DISCUSSION
This stable spatial symmetry with fatigue could be related to the high expertise level of the swimmers as previously observed (2). The temporal asymmetry specific for each point and each subject appeared to be not linked to the side breathing or to the dominant hand and could reflect the force-time distribution within the stroke.

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RELATIONSHIPS BETWEEN ENERGY COST, SWIMMING VELOCITY AND SPEED FLUCTUATION IN COMPETITIVE SWIMMING STROKES.

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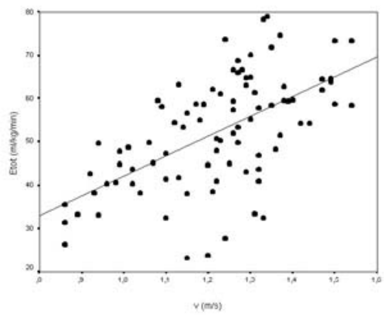
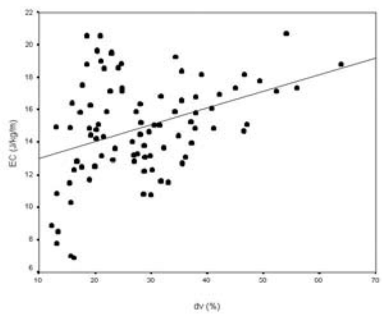
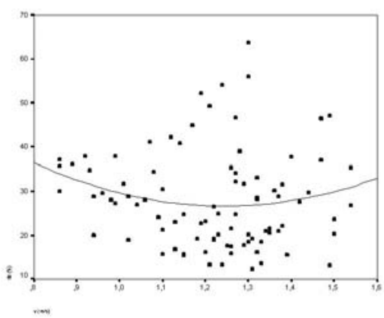
INTRODUCTION
The purpose of this study was to analyse the relationships between the total energy expenditure ($\dot{E}_{tot}$), the energy cost (EC), the intra-cycle variation of the horizontal velocity of displacement of centre of mass (dv) and the mean swimming velocity (v) in the four competitive swimming strokes.

METHODS
17 elite swimmers (4 at Freestyle, 5 at Backstroke, 4 at Breaststroke and 4 at Butterfly) of national or international level were submitted to an incremental set of nx200-m swims ($n \leq 8$). The velocity was increased by 0.05 $m.s^{-1}$ after each swim until exhaustion. Cardio-pulmonary and gas exchange parameters were measured breath-by-breath for each swim to analyse oxygen consumption (VO_2) and other energetic parameters by portable metabolic cart ($K4b^2$, Cosmed, Italy). A respiratory snorkel and valve system with low hydrodynamic resistance was used to measure pulmonary ventilation and to collect breathing air samples. Blood samples from the ear lobe were collected before and after each swim to analyse blood lactate concentration (YSI 1500L, Yellow Springs, US). $\dot{E}_{tot}=VO_2net+2.7[La^-]net$ and $EC=\dot{E}_{tot}.v^{-1}$ were calculated for each swim. The swims were videotaped in sagittal plane with a set of two cameras providing dual projection from both underwater and above the water surface as described elsewhere (Barbosa et al., 2005). APAS system (Ariel Dynamics Inc, USA) was used to analyse dv. Linear regressions between the $\dot{E}_{tot}$ and v, between EC and dv, between EC and v and polynomial regressions between dv and v were computed. Partial correlations between EC and dv controlling v and between EC and v controlling dv were also calculated.

RESULTS AND DISCUSSION







The relationship between $\dot{E}_{tot}$ and v for pooled data was $r=0.59$ ($p<0.01$), where increases of v promoted significant increases of $\dot{E}_{tot}$. When the pooled data was plotted the relationship established between EC and dv was significant and positive ($r=0.38$, $p<0.01$). Increases of dv promoted significant increases of EC. The partial correlation between EC and dv controlling the effect of v was $r=0.39$ ($p<0.01$). The partial correlation between EC and v controlling the effect of dv was $r=0.16$ ($p=0.14$). Polynomial model presented a better adjustment than the linear model, for the relationship between dv and v. Nevertheless, the relationship was not significant (r=0.17, p=0.28). Therefore, it seems that, when a large number of observations from several competitive strokes are pooled, the increases of EC are strongly related to dv. However, the dependence of EC from v it is not so evident.

