Effect of a wet suit on the technical parameters of front crawl stroke in triathletes
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Introduction
The sport of triathlon starts with an open water swim representing 10 to 15 % of the total time of the race. During the swim, under a 20 degrees water temperature, wearing a neoprene wet suit is mandatory to protect the body against the risk of hypothermia. More than the thermal protection, wet suit also increases the swimming speed up to 10% (Lowdon et al., 1992). The gain in performance can be mainly explained by a buoyancy enhancement. This latter is related to the low specific gravity of the suit, inducing a reduction of the swimming resistance encountered by the subject as a result of a smaller frontal area in the water (Toussaint et al., 1989). Wet suit, covered of smooth surface, also decreases friction drag during the swim giving to the swimmer a more gliding aptitude. Theses differences of position in the water and glide can destabilised swimmers not accustomed to this swim. Indeed, high level swimmers, not used to wet suit, had difficulties to perform a maximal effort when wearing it (Chatard et al., 1995). Thus, the purpose of the present study was to determine whether wearing wet suit increases buoyancy, modifies or not stroke technical parameters in triathletes

Methods
Eleven trained male triathletes, from national to international level completed two standardised 1500m front crawl randomly separated by 6 days. They were instructed to swim at the pace of a short distance competitive triathlon while wearing a complete wet suit (WS) or a standard racing suit (SS). The subjects swam alone in a 50-m pool, starting in the water without diving. The water temperature was 26°C. The hydrostatic lift (HL) was measured, using the method described by Chatard et al., (1990), for the both conditions to estimate the static buoyancy of the triathletes. During the test, subjects were filmed with two fixed underwater camcorders (30 Hz) providing sagittal and frontal plans of the motion. The video views were digitised with a Targa board and stored in a PC computer. According to Schleihauf’s kinematic analysis software (1994), the views were semi-manually digitized frame by frame for one aquatic stroke (from the entry of the hand in the water to its exit) in order to obtain 3-D co-ordinates of 22 anatomical landmarks of the body. After smoothing the data with a second-order polynomial function, the aquatic hand trajectory of the left hand was obtained and divided into three parts: the catch, the insweep and push phases (Maglischo E.W., 1987).

Results & Discussion
The wear of the wetsuit has significantly improved the HL (+262%: from 17.9 ±8.8N with SS to 46.9 ±6.8N with WS, p<0.01) and the swimming velocity (+7%: from 1,180 ±0.114m.s⁻¹ with SS to 1,260 ±0.107 m.s⁻¹ with WS, p<0.01). In comparison to the swim in standard suit, wetsuit increased the hip distance per stroke (+13%, p<0.01). This effect occurred mainly during the insweep phase of the hand. Wearing wetsuit also raised the hip position during the swim (+15%, p<0.05) and increased (+12.4%, p<0.05) the depth of the hand trajectory (Cf. Fig.1) in association to a more extended elbow angle at its deepest point (+11.4%, p<0.05).
Concerning the temporal structure of the stroke, the wetsuit did not significantly alter the stroke frequency of the swim. However, dividing the aquatic phase between a catch phase and a propulsive part (insweep and push phases), it appeared that the wetsuit significantly decreased the time of the propulsive phase (0.545 ±0.07s with SS and 0.503 ±0.04s with WS). No change was observed concerning the percent of time of the aquatic phases. The proportion of each phases in reference to the total aquatic part was respectively the same, for the SS and WS conditions: 53.6 ±12% vs 53.7 ±13% for the catch phase, 23.2 ±13% vs 22.8 ±12 % for the insweep phase and 23.1 ±5 % vs 23.5 ±5% for the push phase.
The index of co-ordination between the propulsive actions of the right and left arm (Chollet et al., 1999) was not modified by wearing wetsuit. During the SS test, triathletes swam with a index of co-ordination
of $-18.7 \pm 9\%$ vs $-21.2 \pm 6\%$ with WS, meaning that they swam in the two cases with discontinuous propulsive actions (probably to keep the body horizontally extended).

**Figure 1:** Average hand trajectories for the swim without (SS) and with wetsuit (WS).

Results of this study pointed out that wetsuit increased buoyancy and swimming velocity without altering the temporal structure of the stroke and the co-ordination of the arms. Changes concerned mainly the spatial parameters of the stroke with an increase of distance per stroke during the action of the hand in the insweep phase. As the time devoted to the propulsive phase is smaller during the swim in wet suit, it can be suggested that the efficiency of the arm action is greatly improved by the buoyancy enhancement. Indeed, observing a greater lever arm in the insweep phase, characterised by a pulling movement, it can be hypothesized that triathletes action are mainly devoted to propulsion than to buoyancy, their hydrostatic lift being increased by wearing wetsuit. This suggestion is consistent with the results found by Chatard *et al.* (1990) on a swimmer’s study. These authors found, independently of the anthropometry of the subjects, a positive relation between the hydrostatic lift and the deepest point of the hand trajectory.

**References:**


