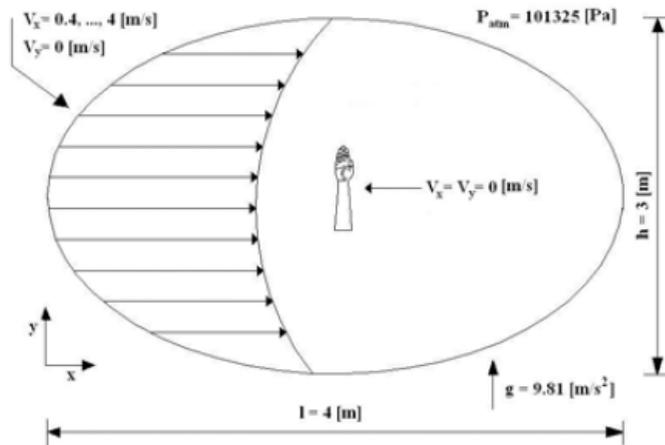
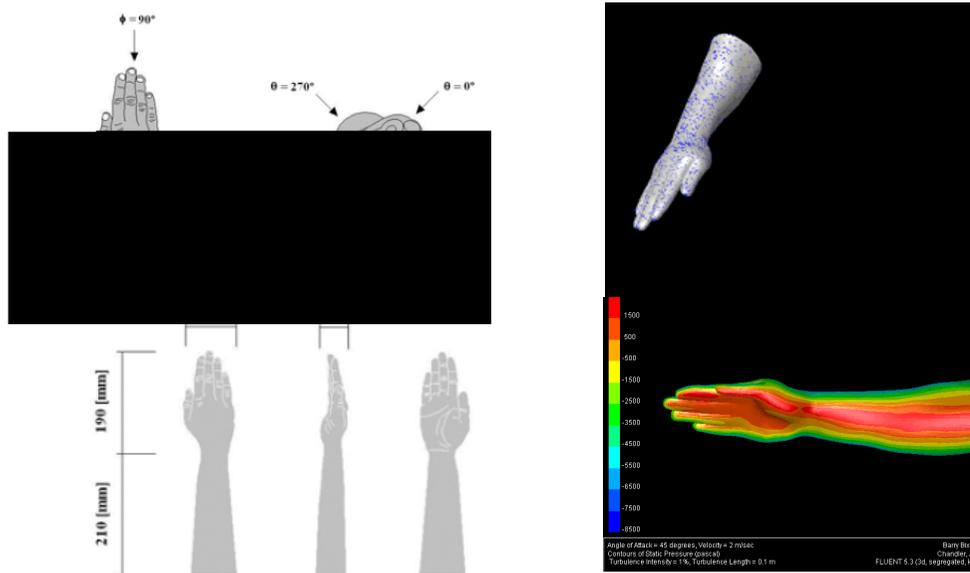


# CFD- Computer Flow Dynamics

## Fluent® software

Marinho, Leal, Sousa, Alves, Vilas-Boas, Machado, Reis, Moreira, Rouboa, Silva (2007). A UTILIZAÇÃO DA DINÂMICA COMPUTACIONAL DE FLUIDOS 3-D NO CÁLCULO DA FORÇA PROPULSIVA EM NATAÇÃO.

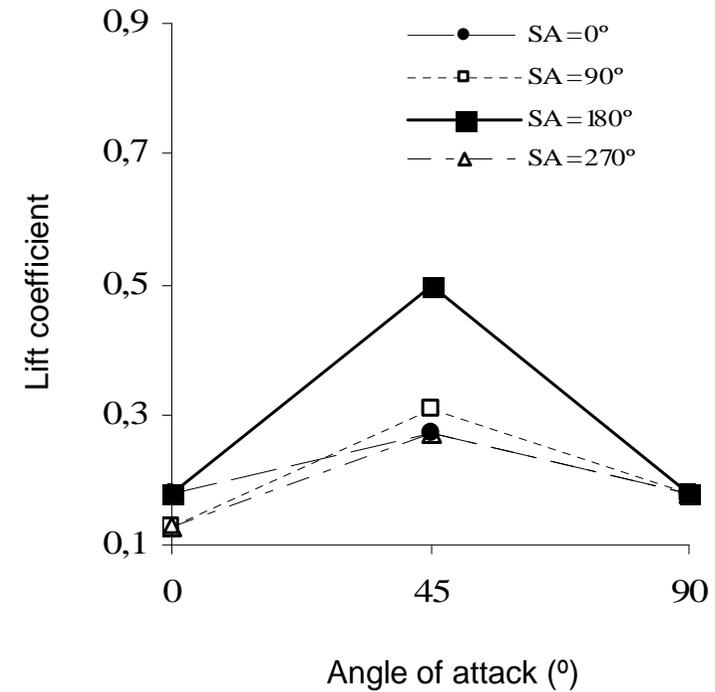
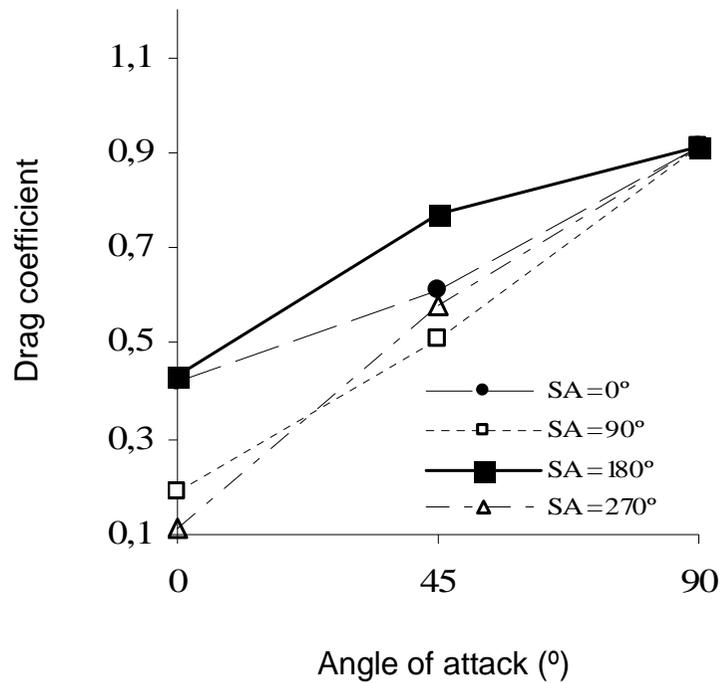


$\alpha$	$C_D$	$C_L$
$0^\circ$	0.35	0.18
$45^\circ$	<b>0.63</b>	<b>0.32</b>
$90^\circ$	1.10	0.05

# CFD- Computer Flow Dynamics

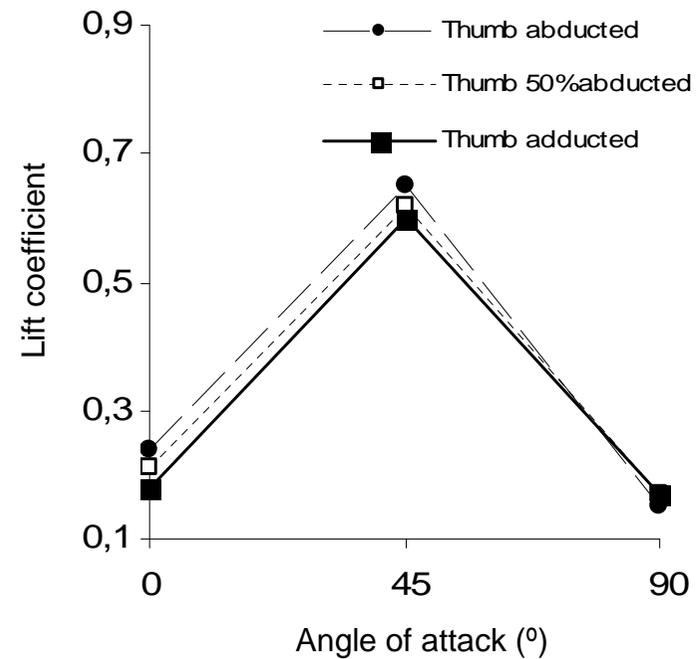
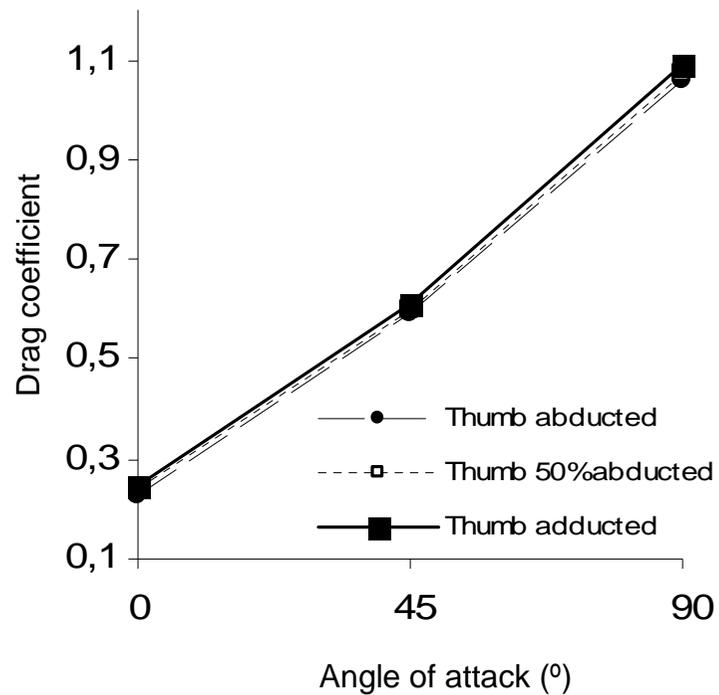
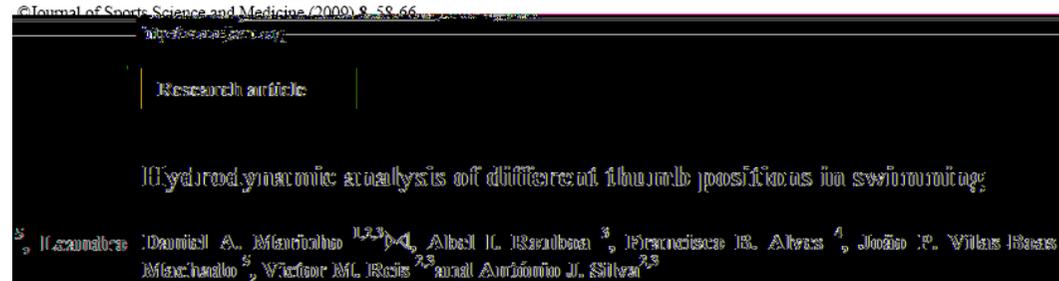
## Fluent® software

Silva, Marinho, Reis, Alves, Vilas-Boas, Machado, Rouboa (2008). The propulsive potential of the hand and forearm in swimming. The study of the propulsive potential of the hand and forearm in swimming (using CFD). ACSM.



# CFD- Computer Flow Dynamics

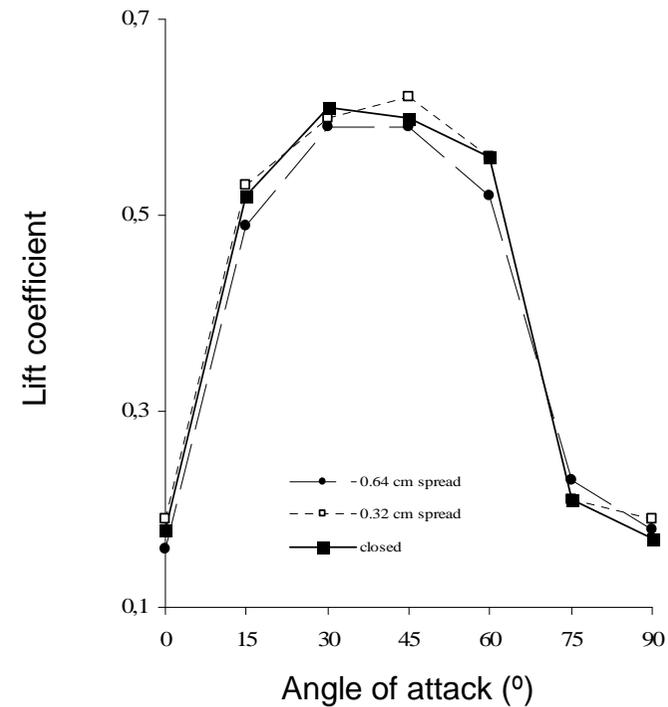
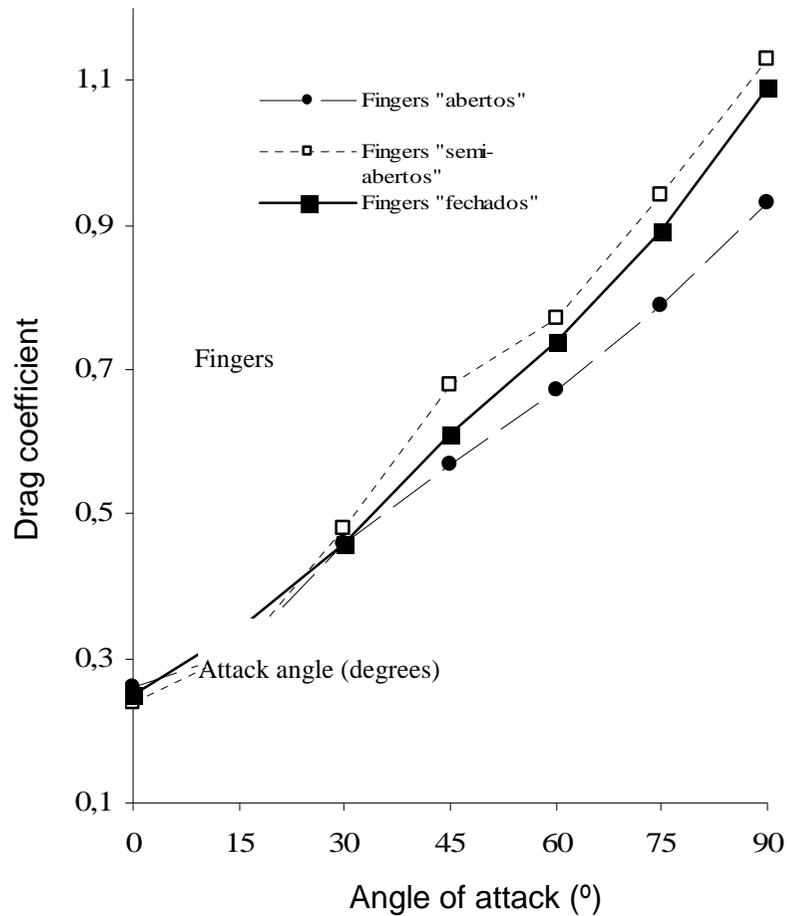
## Fluent® software



# CFD- Computer Flow Dynamics

## Fluent® software

Marinho, Reis, Alves, Vilas-Boas, Rouboa, Machado, Silva (2008c).

