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COMPUTATIONAL ANALYSIS OF THE TURBULENT FLOW AROUND A CYLINDER.

Moreira AM[1], Rouboa AF[2,3], Silva AJ[2,3], Sousa L[2], Marinho D[2], Alves FB[4], Reis VM[2], Vilas-Boas JP[5], Carneiro AL[2], Machado L[5]

[1]*Superior School of Sport, Rio Maior, Portugal*
[2]*University of Trás-os-Montes and Alto Douro, Vila Real, Portugal*
[3]*Centre of Studies, Technology, Environment and Life, CETAV, Portugal*
[4]*Faculty of Human Movement, Technical University of Lisbon, Lisbon, Portugal*
[5]*Faculty of Sport, University of Porto, Porto, Portugal*

INTRODUCTION

Nowadays two techniques to study the turbulent flow, in quasi-static approach, around a cylinder (important for same uptakes to human swimming, when we considered the Re number as dimensionless analysis) are available: experimental research and numerical simulation. Due to the experimental research limitations the use of the numerical simulation has been performing an important role in the biomechanical research area. All the studies of computational fluid dynamics (CFD) developed in swimming used the turbulent model k-ε to the resolution of the Navier Stokes equations (NS). However, no studies were performed to confirm if this model (k-ε) is the most appropriated for CFD in swimming. Therefore, the aim of this study was twofold: i) to evaluate the CFD code capacity to solve simple problems of the turbulent flow around a cylinder, by the comparison of values from different turbulence models with experimental values for similar Reynolds number (Re); ii) to evaluate, for the most appropriated turbulent model, the thickness of the adjusted mesh in order to apply it to similar RE values as it is in swimming.

METHODS

For this purpose various turbulent models were applied (k-ε; k-ω; Spalart-Allmaras; Reynolds Stress) with different mesh spacing (from 0.10 to 0.40), considered a first boarding for treatment of the geometry and conformation of the model, This first boarding allowed allowed not only the mesh generation but also to define the necessary boundary conditions to the application in the commercial code FLUENT. The velocities changed from 0.1 to 10.0 [m/s] in order to obtain the same Re numbers usually observed (Re from 10^5 to 10^7) in human swimming. The model was considered as a fix element with null velocity.

RESULTS

The results allowed to verify that the analysed resistance coefficients (for Re of 10^5, 10^6 and 10^7) decreased with the increase in Re number. It was, also, found that with the increase of the fluid velocity and the increase of Re above 10^5 a turbulent zone appeared in the wake of the cylinder, just like the expected by the fluid mechanics theories, assuming a zone of low pressure and high velocity of fluid displacement.

DISCUSSION

We can conclude by the results that in the FLUENT code the best turbulent model to apply in the numerical study, using the computational fluid dynamic approach, of human locomotion in Re number ranged from 10^5 to 10^7 is the k-ε with a mesh spacing of 0.10.

VALIDATION OF A CABLE SPEEDOMETER FOR BUTTERFLY EVALUATION.

Morouço P[1,2], Lima A[2], Semblano P[3], Fernandes D[3], Gonçalves P[2], Sousa F[2], Fernandes R[2], Barbosa T[4], Correia MV[3], Vilas-Boas JP[2]

[1]*Polytechnic Institute of Leiria, School of Management and Technology, Portugal*
[2]*Faculty of Sports, University of Porto, Portugal*
[3]*Faculty of Engineering, University of Porto, Portugal*
[4]*Department of Sports Sciences, Polytechnic Institute of Bragança, Portugal.*

INTRODUCTION

Most of the approaches available for technical evaluation of swimmers are very expensive and time consuming. Thus, one of the most important goals to achieve in swimming research should be to get fast and interactive results from the evaluation process.
The purpose of this research was to compare the real-time velocimetric results obtained from a cable velocimeter with those extracted from computerised videogrametry.

METHODS

Seven swimmers (including 3 females and 4 males) from the Portuguese national team were studied. Each swimmer performed, with a start in water, 2 repetitions of 25 m butterfly: one at race pace of a 200-m event (V200m) and other at the maximal pace of a 50-m event (V50m). Two stroke cycles for each repetition were analyzed, resulting in a total number of 28 observations. The swimmers were attached by the hip to a cable, connected to a speedometer (Lima et al, 2006) that displays a real time v(t) graphic of the intra-cyclic velocity of the hip of the swimmer. To validate the results provided by the speedometer, it was conducted a computer assisted videogrametric analysis. The trials were simultaneously videotaped, in the sagittal plane, with a set of two cameras providing dual-media images. Ariel Performance Analysis System (APAS) from Ariel Dynamic Inc. was used to digitize the stroke cycles analysed with the speedometer. 24 anatomical landmarks were digitises in each frame, allowing the division of the trunk in 3 articulated parts. Coefficients of correlation between the intra-cyclic variation of the hip velocity obtained with speedometer (V_{hip1}), with videogrametry (V_{hip2}) and the intra-cyclic variation of the centre of mass (V_{CM}) were computed.

