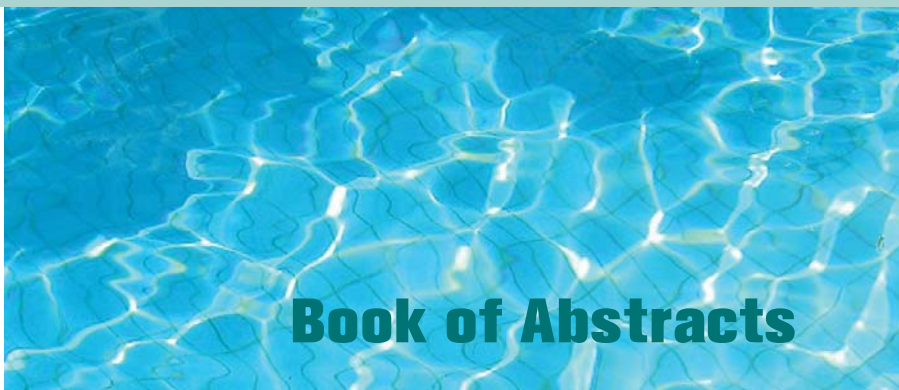Xth INTERNATIONAL SYMPOSIUM

Biomechanics and Medicine in Swimming

PORTO > PORTUGAL > 2006

Book of Abstracts

J.P. Vilas-Boas, F. Alves, A. Marques (eds.)

U. PORTO

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COMITÉ OLÍMPICO
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FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA E DO ENSINO SUPERIOR

Dear participants of BMS2006

Jorge Bento
Director of the Portuguese Journal of Sport Sciences

Certainly you already heard about us. Not in a direct way, but rather through a product that travels around the world. I am referring to the Port wine. The persons who cultivate grapes it in the slopes of the Douro River call this wine 'generous'. Certainly there are reasons for that designation. Homer said that the wine cheers the man heart, thus taking him out from a state of sadness. In the altar of the Christians mass, the wine is a symbol of a miracle that raises us to God. And, in the table of men, the wine celebrates health and fraternity. Therefore wine is indeed generous.

Generous is also the attitude that leads you to participate in this congress. To share knowledge, to exchange and widen perspectives and points of view, to animate and deepen the reflections and discussions, are acts full of human generosity. Therefore, we classify as generous your stay at our Faculty, and our town.

We feel very honoured and gratified with your visit. We will seek to correspond to your generosity with the warmth of our esteem and gratitude. The bread and wine that we will eat and drink together in the forthcoming days will establish the approach. We want that at the end of congress, when you return home, you also feel that distance does not exist and that we all stand closer together. This is our purpose, this is our dream. Welcome!

Xth INTERNATIONAL SYMPOSIUM

Biomechanics and Medicine in Swimming

PORTO > PORTUGAL > June 21 to 24, 2006

A coach-friendly scientific congress on the road to Beijing 2008.

The official host of the Symposium is the University of Porto, Faculty of Sport (Faculdade de Desporto da Universidade do Porto - FADEUP), and the Portuguese Swimming Federation (Federação Portuguesa de Natação - FPN).
The Symposium is organized in close cooperation with the Portuguese Swimming Coaches Association (Associação Portuguesa de Técnicos de Natação - APTN), and the Swimming Association of the North of Portugal (Associação de Natação do Norte de Portugal).
The Xth International Symposium on Biomechanics and Medicine in Swimming is an event promoted by the Steering Group Biomechanics and Medicine in Swimming of the World Commission of Sport Sciences (WCSS).

TOPICS

Scientific topics
~ Swimming Biomechanics
~ Swimming Physiology and Biochemistry
~ Swimming Bioenergetics
~ Swimming Medicine and Traumatology
~ Swimming Psychology

Applied topics
~ Swimming training (pure competitive swimming, including master swimming, synchronized swimming, water-polo, diving, fin swimming and life saving)
~ Swimming evaluation, advice and biofeedback
~ Adapted swimming sports and Rehabilitation
~ Hydro-gymnastics and Leisure aquatic sports

Welcome message of the Chairmen of the Xth International Symposium on Biomechanics and Medicine in Swimming