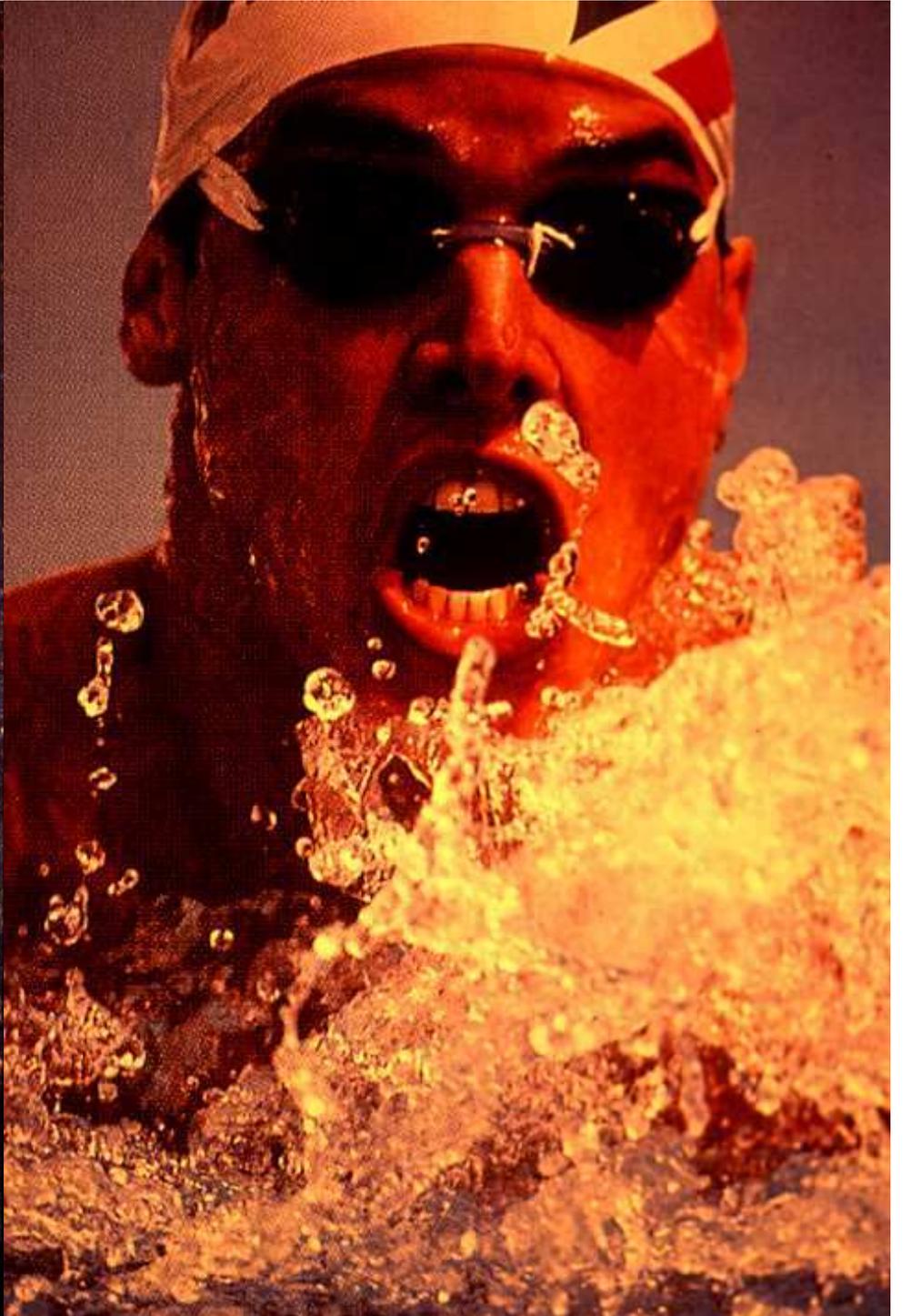


# Biomecânica

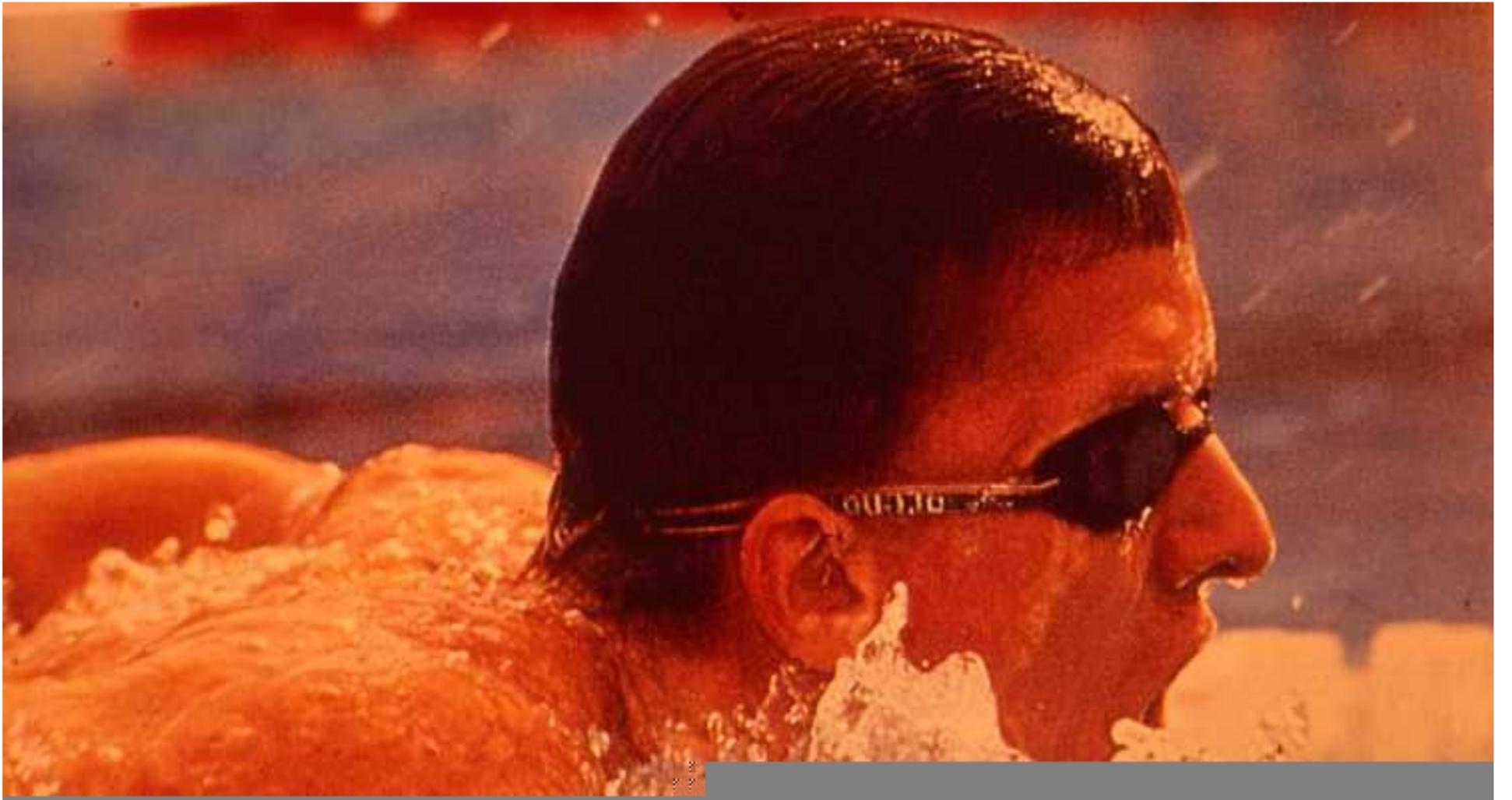


## Sumário da exposição

- (iii) **determinação dinamométrica de parâmetros caracterizadores da onda produzida por nadadores de elite nas quatro técnicas de nado a diferentes velocidades;**



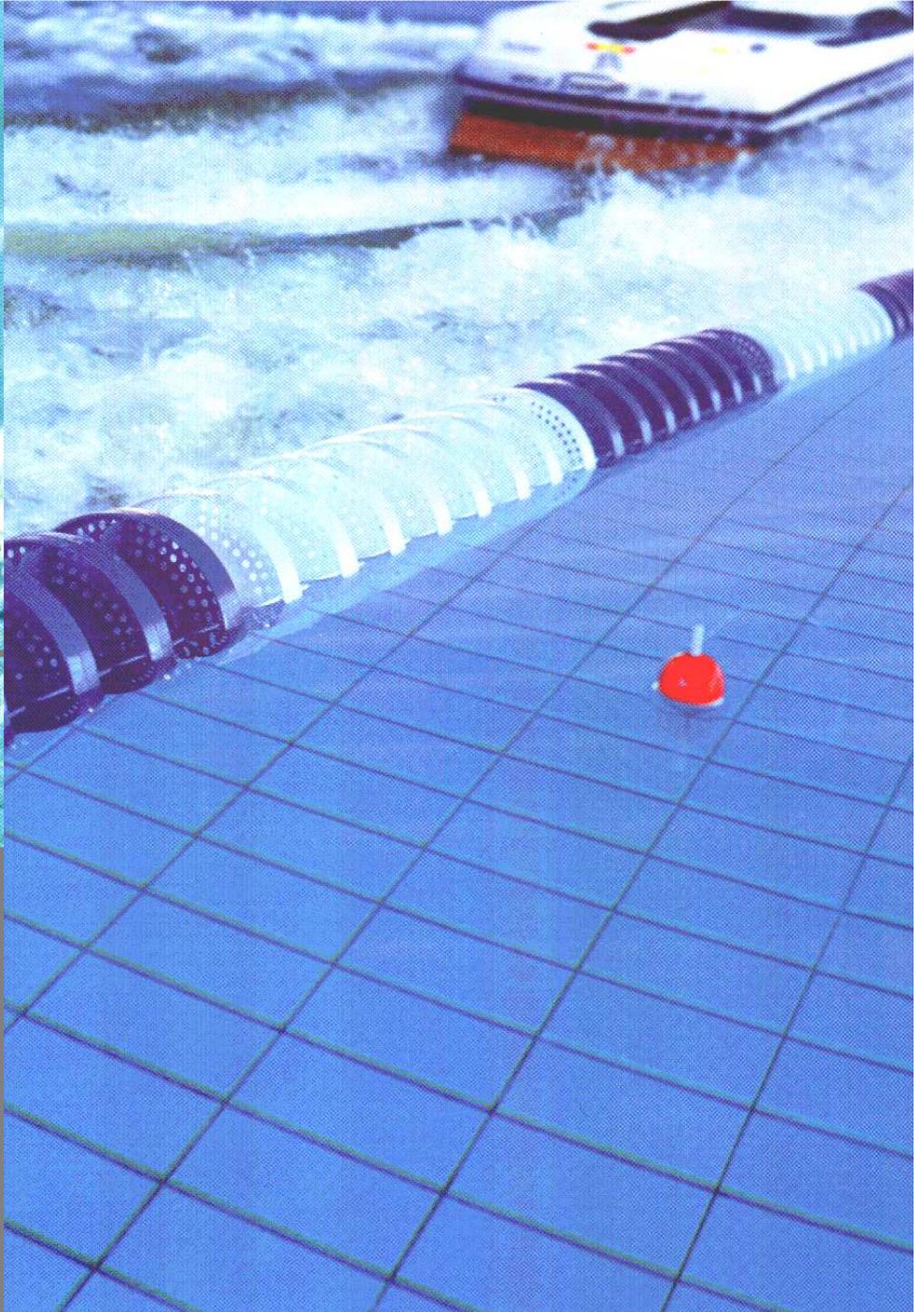
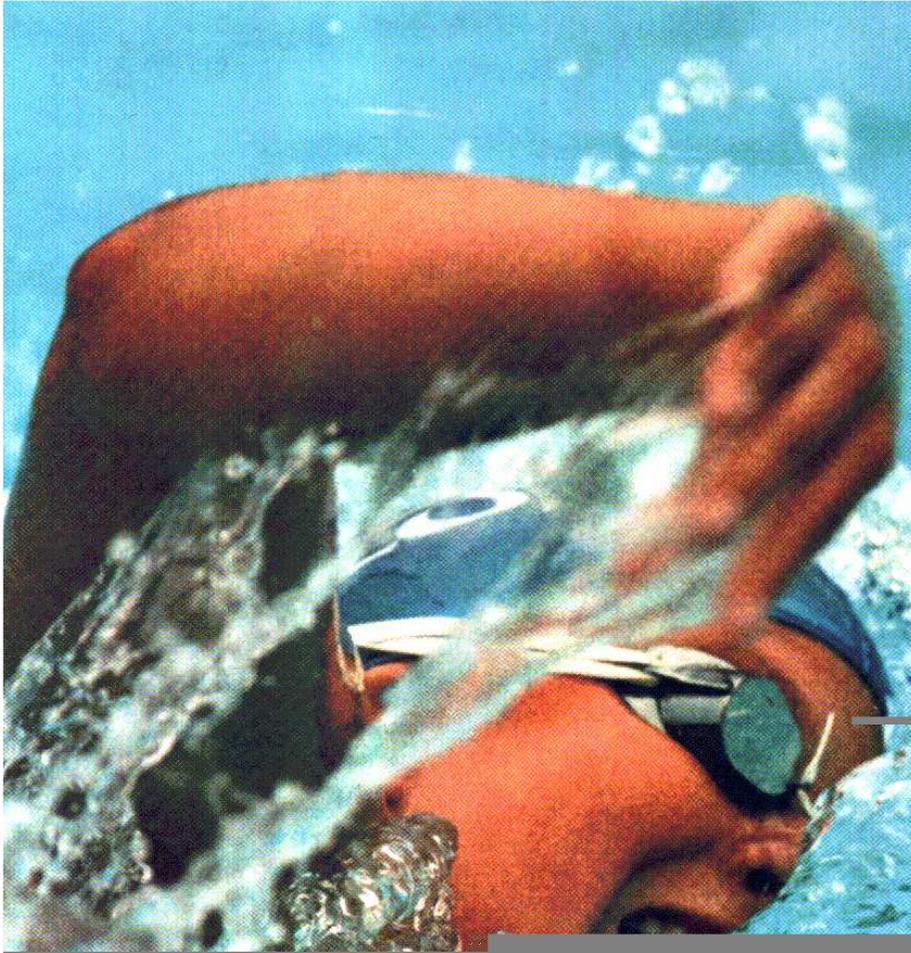




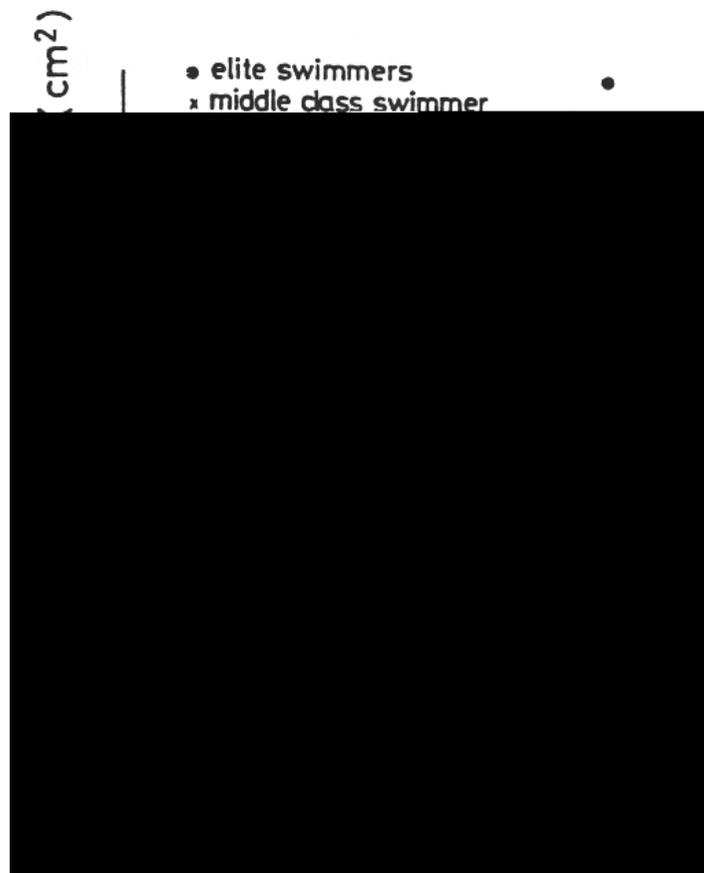
# Arrasto de onda (DO)

**Arrasto por produção  
de ondas**

**Transferência de  
*momentum* ondulatório**



# Potência da onda



(Takamoto et al., 1985)

## Toussaint (2002)

---



Para medir a altura da onda utilizou transdutores de pressão e uma escala colada a uma vara.

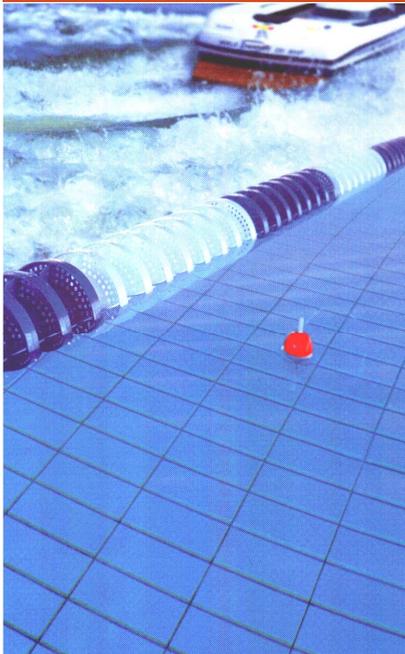
Registou em vídeo as ondas para as medir relativamente à “escala” (zoom).

# Força e impulso de uma onda

## Medição em plataforma de forças

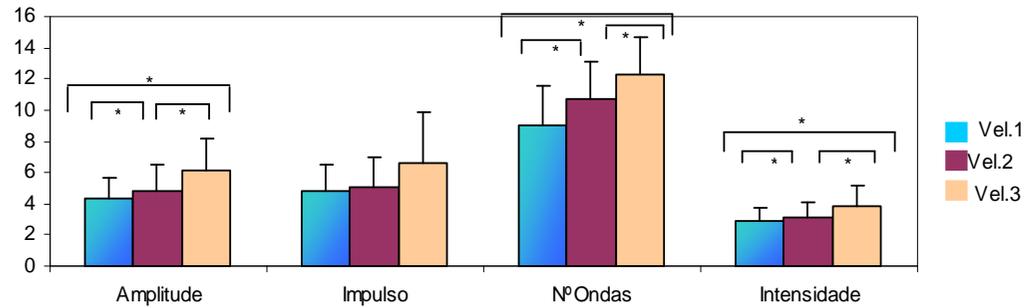
Pereira, S; Roeseler, H.; Esteves, C.; Gonçalves, P.; Sousa, F.; Conceição, F.; Machado, I.; Lima, A.; Vilar, S.; Fernandes, R.; Vilas-Boas, J.P. (2006). Dynamometric system for the evaluation of swimming turns. In: Vilas-Boas, J.P., Alves, F. and Marques, A. (Eds.), *Book of Abstracts of the Xth International Symposium Biomechanics and Medicine in Swimming. Portuguese Journal of Sport Sciences*, 6 (Supl.1): 22.