RESULTS

The individual Pearson correlation coefficients were highly significant ($p<0.01$) and their mean values were: (i) between v_{hip1}

and v_{hip2} - r=0.96±0.03; (ii) between v_{hip1} and v_{CM} - r=0.92±0.05 and (iii) between v_{hip2} and v_{CM} - r=0.88±0.05.

DISCUSSION

It was concluded that the speedometer is a real-time reliable apparatus for the analysis of the intra-cyclic variation of the velocity of the hip in butterfly stroke. Moreover, the speedometer avoids: (i) the high costs and time spend with videogrametry, (ii) the errors of digitalization, and (iii) the need of special expertise to conduct the analysis. It allows, inclusively, the concomitant display of kinematical data with video images of the swimmer; all these advantages without compromising the swimmers performance.

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EMG ANALYSIS OF THE MUSCLES PECTORALIS MAJOR AND DELTOID POSTERIOR.

Müller E, Krumholz F, Black G, Figueiredo P, Appell H-J, Kruel L

Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil

INTRODUCTION

Only few studies exist about the neuromuscular activity during exercise in an aquatic environment. A good understanding about efficient movement patterns is necessary for the planning of training. We therefore studied muscle activity (EMG) during arm movements in water at different velocities.

METHODS

Four woman aged between 20 and 25 years participated in this study. Electromyographic activities of the posterior Deltoid and the Pectoralis major muscles were analysed during horizontal flexion and extension movements of the shoulder. Participants performed 8 repetitions in four cadences: at 40, 60 and 80 bpm, paced by a metronom. These repetitions were also performed at maximum velocity. The electromyographic sign was filtered and the RMS values of the third, fourth and fifth repetition were analysed. An ANOVA statistics analysis for EMG was performed to verify the velocity (cadence) effect ($p<0,05$).

RESULTS

The EMG values were normalized to maximum velocity and are represented by percentage of maximum velocity. The value for the posterior Deltoid and the Pectoralis major were, respectively: cadence 40 bpm (13,6±13,75 and 31,02±8,88), 60 bpm (20,24±17,18 and 56,64±22,86), 80 bpm (37,91±27,05 and 70,19±23,93). The post hoc test LSD demonstrated increased RMS values which went along with the increase of the cadences. The exercise realized in the cadence of 80 bpm showed a statistically relevant difference from the exercise realized in cadence 40 bpm in the electromyographic sign for both analyzed muscles.

DISCUSSION

A significant increase of the eletromyographic activity is provoked probably because of the need of a larger number of motor units, since the liquid environment offers more resistance when the movement is done at higher speed (1). This shows that movement speed could be a useful tool for the control of the exercise or training in the liquid environment.

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ELECTROMYOGRAPHIC DIFFERENCES OF ABDOMINAL EXERCISE IN WATER AND ON LAND.

Müller E, Krumholz F, Black G, Figueiredo P, Appell H-J, Kruel L

Universidade Federal do Rio Grande do Sul, Porto Alegre, Brasil.

INTRODUCTION

There are a lot of researches about the electrical activity of the abdominal muscles on land, but little is known about the EMG behavior when the exercise is carried through in water. This research verifies the electric activity of the abdominal muscles and hip flexor muscles during the "sit up" exercise in land and water.

METHODS

Twenty woman aged between 21 and 29 years participated. The electric activity of the Obliquus externus abdominis (OE), Rectus femoris (RF) and of the Rectus abdominis (RA) were measured with surface electrodes. The exercise of trunk flexion up to a seated position, performed on land was used as standard exercise and the root mean square (RMS) of the ascending phase of this exercise were being used for normalization the signal that was collected during another variations of speed and environment. Trunk flexions in water were performed in a horizontal position with the support of a floating device for the upper members. The exercise was performed in a standard rhythm and also in maximum speed. For each muscle ANOVA was used for the factors phase, speed and environment ($p<0,05$) was performed.

RESULTS

Statistically differences were found in the mean value of the percentual of EMG activation when the two phases, two environments and two speeds were analysed separetaly for all muscles; in the interaction of the factors environment/phase the muscles RF, upper and lower RA and OE; in the interaction of the factors environment/speed to the muscles upper and lower RA and OE and in the interaction of the factors phase/speed for all muscles analysed. When the exercise was performed in maximum speed and in the ascending fase of the exercise in the water the observed EMG activity was stronger than the muscle activity for the exercise performed in standard speed. This was observed in water and on land. The EMG activity of the RF when performing the exercise in maximum speed in water was lesser than on land.