment of muscular function during the flip turn technique, giving relevant information to the teaching and training of this specific swimming skill.

The data obtained with the EMG muscle analysis during the swimming turns seems to complement the information provided by other areas of applied research in swimming. The inclusion of other muscular groups as well as new technologies of analysis seems to be valid suggestions for a better understanding of the complex movements of turning techniques in swimming.

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