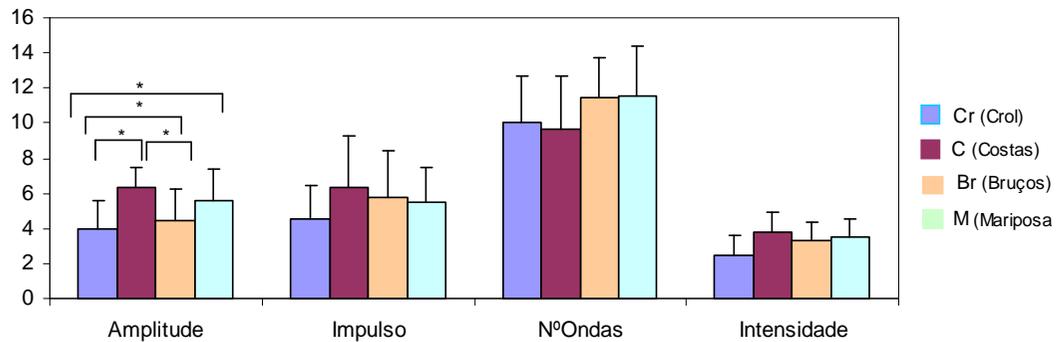


Santos, Machado, Gonçalves, Fernandes, Vilas-Boas (2008). *Wave produced by the for swimming strokes at three different velocities.*

**Velocidade 1 vs Velocidade 2 vs Velocidade 3**



**Técnicas de nado (Cr/C/Br/M)**



# Biomecânica



## Sumário da exposição

- (iv) **caracterização biomecânica de partidas de nado ventral e dorsal em natação;**

EUROSPORT  
LIVE

1/2  
0:11:57  
0:09:18



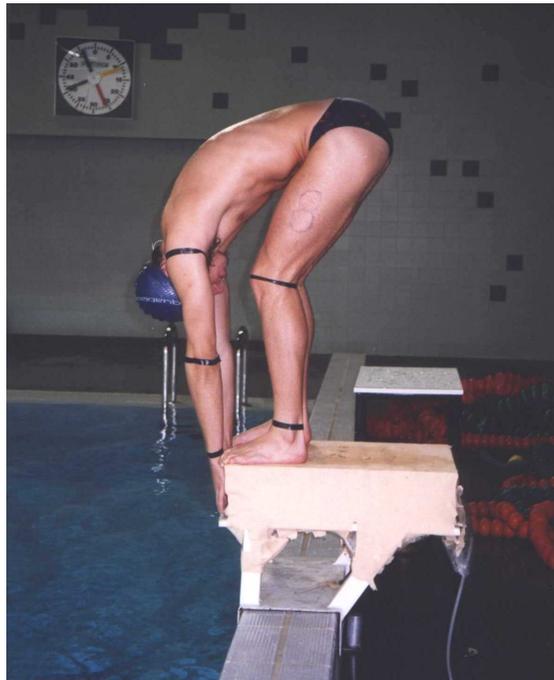


Vilas-Boas, Cruz, Sousa, Conceição, Fernandes, Carvalho (2003). *Biomechanical analysis of ventral swimming starts: comparison of the grab start with two track-start techniques.*

**Objectivo:**

**Caracterizar e comparar as técnicas de partida ventral mais utilizadas em natação.**

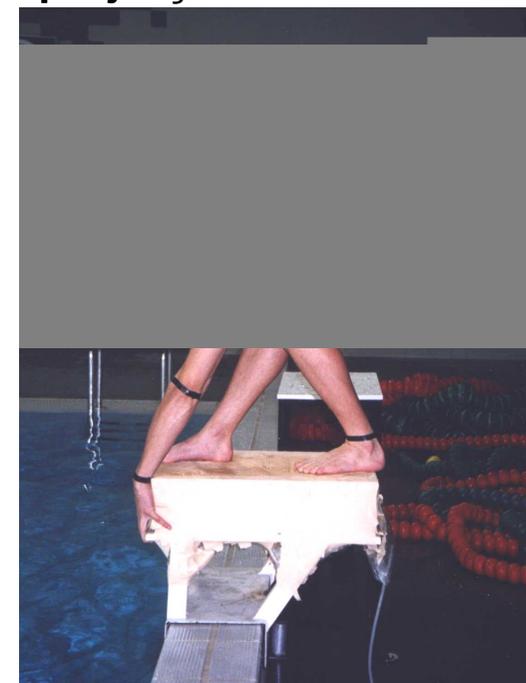
**Grab Start**



**Track Start  
projecção à frente do CG**

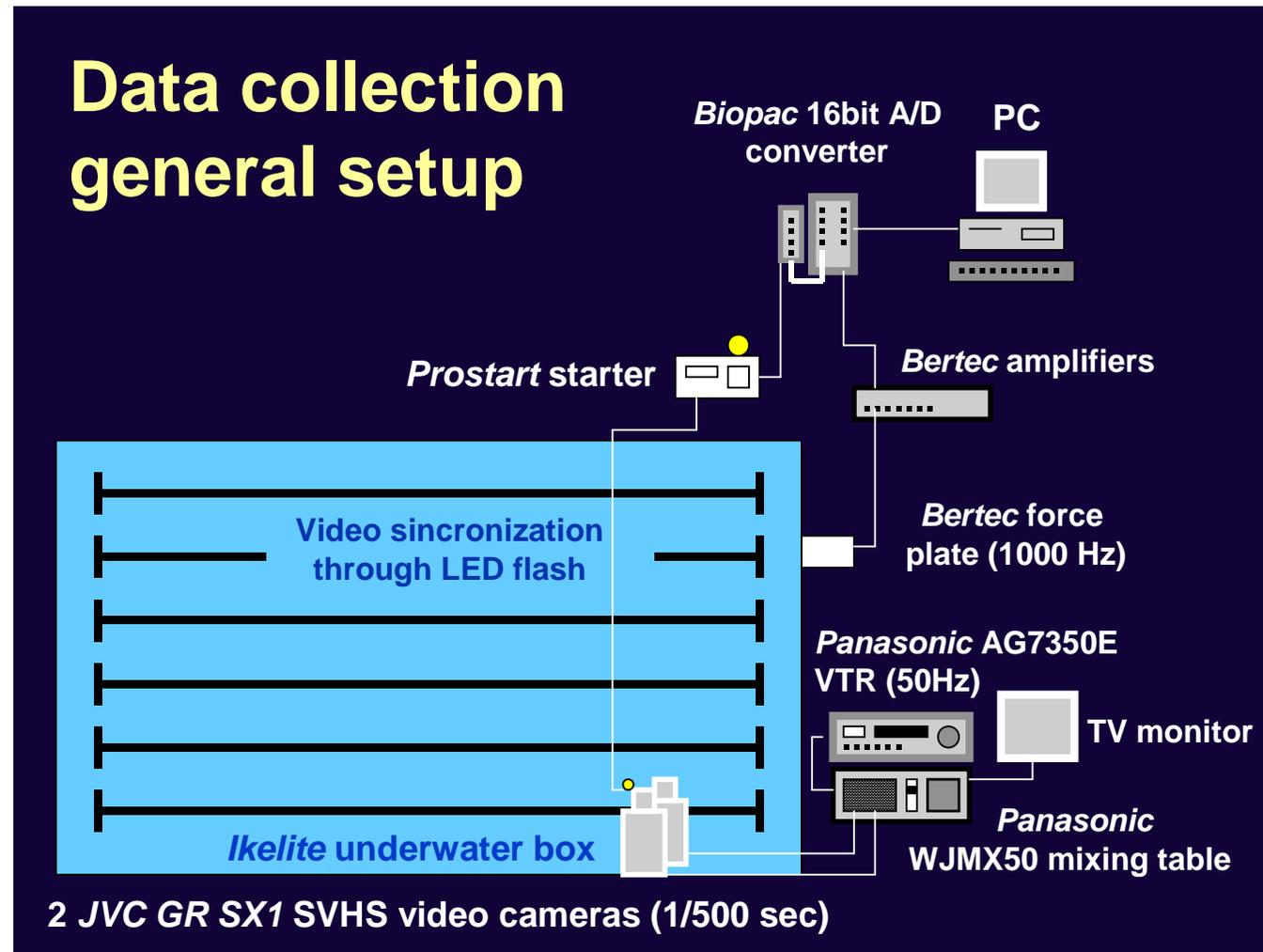


**Track Start  
projecção atrás do CG**

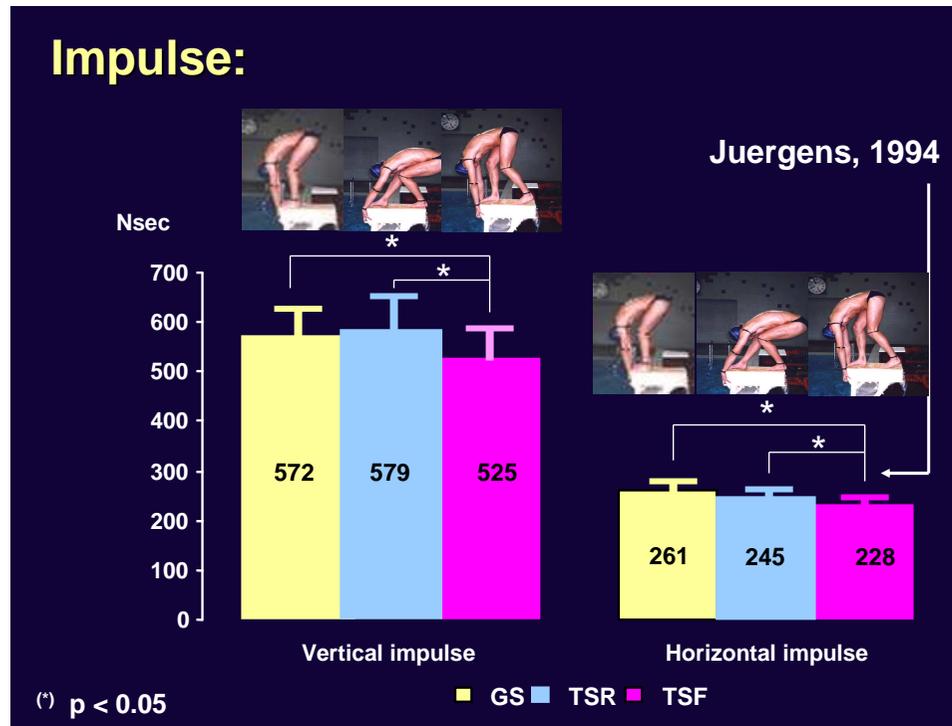
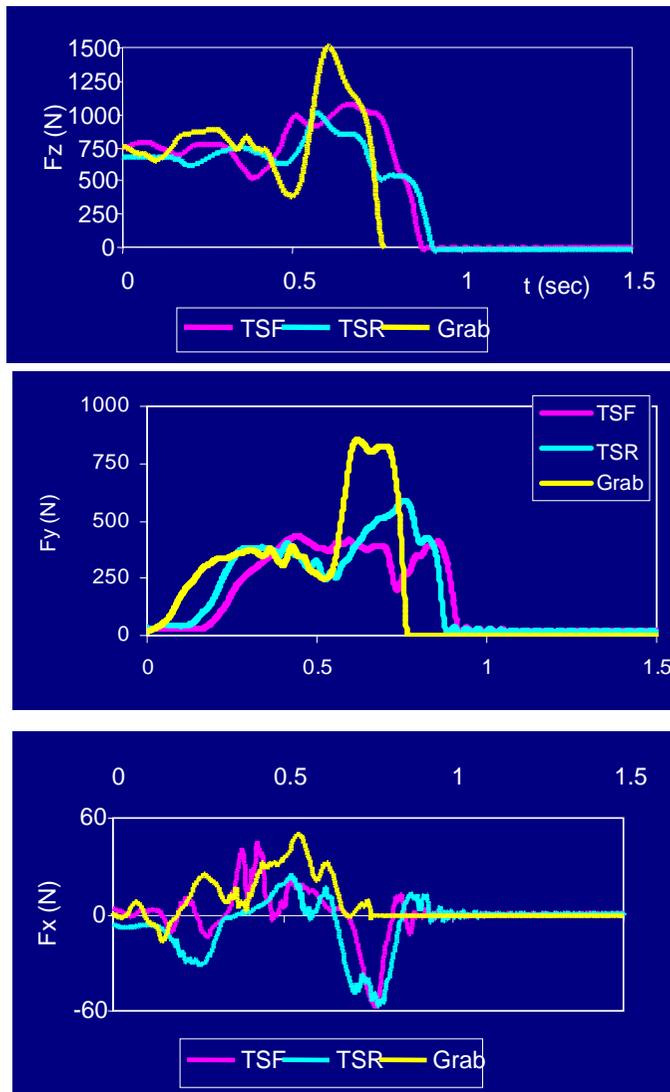


Vilas-Boas, Cruz, Sousa, Conceição, Fernandes, Carvalho (2003). *Biomechanical analysis of ventral swimming starts: comparison of the grab start with two track-start techniques.*

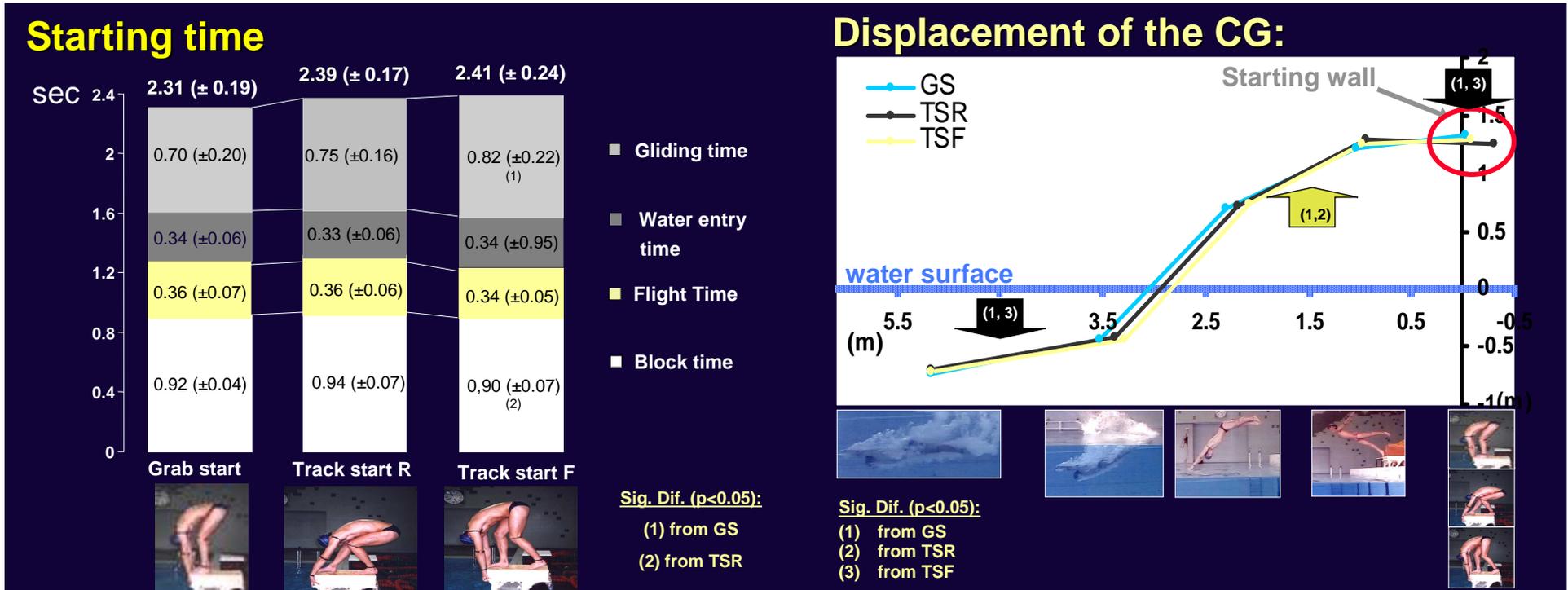
**N = 11**  
**POR elite swimmers**  
**18 ± 2 anos**  
**73 ± 7 Kg**  
**1.80 ± 0.07 m**



Vilas-Boas, Cruz, Sousa, Conceição, Fernandes, Carvalho (2003). *Biomechanical analysis of ventral swimming starts: comparison of the grab start with two track-start techniques.*



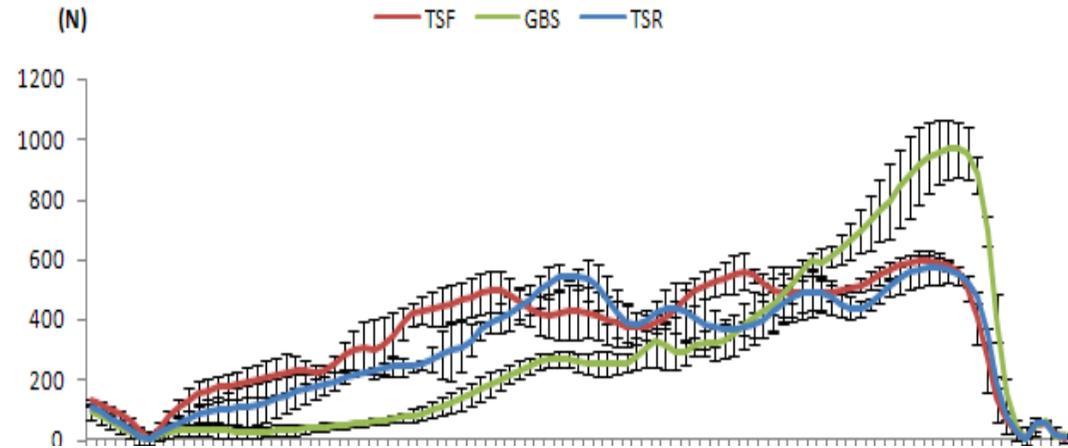
Vilas-Boas, Cruz, Sousa, Conceição, Fernandes, Carvalho (2003). *Biomechanical analysis of ventral swimming starts: comparison of the grab start with two track-start techniques.*