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3D UNDERWATER HAND PATH PATTERNS IN BUTTERFLY SWIMMERS.

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INTRODUCTION

The purpose of this study was to characterize underwater path patterns of the hand in a group of butterfly swimmers in non-breathing cycles in order to identify predictors of swimming velocity.

METHODS

Eight Portuguese international level male swimmers participated in this study (age: 18.75 ± 4.02 years, height: 179.50 ± 9.36 cm, body mass: 69.59 ± 6.66 kg, best time at 100m butterfly long course: 59,19 ± 3,15s), four of them competing at a junior age-group level. Each subject performed a maximal sprint of 50 m butterfly, in a 50 m pool. Swimmers were asked to retain breathing after passing the 25 m mark until the two final stroke cycles. Oblique underwater front views from below and from both sides were taken by two fixed digital and two other fixed digital cameras were positioned on the pool deck, one in front and one lateral in order to film the swimmers above the water. Images were retained for 3D kinematical analysis (APAS). The average intracycle horizontal speed (SS) of body centre of mass (CM) was used as the dependent variable.

RESULTS

The underwater arm stroke patterns found matched those described by the literature. Both horizontal and vertical velocity components of the underwater path of the hands showed to influence the SS. The fastest swimmers displayed an anteroposterior component in the hand path during the outsweep, accompanied by a higher flexion of the elbow during this phase. Mean intracycle swimming velocity was related to horizontal velocity of the body CM during the upsweep. In this phase, the anteroposterior displacement of the hand path and the hand horizontal velocity showed significant correlation with swimming velocity ($r= 0.820$, $p\leq 0.05$ and $r=0.890$, $p\leq 0.01$, respectively).

DISCUSSION

In this group of swimmers, an early catch and a more pronounced horizontal velocity of the hand in the upsweep, both denouncing a drag oriented propulsive pattern of the hands, seem to be related with better performances in butterfly sprint swimming.

BILATERAL AND ANTERIOR-POSTERIOR MUSCULAR IMBALANCES IN SWIMMERS.

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INTRODUCTION

Bilateral differences are common in swimmers. Anterior-posterior differences are not only common, but also related to injuries (1). The purpose of this study was to determine the relative magnitude of bilateral and anterior-posterior differences in swimmers.

METHOD

The subjects were 19 competitive swimmers (12 males and 7 females) between the ages of 14 and 17. Peak hand force was measured performing two aquatic exercises (horizontal arm abduction and adduction in a standing position) and two swimming strokes (freestyle and backstroke) with Aquanex (previously described and validated in 2).

RESULTS

The peak force values were significantly higher ($p<.05$) for both exercise adduction than abduction and for the swim stroke with the arm in the adducted position (freestyle) than the abducted position (backstroke). Bilateral differences were trivial (.1σ) in comparison.

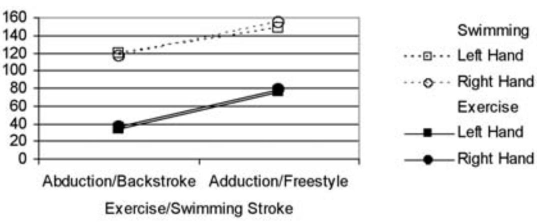

Figure 1: Peak Hand Force Values for Exercise and Swimming.

DISCUSSION

The magnitudes of the anterior-posterior differences were large for both exercise (1.5σ) and swimming (.8σ). A training regimen that strengthens the arm abductors may not only decrease the incidence of injuries, but also increase hand force and, therefore, performance in backstroke. Clinical evaluations can identify related structural conditions.

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