J. Paulo Vilas-Boas
Francisco Alves

Dear Colleague, Swimming Scientist, Coach, Physician, Paramedical, or Student:
The University of Porto, the Portuguese Swimming Federation, the city of Porto and its whole Metropolitan area, are very pleased to host the 2006 edition of the International Symposium on Biomechanics and Medicine in Swimming, its 10th edition.
We are honoured for the distinction the Steering Group of the World Commission for Sports Science gave us, and we are looking forward to not disappointing them!
The Portuguese Swimming community, including both the scientific and the coaching groups and interests, friendly and converging, is anxious to receive you all, the world swimming community, for the most "applied" scientific conference on the topic of all times! We expect BMS2006 will launch relevant scientific foundations for the promotion of performance of our swimmers around the world, helping to make possible the desired new and important achievements in Beijing 2008.
We are on the road to Beijing 2008, and we believe that a stop in Porto, for a scientific meeting, will profit all, once we have a very good scientific program, as much "coach friendly" as possible, and also a nice social collection of events. We are also inviting you to visit Porto, to taste Port Wine, and to experience Portuguese food and joy, during one of the most exciting popular parties of the city: the St. John's Eve.
Please enjoy yourselves, and help us all to grow!

Welcome message of the Chairman of the Steering Group Science in Swimming

Peter Hollander

The Xth International symposium on Biomechanics and Medicine in Swimming will be organized in 2006 in Porto. A tradition that started in 1970 is still alive.
Since the start of this particular symposium in 1970 (it was the first symposium in the field of Sport Sciences, nowadays unified within the World Commission of Science & Sports) every four year another edition of the symposium was organized. And any time again its impact was progressing. The number of papers presented during the symposium, the number of papers published in the Proceedings as well as the number of pages of the Proceedings was growing. Over more than 25 years the symposium provides (scientific) understanding of swimming and a more solid background of trainers and coaches in the field of swimming.
Although many problems have been solved, even more knowledge is needed to understand the way human beings propel themselves from one and of the pool to the other. And much more knowledge is necessary to choice the right race strategy of the proper way of preparing the athletes during the season.
It will be a serious challenge for the Porto organizers of the symposium to beat the former ones and to give the floor to scientists from all over the world in order to give the final answers raised in the sentence before. I am quite sure that the organizers will make the symposium to a very successful one, and nobody interested in the science of swimming will miss it. Joining the symposium means updating your knowledge of the science of swimming, meeting old friends, and make new ones. Can there be better arguments to come to Porto and join this meeting.

HISTORY

Since 1970 the International Symposium on Biomechanics and Medicine in Swimming (BMS) – till 1978 initially named "International Symposium on Biomechanics in Swimming" - has provided the most distinguished contributions for the progress of knowledge in the area, and has built up a friendly, united, but scientifically exigent community of scientists that has written the most quoted books related to the science of swimming. This is the list of the past events and published books that wrote the glorious history of this community:

1970 – Brussels, Chairmen: L. Lewillie, J. P. Clarys
L. Lewillie, J.P. Clarys (eds.), Proceedings of the First International Symposium on Biomechanics in Swimming, Waterpolo and Diving. Université Libre de Bruxelles, Bruxelles, 1971.

1974 – Brussels, Chairmen: J. P. Clarys, L. Lewillie
J.P. Clarys, L. Lewillie (eds.), Swimming II. University Park Press, Baltimore, 1975.

1978 – Edmonton, Alberta, Chairmen: J. Terauds, E. W. Bedingfield
J. Terauds, E. W. Bedingfield (eds.), Swimming III. University Park Press, Baltimore, 1979.

1982 – Amsterdam, Chairmen: A. P. Hollander, P. A. Huijing, G. de Groot
A. P. Hollander, P. A. Huijing, G. de Groot (eds.), Biomechanics and Medicine in Swimming. Human Kinetics Publishers, Champaign, Illinois, 1983.

1986 – Bielefeld, Chairmen: B. E. Ungerechts, K. Wilke, K. Reischle
B. E. Ungerechts, K. Wilke, K. Reischle (eds.), Swimming Science V. Human Kinetics Publishers, Champaign, Illinois, 1988.

1990 – Liverpool, Chairmen: D. MacLaren, T. Reilly, A. Lees
D. MacLaren, T. Reilly, A. Lees (eds.), Biomechanics and Medicine in Swimming, Swimming Science VI. E & FN Spon, London, 1992.

1994 – Atlanta, Chairmen: J. P. Troup
J. P. Troup, A. P. Hollander, D. Strasse, S. W. Trappe, J. M. Cappaert, T. A. Trappe (eds.), Biomechanics and Medicine in Swimming VII. E & FN Spon, London, 1996.

1998 – Jyväskylä, Chairmen: K. Keskinen, P. Komi
K. Keskinen, P. Komi, A. P. Hollander (eds.), Biomechanics and Medicine in Swimming VIII. Dep. of Biology of Physical Activity, University of Jyväskylä, Jyväskylä, 1999.