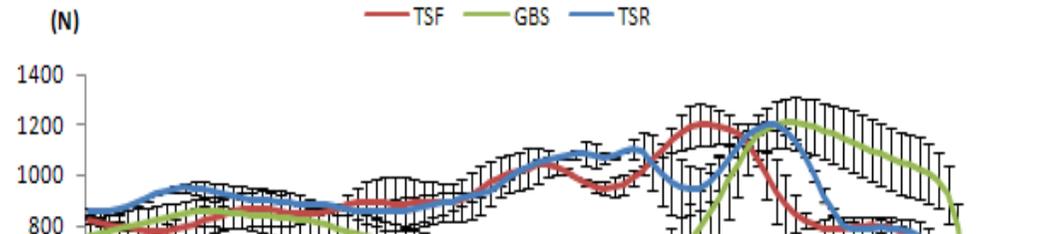


Monteiro, Figueiredo, Gonçalves, Machado, Fernandes, Vilas-Boas (2008). *Biomechanical analysis of three ventral swimming starts through EMG, videogrametry and dynamometry.*

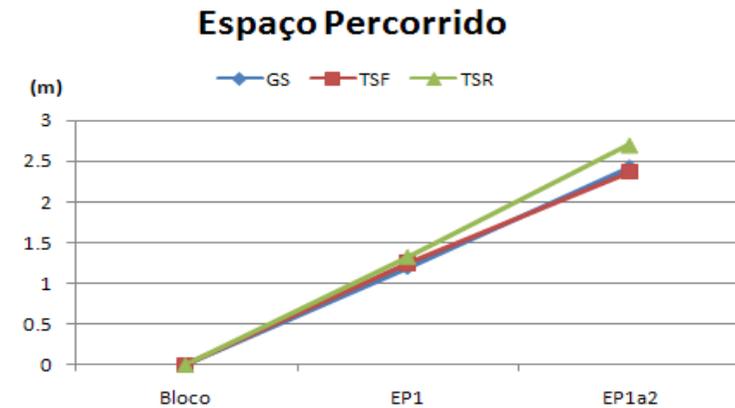
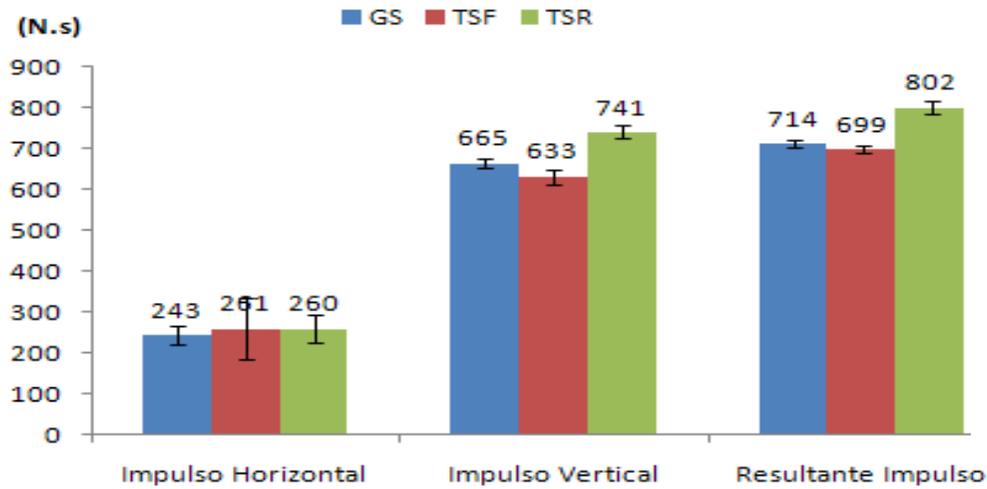
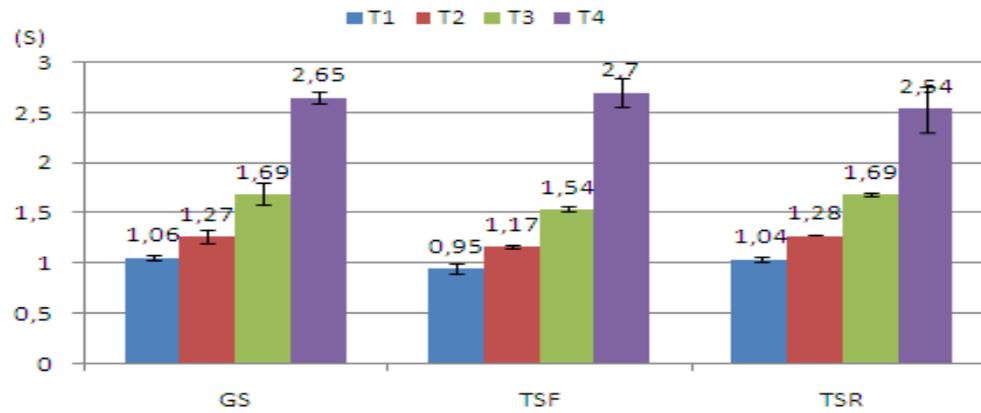
## Horizontal force



## Vertical force



Monteiro, Figueiredo, Gonçalves, Machado, Fernandes, Vilas-Boas (2008). *Biomechanical analysis of three ventral swimming starts through EMG, videogrametry and dynamometry.*

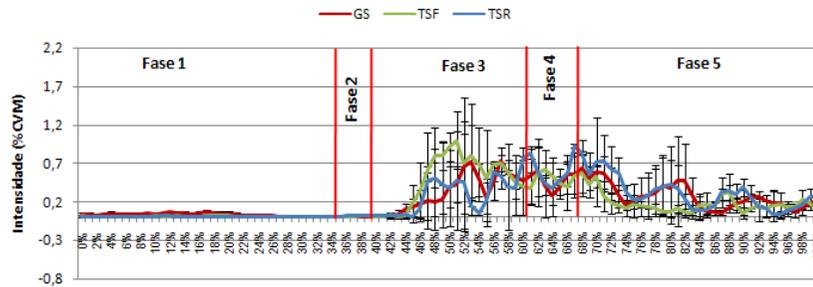


# EMG

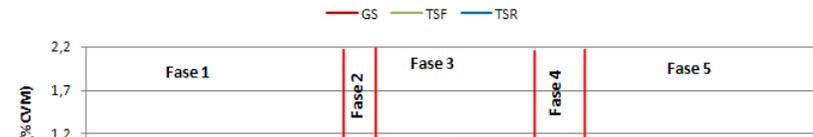
Monteiro, Figueiredo, Gonçalves, Machado, Fernandes, Vilas-Boas (2008). Análise biomecânica integrada de três técnicas de partida ventral em natação. Cinemática, dinamometria e EMG. Unpublished.



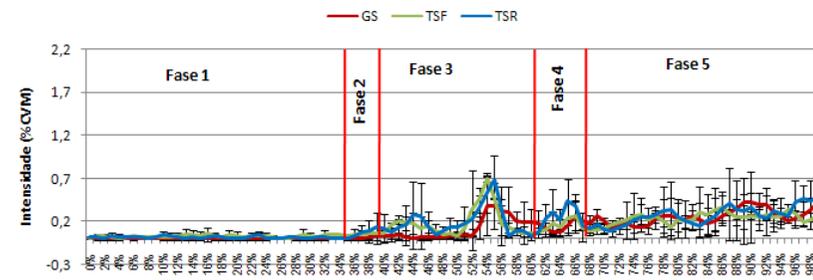
**Deltóide Anterior**



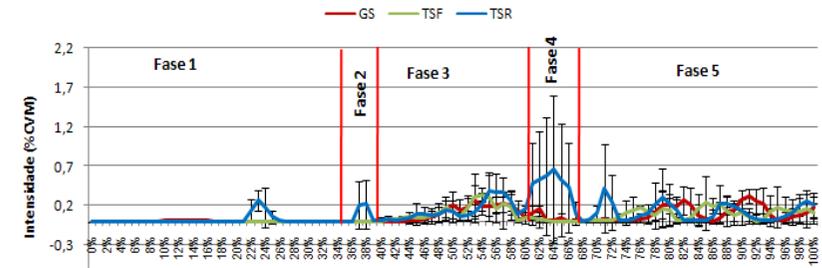
**Biceps Braquial**



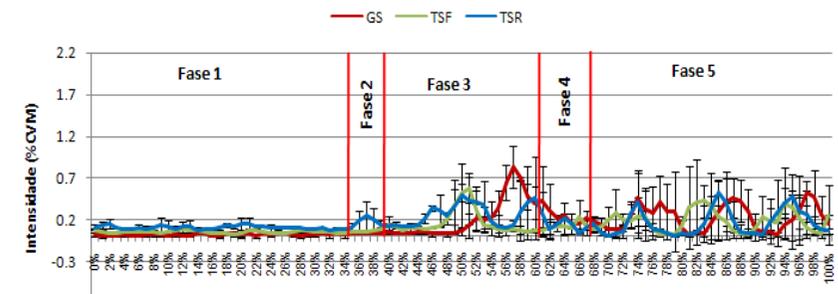
**Trícepts Braquial**



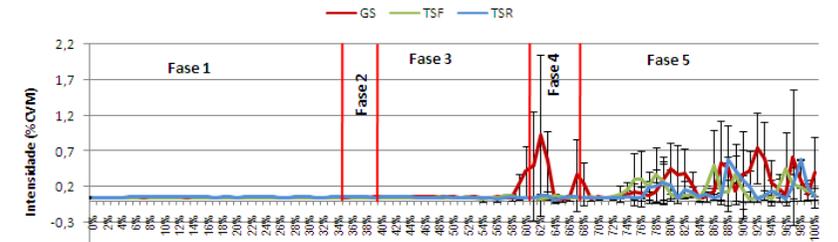
**Glúteo Máximo**



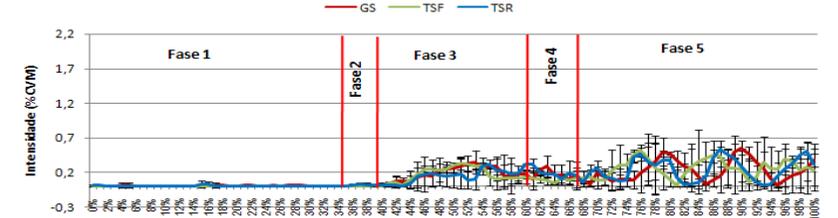
**Reto Femoral**



**Gastrocnémio Medial**

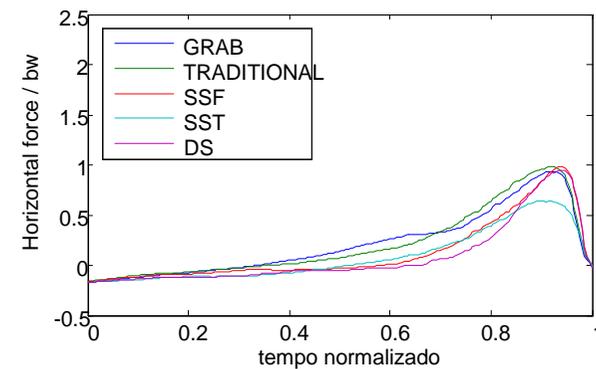
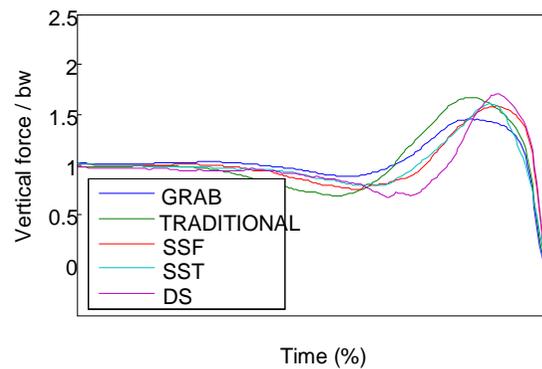
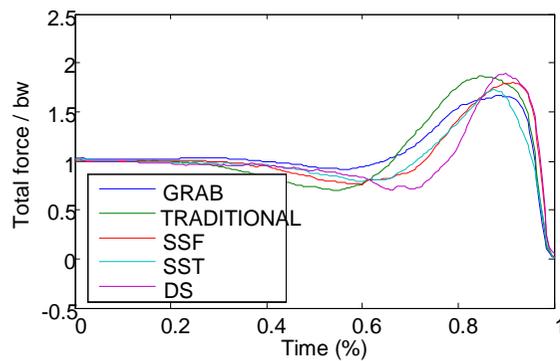
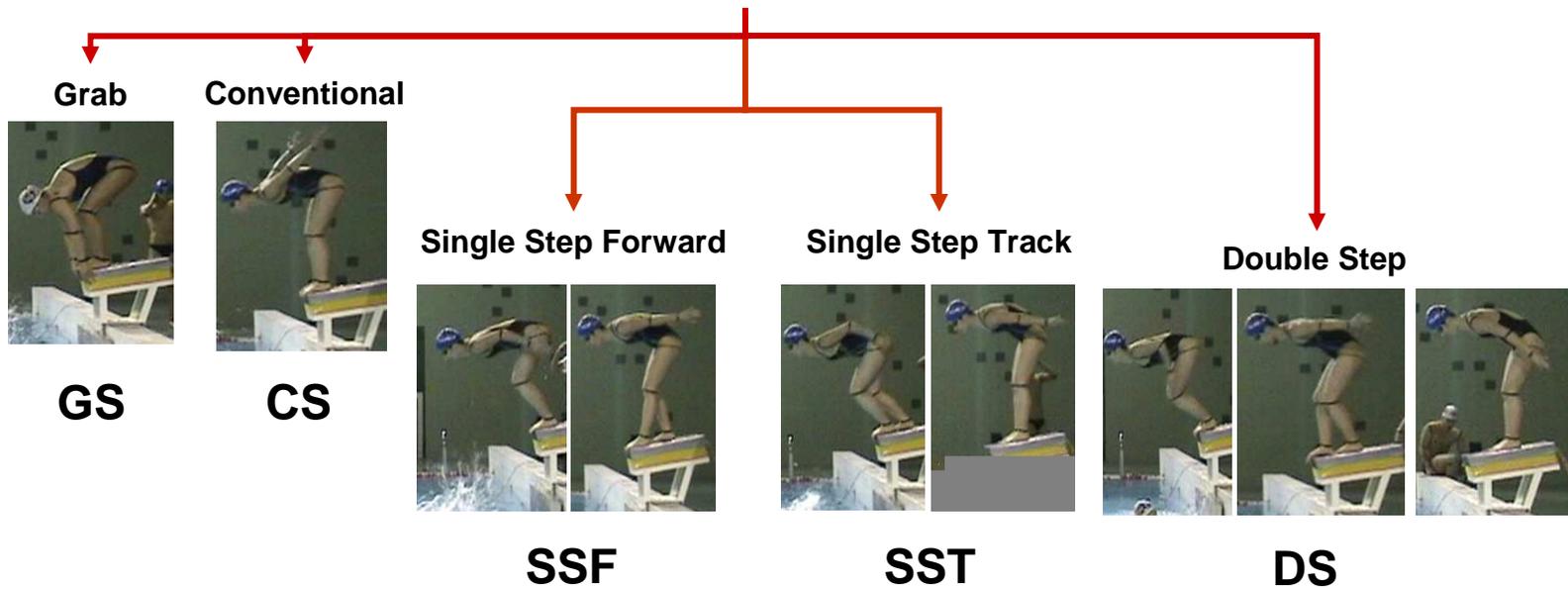


**Erector Espinal**



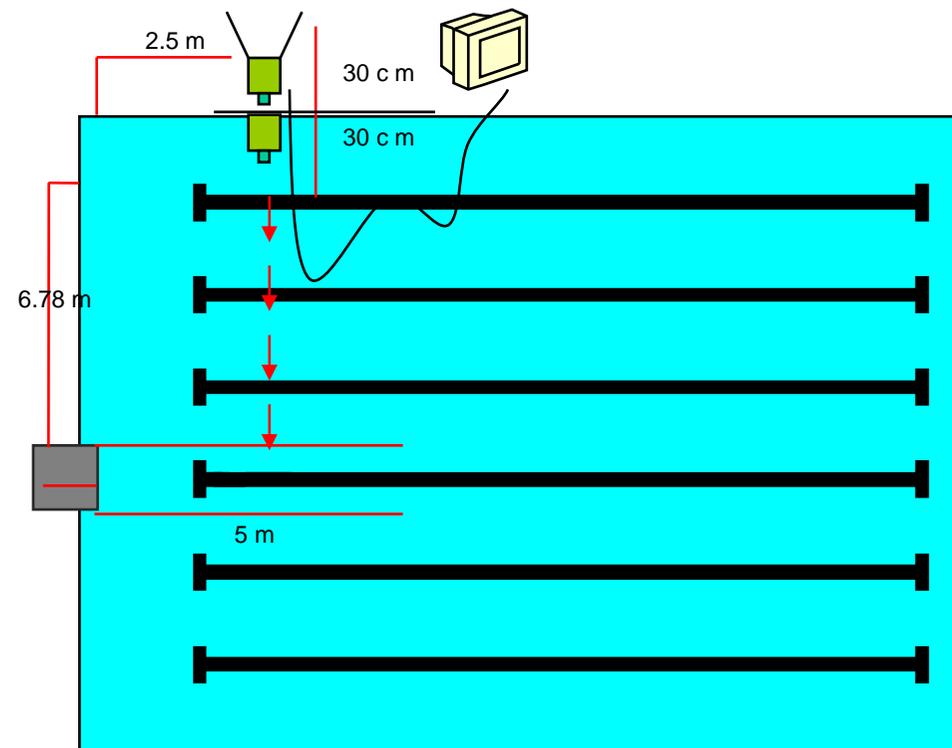
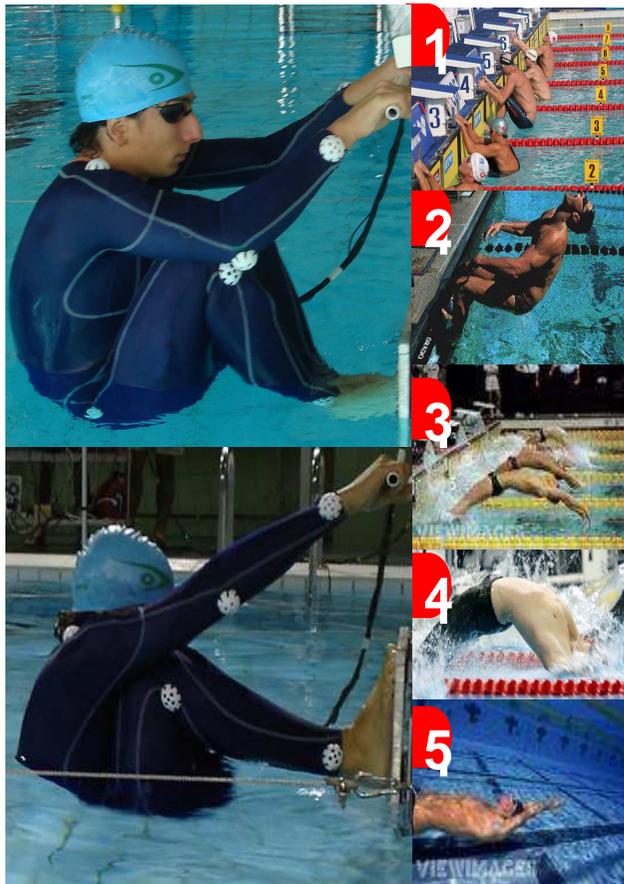
Esteves, C.; Pereira, S.; Roeseler, H.; Gonçalves, P.; Lima, A.; Sousa, F.; Conceição, F.; Machado, L.; Fernandes, R.; Vilas-Boas, J.P. (2006). Dynamometric system for the evaluation of relay starts (resumo). In: Vilas-Boas, J.P., Alves, F. and Marques, A. (Eds.), *Book of Abstracts of the Xth International Symposium Biomechanics and Medicine in Swimming. Portuguese Journal of Sport Sciences*, 6 (Suppl.1): 21.