2002 – Saint-Etienne, Chairmen: J. C. Chatard
J.C. Chatard (ed.), Swimming Science IX. Biomechanics and Medicine in Swimming IX. Publications de l'Université de Saint-Étienne, Saint-Étienne, 2003.

2006 – Porto, Chairmen: J. P. Vilas-Boas, F. Alves
J.P. Vilas-Boas, F. Alves, A. Marques (eds.), Biomechanics and Medicine in Swimming X. Portuguese Journal of Sport Sciences, Suppl 2, 2006.

IN MEMORIAM
Prof. Dr. Léon Lewillie

SWAMMERDAM, GALVANI, VOLTA, VON HELMHOLTZ, DUCHENNE DE BOULOGNE, LEON LEWILLIE… AND THE OTHERS.
In memoriam lecture Prof. Dr. Léon Lewillie, president of the "1st International Symposium Biomechanics in Swimming, Brussels 1970"

Clarys JP
Past President of the World Commission of Sport Sciences (WCSS) of the International Council of Sport Sciences and Physical Education (ICSSPE/CIEPS) of UNESCO

Léon Lewillie… Doctor in Physical Education & Physiotherapy, Professor in Biomechanics, Anthropometry and History, swimmer and waterpolo player, was born in Brussels, Belgium in 1925 and died at the age of 76.

He was Belgian Champion in 1938 of the 200m "free style" and twice champion in water polo, be it with 40 years of interval, namely at 16 with a junior team and at 56 years, not with a veteran team but with a national 3rd division team.

But Leon Lewillie was much more because he lived many lives.

Lewillie the society initiator: he was the co-founder of "La societée de Biomécanique de langue Française. Co-founder of the working group of sport Biomechanics of Unesco and of Biomechanics in Swimming (Today both organisations became part of WCSS); he was co-founder of the International Society of Biomechanics (ISB) and of the International Society of Electrophysiology and Kinesiology (ISEK).

Lewillie the inventor was fascinated with electronics and developed various pieces of equipment, first for telemetric data acquisition of heart rate and frequency, later of EMG, EEC and respiratory function signals… and since he was a believer of measuring on location under "real motion/effort" circumstances he had miniaturised all his devices, to allow research in the swimming pool or any other sports environment.

Lewillie the physiologist. Inherent to his interest in the cardio-respiratory function, he has focussed on fatique, gender and age.

Lewillie the Biomechanist, brought the EMG out of the single fibre electrophysiology into the analysis of global motion and movement synchronisation. He was master in combining complex electronics with (according to him) simple imaging techniques such as light trace techniques, stroboscopy and dual camera synchro.

Lewillie the electro-kinesiologist deserves a separate mention. His telemetric EMG for an aquatic environment is known all over the world because he was the pioneer of it, together with Mitsimasa Miyashita (long-time Nat. trainer of the Japanese Swimming team).

Lewillie the historian, or better sports historian. Libraries were his second home and his research in that area resulted in "Professional Sport in the Greek World", and "Swimming through the ages" or "History of scientific data acquisition".

Lewillie Homme du Monde… member of the resistance during WW II; free Macon… Oenologue, sportsmen and above all a team man.

Tom Cureton, Jim Counsilman, Ernest Magl ischo… Léon Lewillie … could have been another title of this too late "in memoriam"!?

FUNDAMENTAL HYDRODYNAMICS OF SWIMMING PROPULSION.

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INTRODUCTION
The study of human swimming propulsion is one of the most complex areas of interest in sport biomechanics. Over the past three decades research in swimming biomechanics has evolved from the observation subject's kinematics to a basic flow dynamics approach, following the line of the scientists working on this subject in experimental biology (1, 2).
The understanding of swimming propulsion based on steady-state flow mechanics left many questions unanswered, leading us to apply unsteady mechanisms of force production to resolve them. However, this approach needs to analyze the flow behaviour around the propulsive limbs to identify the phenomena, a difficult task in a swimming pool.
Vortices, circulation, vorticity, delayed stall, stroke reversal, wake, Strouhal number, CFD, PIV and so on are some terms and concepts that have recently been included in the vocabulary of swimming biomechanics and have opened up new ways of research.