## Relay starts



De Jesus, de Jesus, Gonçalves, Pereira, Machado, Vilas-Boas, Fernandes (2008). *Biomechanical comparison of the effect of feet position during the backstroke start.*

	Idade (anos)	Massa (kg)	Altura (m)	Anos de treino	Tempo 50m (s)	Tempo 100m (s)
N = 6	22.5 ± 2.94	76.6 ± 8.94	1.80 ± 0.07	13.3 ± 5.46	27.2 ± 1.14	58.7 ± 2.58



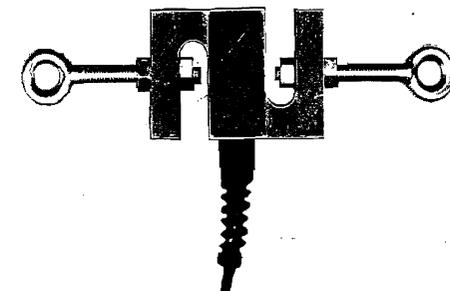
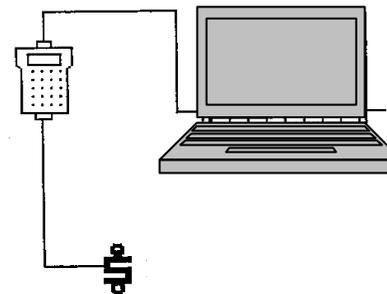
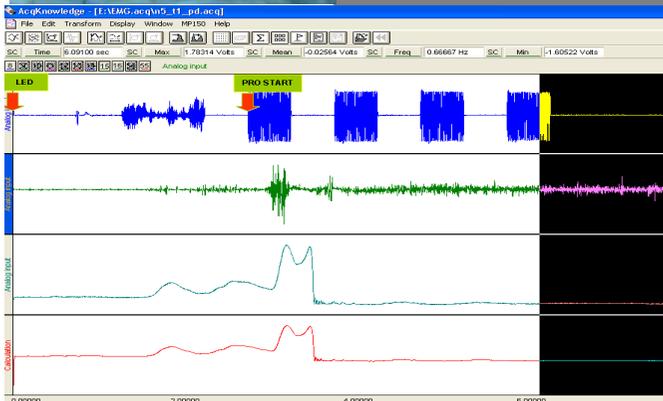
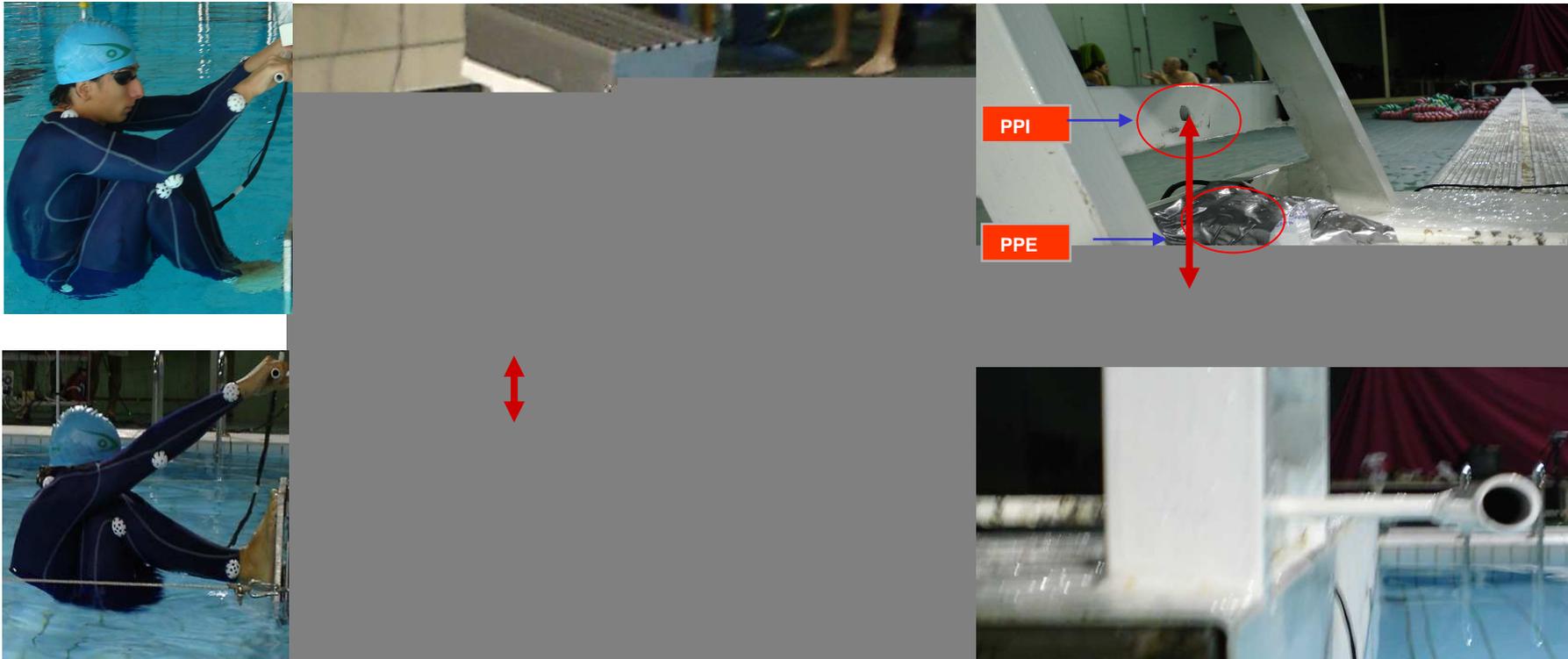
2 sessões (int. 60 min) com 6 x 15 m  $v_{\text{máx}}$ , int = 2 min

De Jesus, de Jesus, Gonçalves, Pereira, Machado, Vilas-Boas, Fernandes (2008). *Biomechanical comparison of the effect of feet position during the backstroke start.*

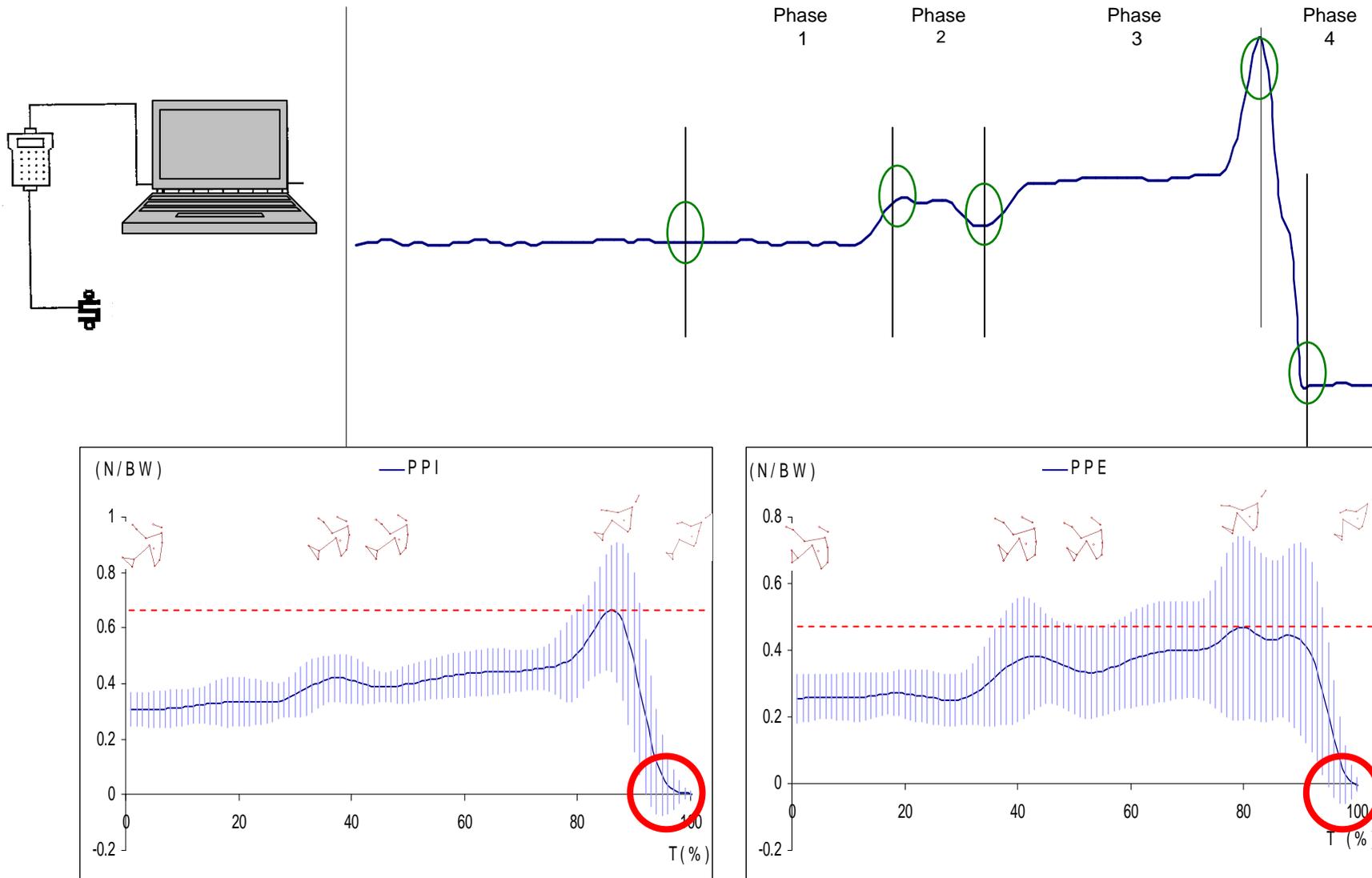
## Cinemetria

Variáveis (s)	PPI	PPE	Student t- Test
Tempo de reacção	0.29 ± 0.04	0.25 ± 0.05	0
Tempo de suporte das mãos	0.55 ± 0.04	0.59 ± 0.08	0
Tempo até à perda de contacto dos pés	0.77 ± 0.03	0.84 ± 0.09	0
Tempo de voo	0.18 ± 0.09	0.16 ± 0.08	0.01
Tempo de entrada	0.51 ± 0.14	0.34 ± 0.18	0
Tempo de deslize	0.64 ± 0.18	0.85 ± 0.48	0
<b>Tempo TOTAL de partida (5 m)</b>	<b>2.03 ± 0.19</b>	<b>2.14 ± 0.36</b>	<b>0.04</b>

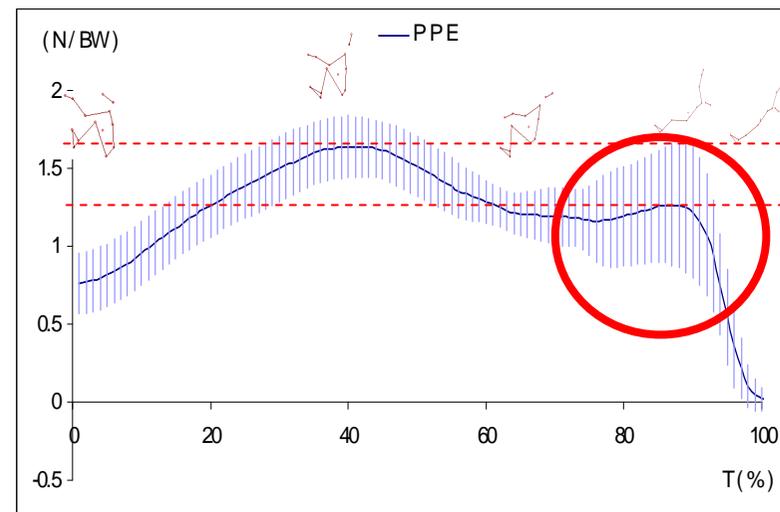
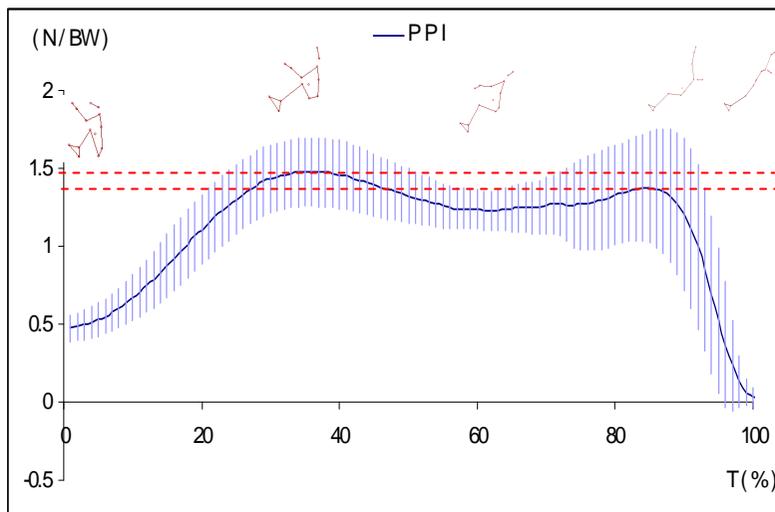
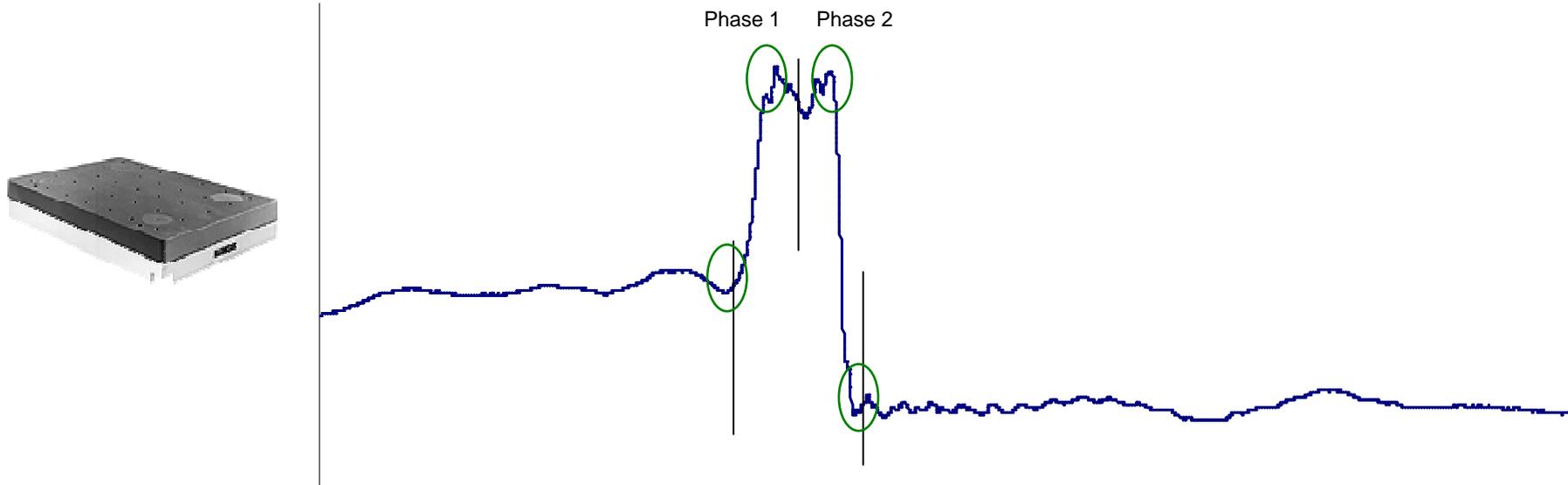
De Jesus, de Jesus, Gonçalves, Pereira, Machado, Vilas-Boas, Fernandes (2008). *Biomechanical comparison of the effect of feet position during the backstroke start.*



De Jesus, de Jesus, Gonçalves, Pereira, Machado, Vilas-Boas, Fernandes (2008). *Biomechanical comparison of the effect of feet position during the backstroke start.*

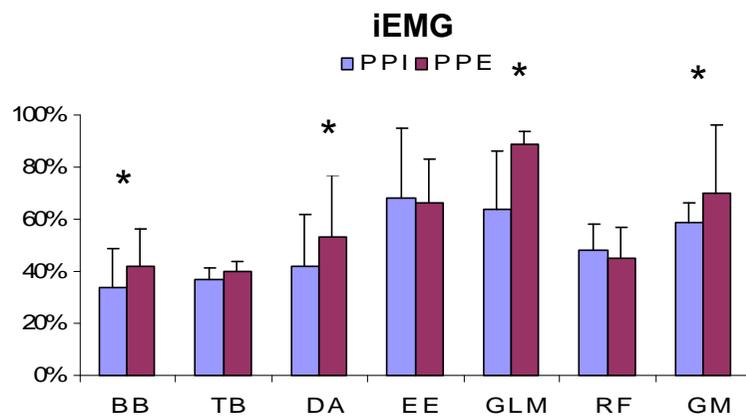
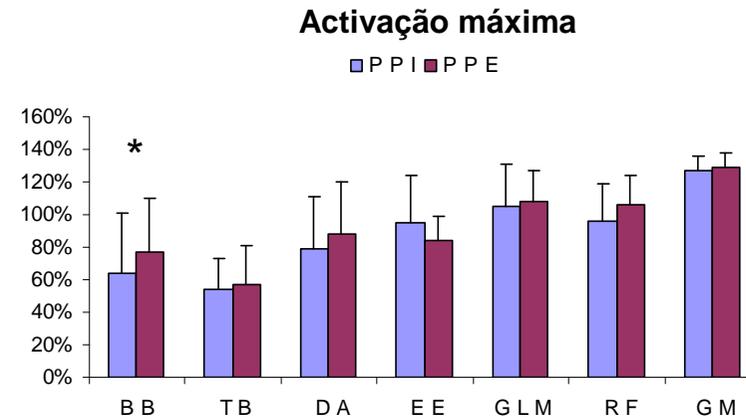
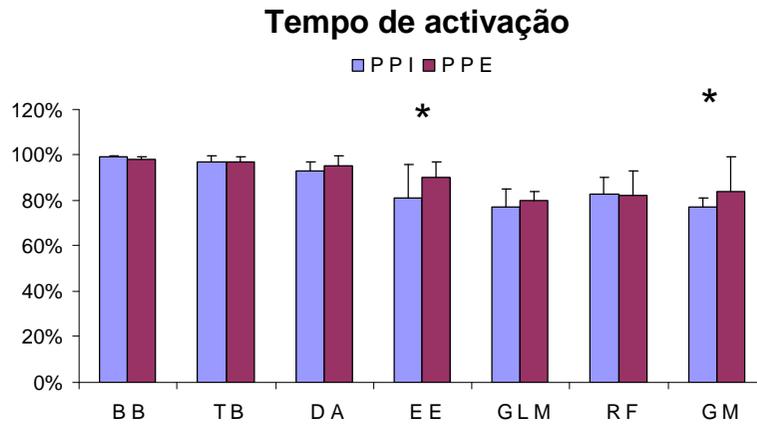


De Jesus, de Jesus, Gonçalves, Pereira, Machado, Vilas-Boas, Fernandes (2008). *Biomechanical comparison of the effect of feet position during the backstroke start.*



De Jesus, de Jesus, Gonçalves, Pereira, Machado, Vilas-Boas, Fernandes (2008). *Biomechanical comparison of the effect of feet position during the backstroke start.*

## EMG – tempo TOTAL de partida



*BB - Biceps Brachii (longa cabeça)*

*TB - Tríceps Brachii (longa cabeça)*

*DA - Deltoideus Anterior*

*EE - Erector spinae longissimus*

*GLM - Gluteus Maximus*

*RF - Rectus Femoris*

*GM - Gastrocnemius Medialis*

# Biomecânica



## Sumário da exposição

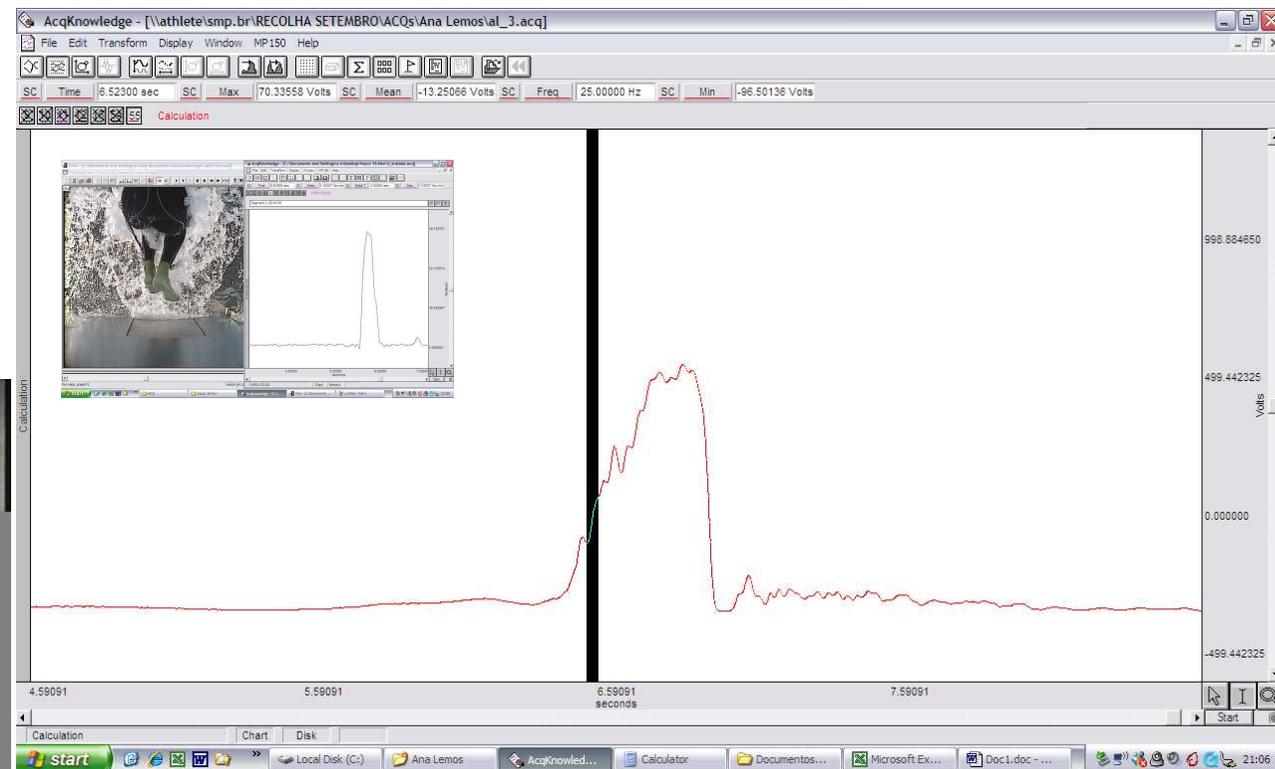
- (v) **caracterização biomecânica de diferentes variantes da viragem de estilo livre;**



# Força e impulso de uma onda

## Medição em plataforma de forças

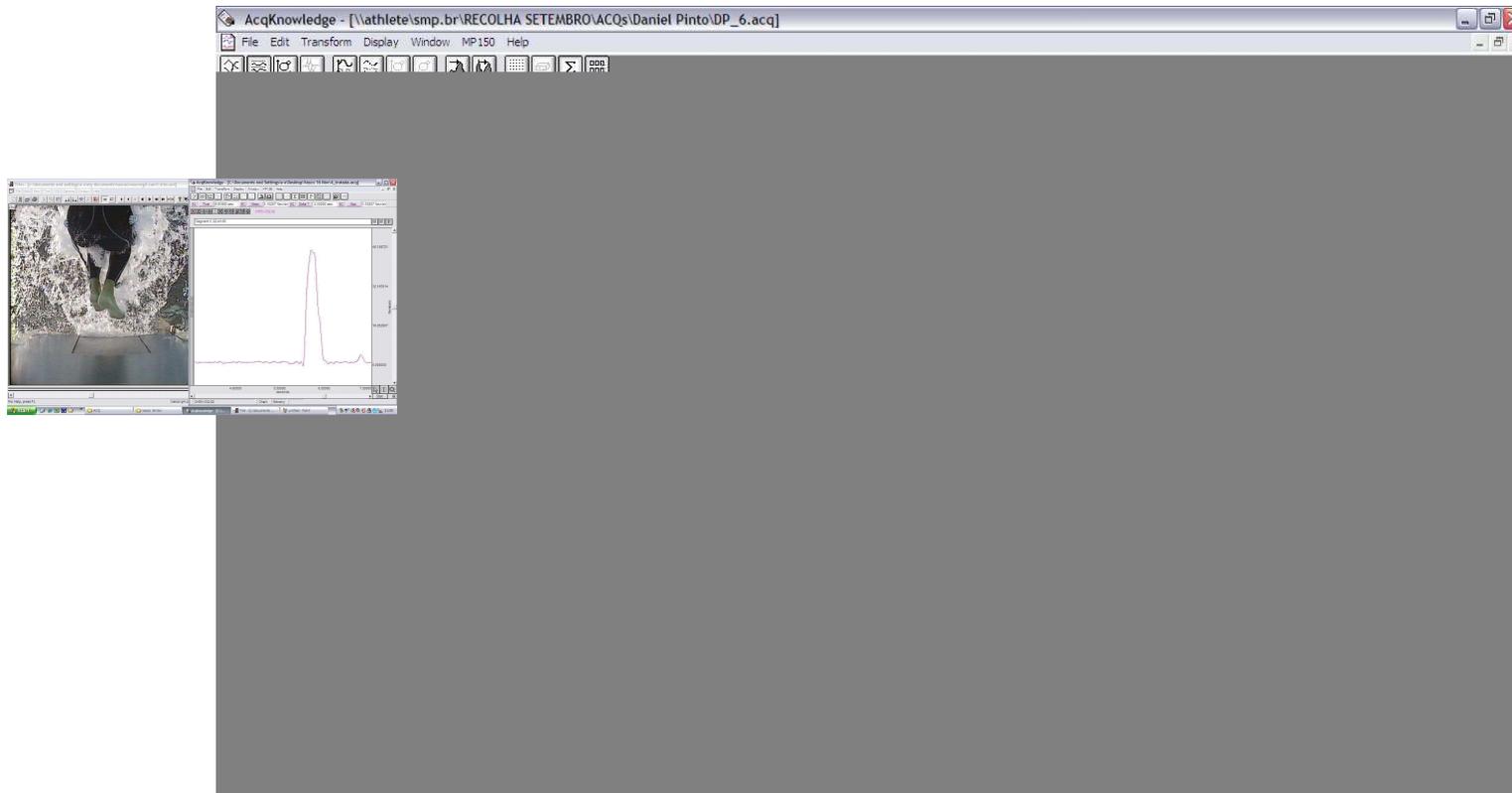
Pereira, S; Roeseler, H.; Esteves, C.; Gonçalves, P.; Sousa, F.; Conceição, F.; Machado, I.; Lima, A.; Vilar, S.; Fernandes, R.; Vilas-Boas, J.P. (2006). Dynamometric system for the evaluation of swimming turns. In: Vilas-Boas, J.P., Alves, F. and Marques, A. (Eds.), *Book of Abstracts of the Xth International Symposium Biomechanics and Medicine in Swimming. Portuguese Journal of Sport Sciences*, 6 (Suppl.1): 22.



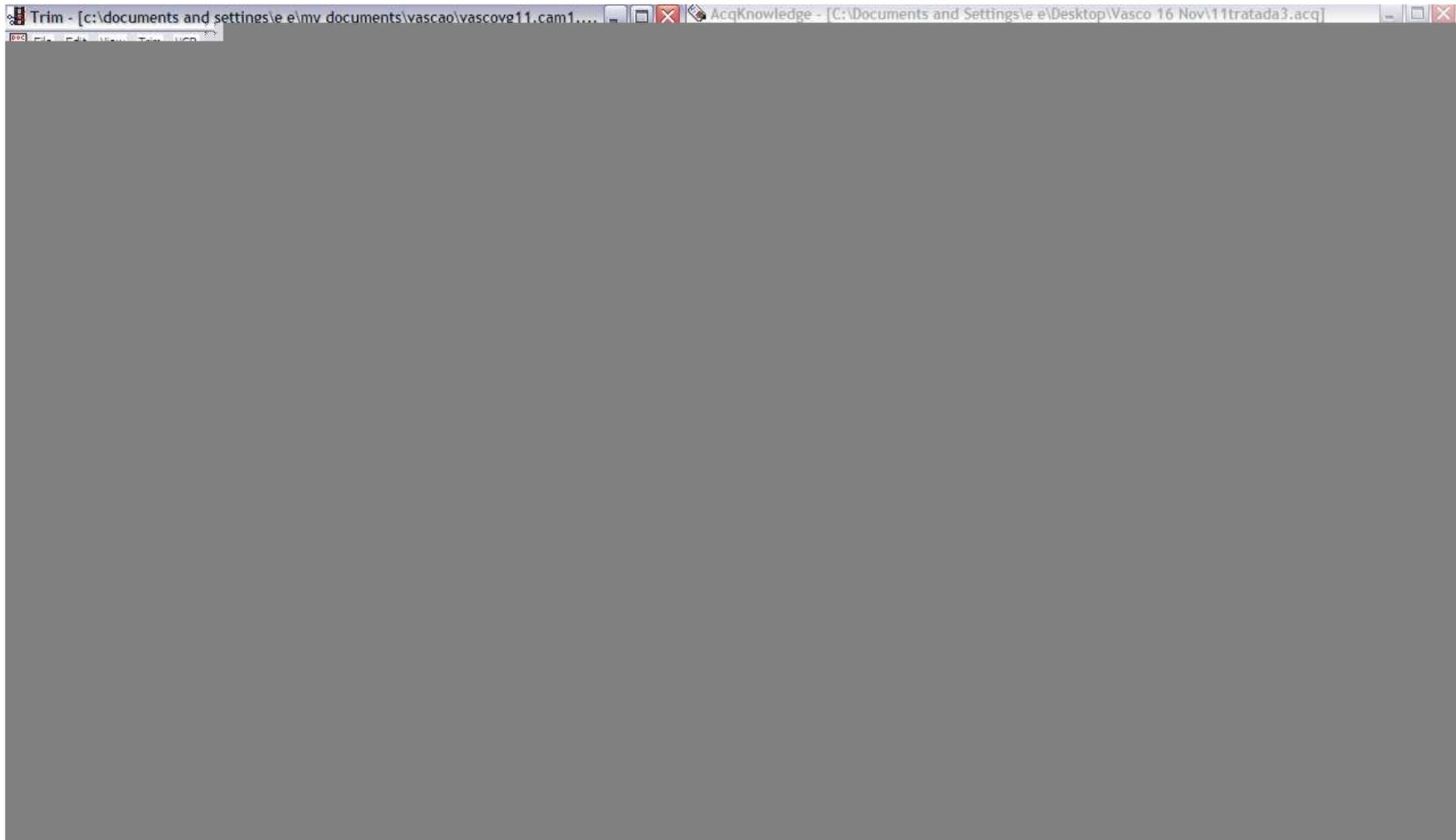
# Força e impulso de uma onda

## Medição em plataforma de forças

Pereira, S; Roeseler, H.; Esteves, C.; Gonçalves, P.; Sousa, F.; Conceição, F.; Machado, I.; Lima, A.; Vilar, S.; Fernandes, R.; Vilas-Boas, J.P. (2006). Dynamometric system for the evaluation of swimming turns. In: Vilas-Boas, J.P., Alves, F. and Marques, A. (Eds.), *Book of Abstracts of the Xth International Symposium Biomechanics and Medicine in Swimming. Portuguese Journal of Sport Sciences*, 6 (Suppl.1): 22.



# EMG



# Biomecânica



## Sumário da exposição

- (vi) **fadiga, flutuações intracíclicas da velocidade de nado e custo energético;**

$$\dot{W} = D \cdot v$$

$$D = \frac{1}{2} r C_D S v^2$$

$$\dot{W} = K \cdot v^3 \quad (K = \frac{1}{2} \rho C_D S)$$

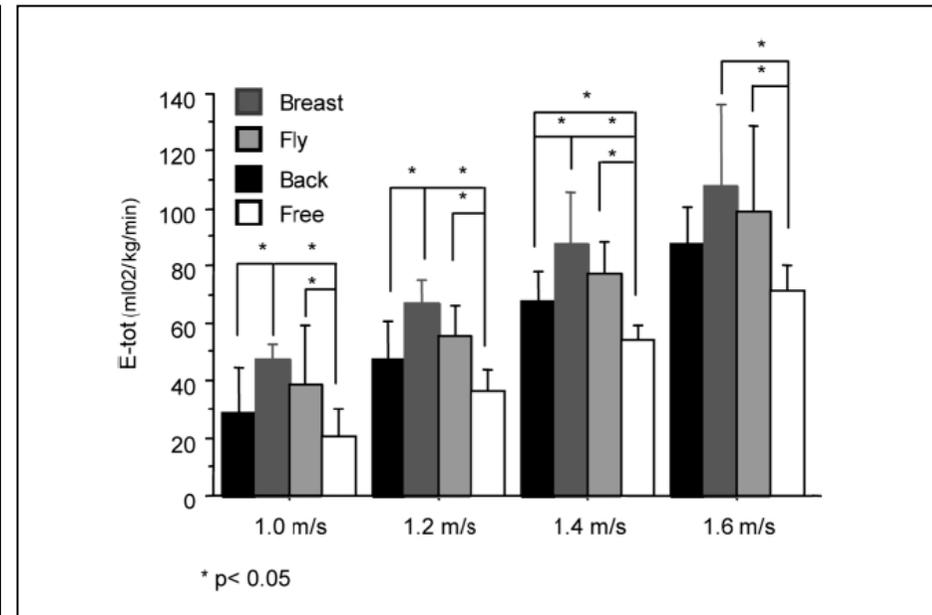
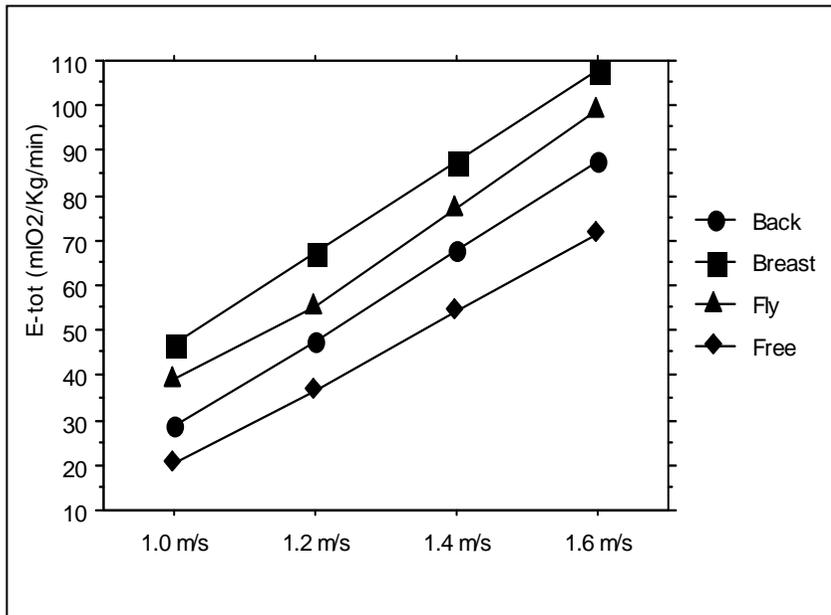
$$\dot{W} = \dot{E} \cdot e_p$$

$$\dot{W} = D \cdot v = \dot{E} \cdot e_p$$

$$v = \dot{E} \cdot \frac{e_p}{D}$$

$$\frac{\dot{E}}{v} = \frac{D}{e_p}$$

Barbosa, Keskinen, Fernandes, Colaço, Lima, Vilas-Boas (2006). *Evaluation of the energy expenditure in competitive swimming strokes. IJSM.*





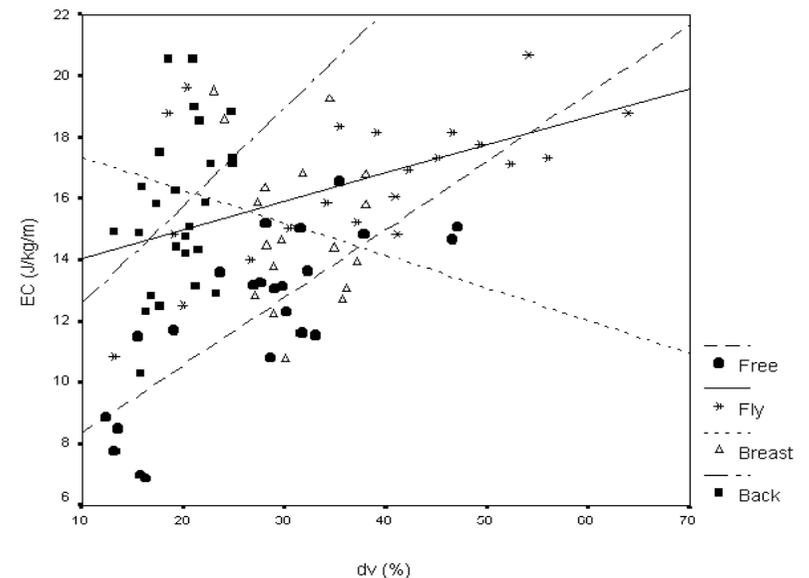
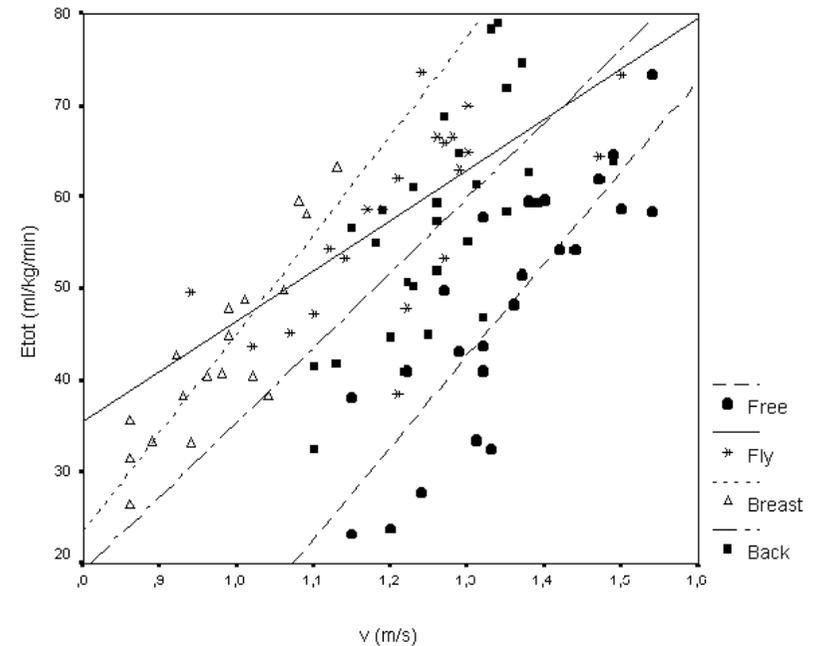
Barbosa, T.M.; Lima, F.; Portela, A.; Novais, D.; Machado, L.; Colaço, P.; Gonçalves, P.; Fernandes, R.; Keskinen, K.L.; Vilas-Boas, J.P. (2006). Relationships between energy cost, swimming velocity and speed fluctuation in competitive swimming strokes. In: Vilas-Boas, J.P., Alves, F. and Marques, A. (Eds.), *Biomechanics and Medicine in Swimming X. Portuguese Journal of Sport Sciences*, 6 (Suppl.2): 192-194.

**N = 17, POR NT; 4 Brest, 4 Butt, 4 Free, 5 Back;**  
**n x 200 (0.3 m/s less PB; 0.05m/s increases; 30 s rest**



**Partial correlations between energy cost, speed fluctuation, and velocity in competitive swimming.**

Swimming technique	Partial correlation between EC and v, controlling dv	Partial correlation between EC and dv, controlling v
Front Crawl	R = 0.43 (P = 0.05)	R = 0.62 (P < 0.01)
Backstroke	R = 0.56 (P < 0.01)	R = 0.55 (P < 0.01)
Breaststroke	R = 0.86 (P < 0.01)	R = 0.60 (P = 0.01)
Butterfly stroke	R = 0.51 (P = 0.02)	R = 0.55 (P < 0.01)
Overall sample	R = 0.16 (NS)	R = 0.39 (P < 0.01)



Tiago M. Barbosa · K. L. Keskinen · R. Fernandes  
P. Colaço · A. B. Lima · J. P. Vilas-Boas

## Energy cost and intracyclic variation of the velocity of the centre of mass in butterfly stroke

Eur J Appl Physiol (2005) 93: 519–523

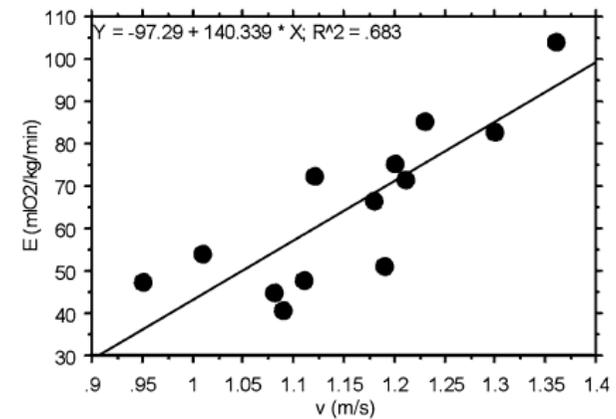
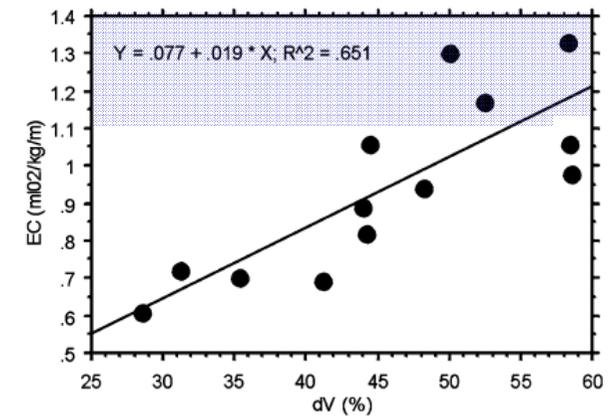
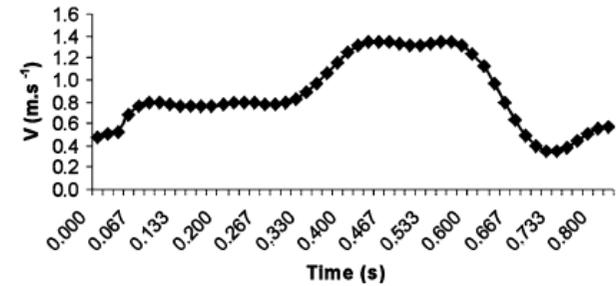
N = 5

3 x 200 (75, 85, 100%)

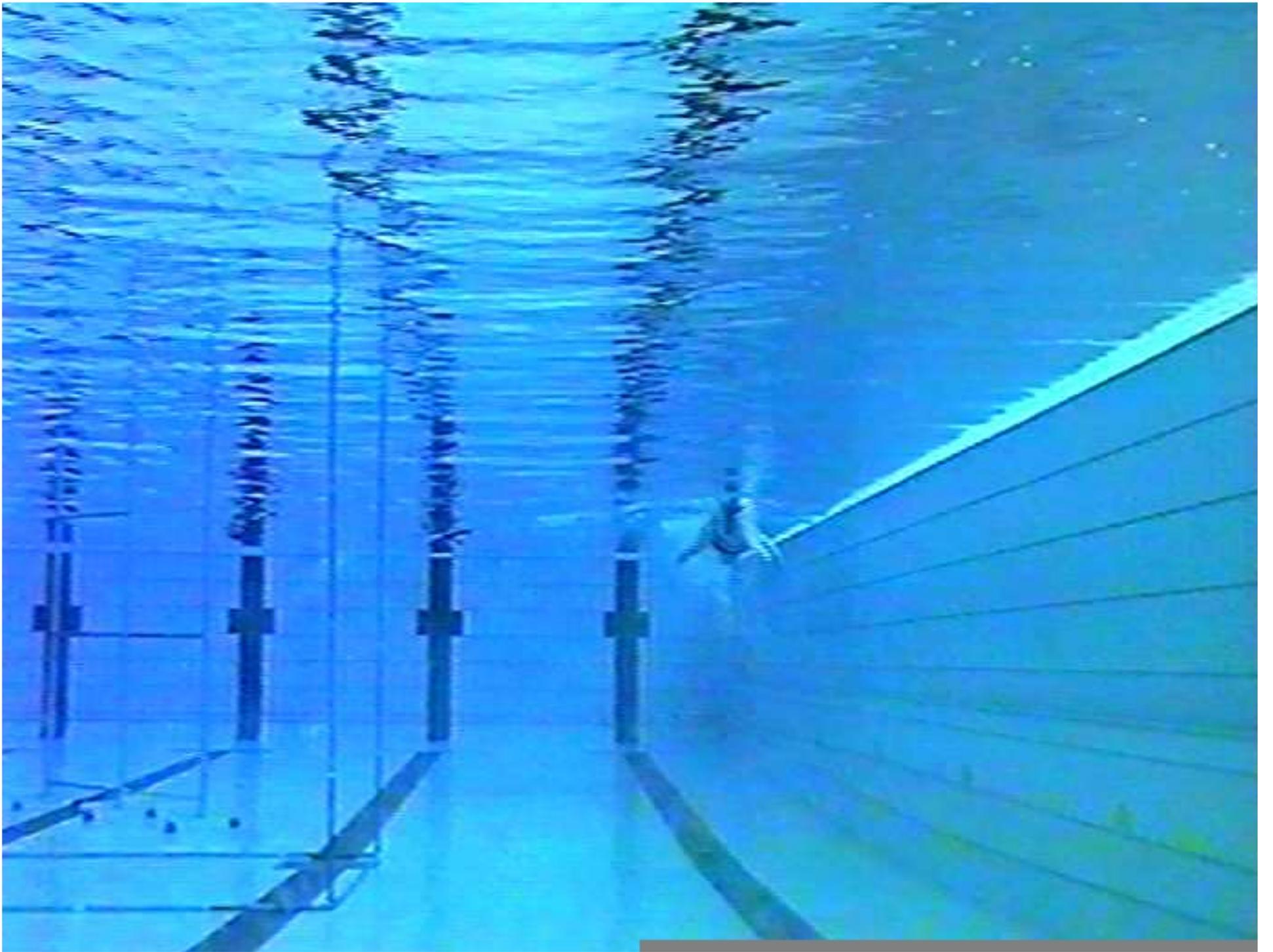
30 min rest

$$P = 0.5 \rho C_D S v^3$$

$$EC = f(\Delta v/c)$$



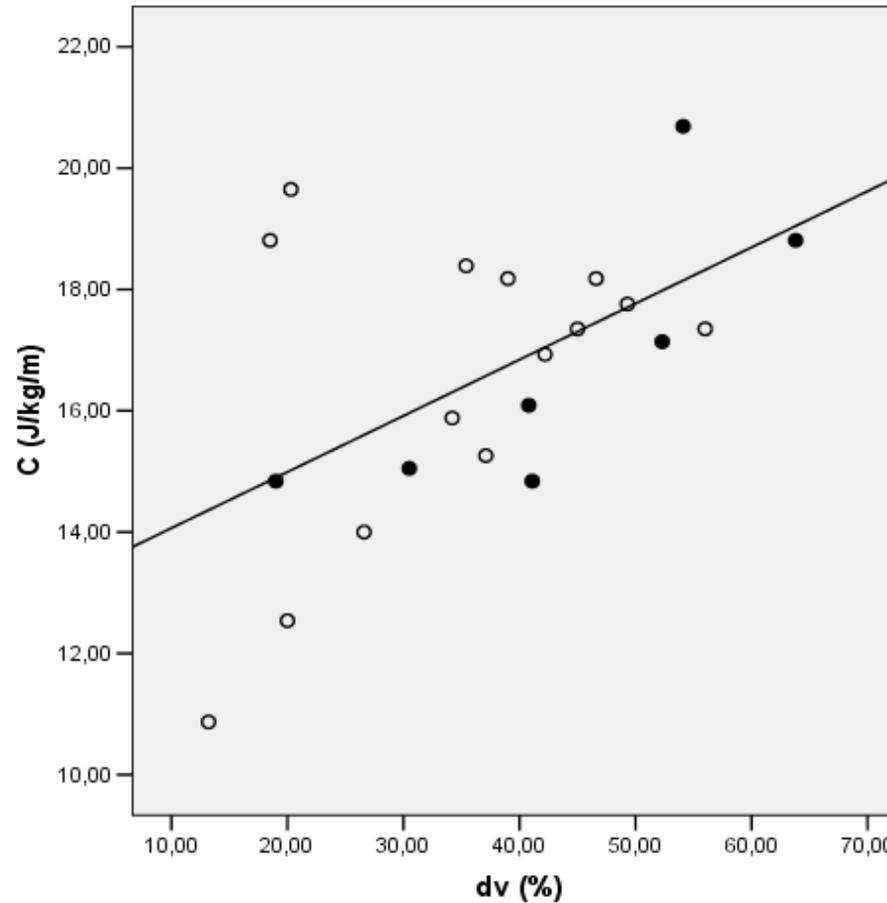






Barbosa, T.M.; Lima, F.; Portela, A.; Novais, D.; Machado, L.; Colaço, P.; Gonçalves, P.; Fernandes, R.; Keskinen, K.L.; Vilas-Boas, J.P. (2006). Relationships between energy cost, swimming velocity and speed fluctuation in competitive swimming strokes. In: Vilas-Boas, J.P., Alves, F. and Marques, A. (Eds.), *Biomechanics and Medicine in Swimming X. Portuguese Journal of Sport Sciences*, 6 (Suppl.2): 192-194.

## Mariposa



N = 3M + 1F  
 $C = 13.39 + 0.093 * dv$   
 (Rsqd = 0.30; P = 0.01)

De Jesus, de Jesus, Gonçalves, Pereira, Machado, Vilas-Boas, Fernandes (2008). *Analysis of the effects of fatigue and swimming velocity upon the velocity fluctuation profile in butterfly swimming.*

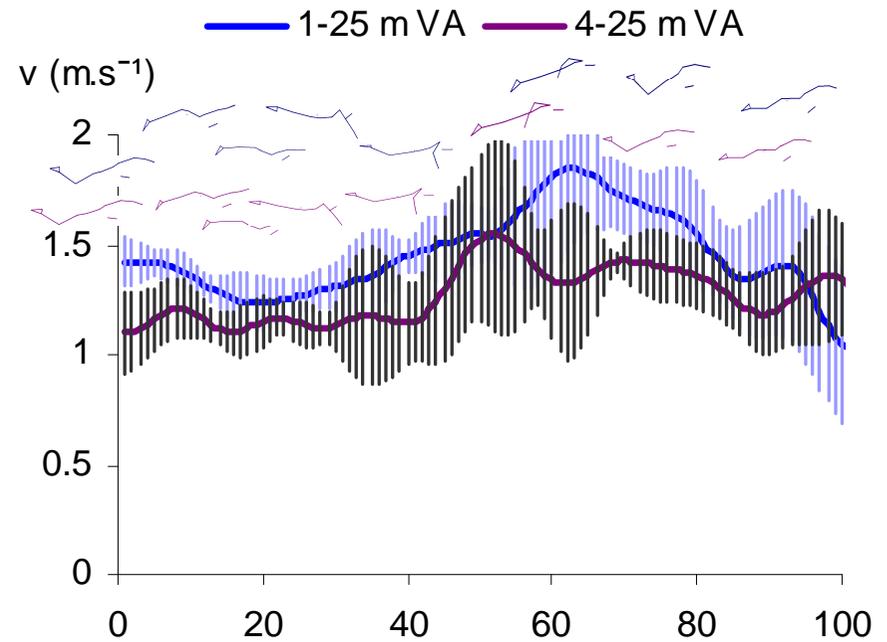
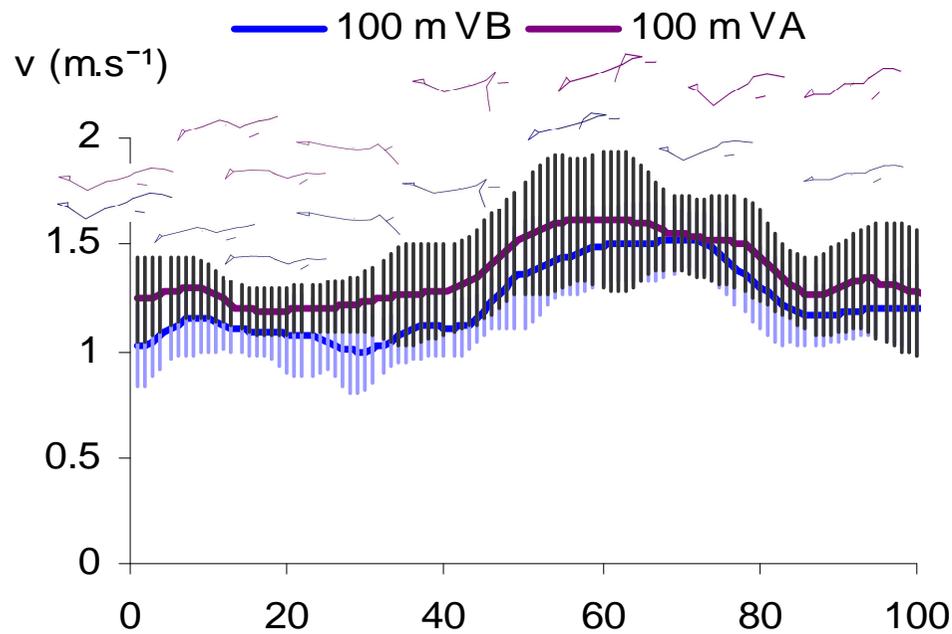
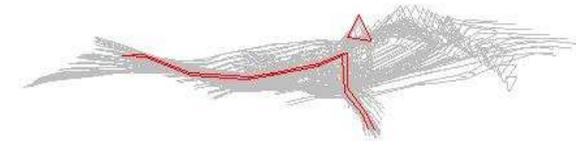
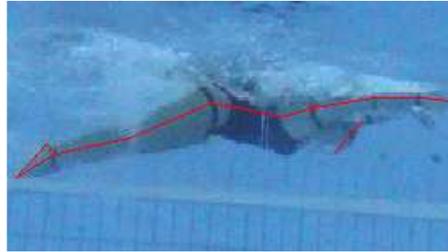
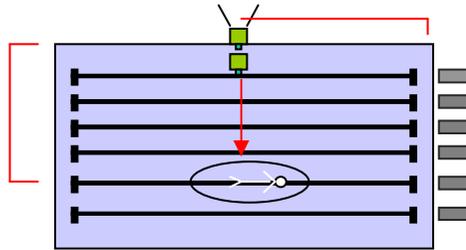
**N = 7 females**

**17.57 ± 1.98 yy**

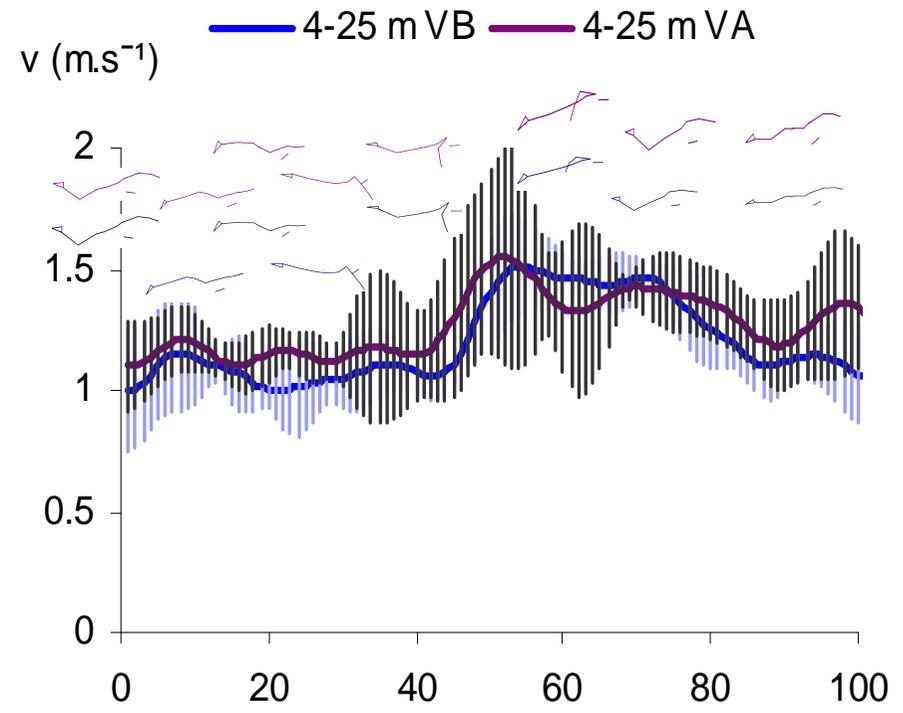
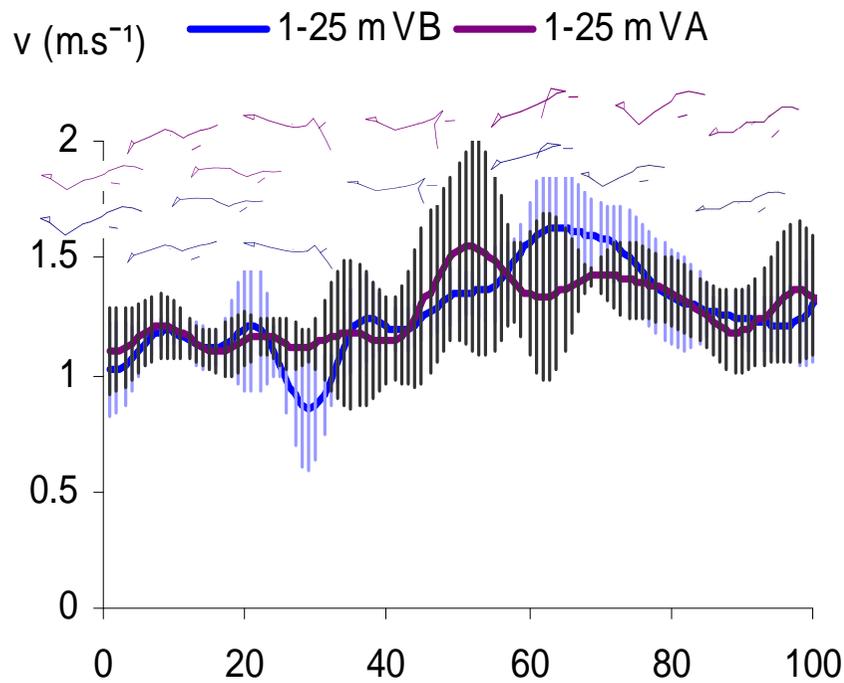
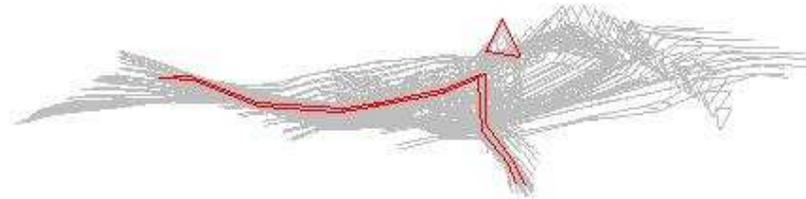
**56.94 ± 3.75 kg**

**166.14 ± 6.22 cm**

**66.36 ± 1.07 sec**



De Jesus, de Jesus, Gonçalves, Pereira, Machado, Vilas-Boas, Fernandes (2008). *Analysis of the effects of fatigue and swimming velocity upon the velocity fluctuation profile in butterfly swimming.*



# Biomecânica



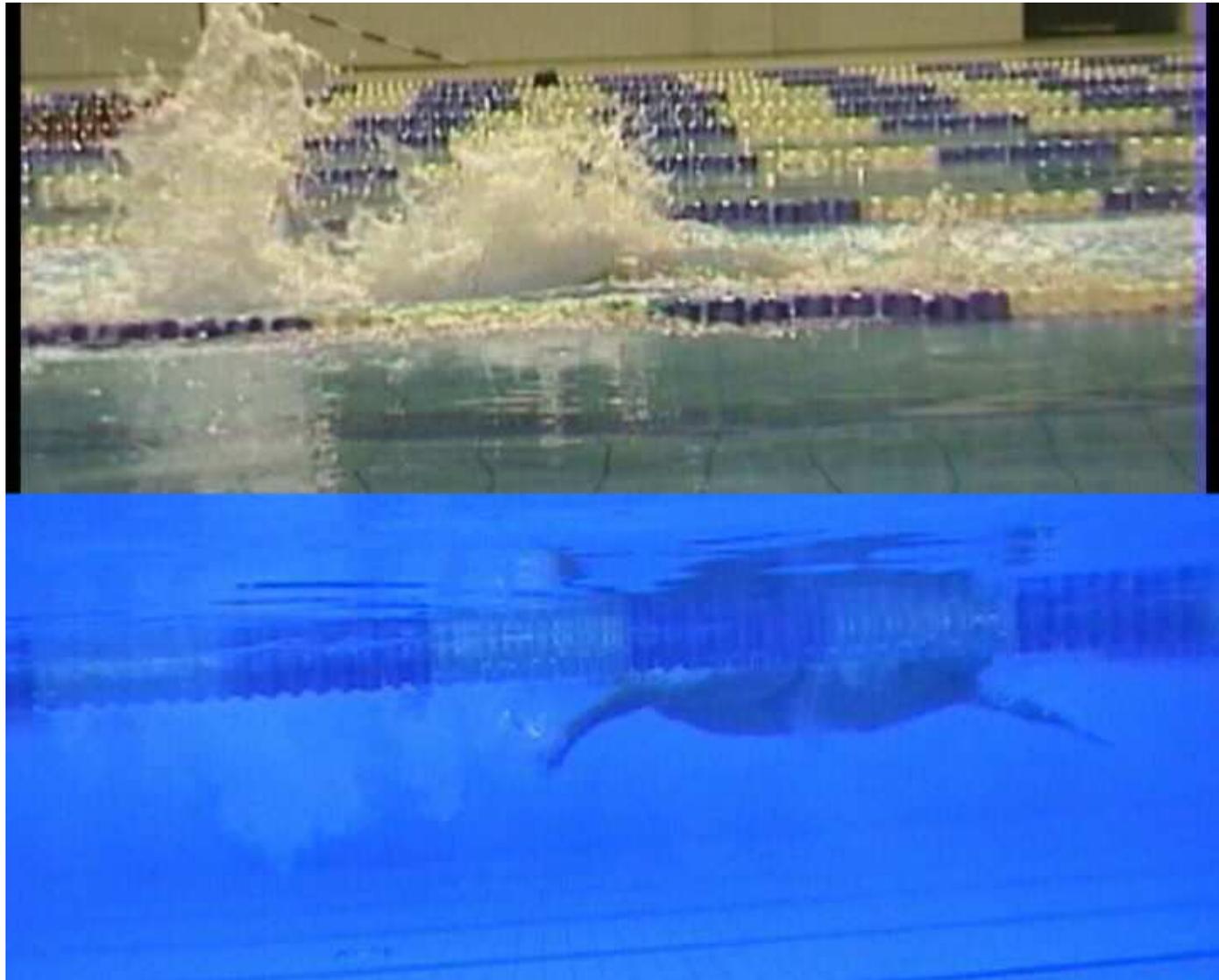
## Sumário da exposição

- (vii) **avaliação e aconselhamento do treino técnico e prescrição do exercício com base em velocimetria mecânica;**

## Imagens tradicionais em natação

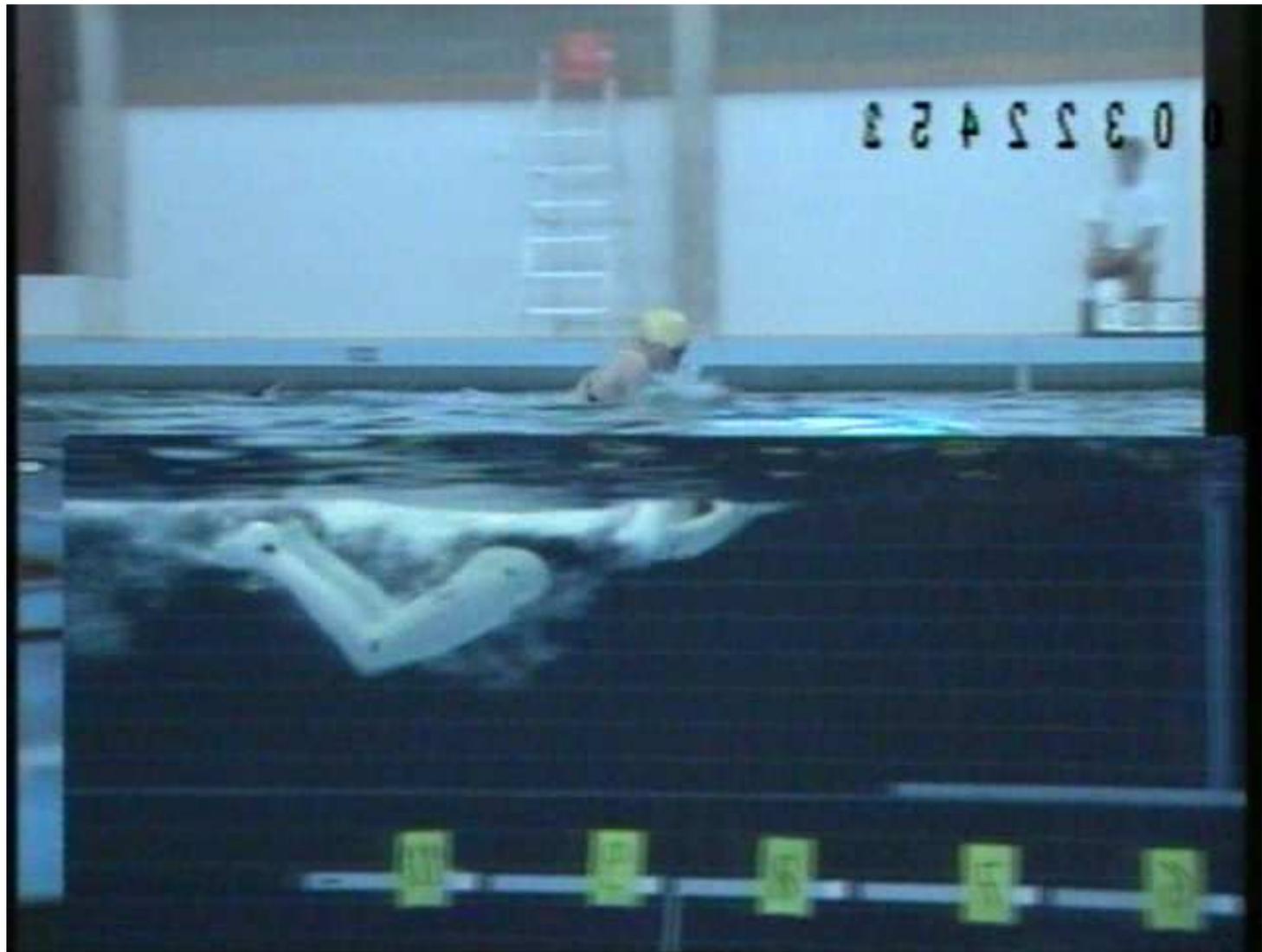


## Imagens de duplo meio reconstruídas para desportos aquáticos:



Friendly shared by R.  
Haljand ([www.swim.es](http://www.swim.es))

## Imagens de duplo meio reconstruídas para desportos aquáticos:



Friendly shared by Persyn  
et al. (KULeuven, Belgium)