METHODS
A compilation of flow visualization methods applied in human swimming research will be presented including: natural or spontaneous bubbles, tuft method, shadowgram, injected dye, reflective small particles, injected bubbles and bubble wall. Simultaneously, some researchers are using Computer Fluid Dynamics to simulate the water and hand and forearm interactions. To quantify the information gathered thanks to the flow visualization methods it is necessary to apply a tool called Particle Image Velocimetry, which gives a velocity vector map of the flow around the propulsive element. This useful tool has been extensively used by biologists to study the wake of the propulsive movements of water animals, but very few studies have been developed in human swimming.
Our work has been oriented during the recent years to applying different flow visualization methods during simple and complex propulsive movements, developing new tools to visualize the wake generated by the human propulsive limbs. Vortices are generated in different magnitude and position after the hand or feet, depending on limb velocity, angle of attack and change of direction of the propulsive path and compared with some water animals.
A clear Karman vortex street was observed after the underwater undulatory swimming of top performers combined with a more efficient Strouhal number. Complex wake structures were observed after simple sculling movements where the lift force is the primary source of propulsion, suggesting the use of stroke reversal to combine the forces generated in both directions. The application of the methods referred to above in normal stroke mechanics seems less clear and more complex. The 3D pulling swimming path increases the difficulty of obtaining clear water wakes around or behind the hand and only incidental vortices are found after very restricted conditions, in spite of the clear wakes generated by the hands in laboratory tests.

CONCLUSIONS
The analysis of vortices generated and 3D analysis of the pulling path seems the most adequate method to develop a new understanding of swimming propulsion in the near future.

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THE USE OF CRITICAL VELOCITY IN SWIMMING?
A PLACE FOR CRITICAL STROKE RATE?

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For any swimmer, a hyperbolic relationship links velocity (v) to time to exhaustion (t) (Figure 1). The asymptote of the relationship is called Critical Velocity (CV) and this particular v could be maintained, at least in theory, indefinitely. Stroke rate (SR), changes in a similar manner with time (Figure 1), the asymptote of this relationship being called Critical Stroke Rate (CSR; 2). This comes from the original work of Monod and Scherrer (1), authors of the original Critical Power concept (CP).
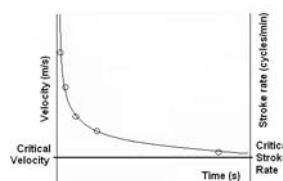
Figure 1: Velocity-time and stroke rate-time relationships

Numerous studies have been conducted on the CP and CV parameters in order to test their reliability, better understand their physiological meanings (3) and validate their use for training. Whilst most of the studies have been conducted in laboratories, mainly on ergometers, some studies have been undertaken in swimming. While being aware of the several assumptions underlying the application of the CP concept in swimming (4), coaches should appreciate the ease in using the CV model to predict performance, set training loads, discriminate effects of training, and establish energetic potentials of swimmers.
Alongside the CV/CP concept, a SR concept has been proposed, CSR being the SR spontaneously chosen by swimmers at CV (2). Knowing the CV and CSR of a swimmer would enable valuable technical work performed around CV.
Further research is required investigating these concepts. However, current available knowledge suggests there is merit in using the parameter for training.

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3. Hill DW, Ferguson CS (1999). A physiological description of critical velocity. Eur J Appl Physiol Occup Physiol 79: 290-293.
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STATE OF THE ART ON SWIMMING PHYSIOLOGY AND COACHING PRACTICE: BRIDGING THE GAP BETWEEN THEORY AND PRACTICE.

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INTRODUCTION
The description of the art of swimming dates back to 5000 y BC by Egyptian hieroglyphs and paintings. Kahein papyrus 3000 y BC mentioned medical findings related to protection against Schistosomiasis while swimming (Clarys, 1996). The modern history of Swimming Physiology dates back to early 1900's where we recall pioneering work of e.g. Du Bois-Reymond (1905) and Liljenstrand & Stenström (1919) in cardiovascular and metabolic aspects of swimming as well as Hill (1923) who explored the basic relationships between the maximal performance and maximal oxygen consumption describing also the role of lactic acid in the muscle after exercise. Holmer & Åstrand laid the basics for physiological testing of swimmers in 1970's. Since then the literature has accumulated rapidly. The aim of the present paper was to survey the state of the art on swimming physiology as related to coaching practice in order to help bridging the gap between theory and practice.

METHODS
Systematic literature searches were performed through the years 1990 – 2006 utilising EBSCOhost Research Databases and SportDiscus. Ovid Medline was used to scan materials for randomized controlled trials (RCT). The searches were done in three steps using both key words and thesaurus decodes. In the first phase, "Swimming" without any limitations was fed to the system and again with animals excluded, second, "Swimming and Physiology" was used and third, subdivisions were connected to the precedents.

RESULTS
When the time line was kept unlimited a total of 22.192 hits by key words (16.362 by thesaurus decode) were observed with Swimming. When animal experiments were excluded 21.882 (16.067) hits were found. During the 1990 – 2006 there were 9.778 (7.092) papers in English including 2.212 (1.451) in advanced and 688 (507) in intermediate category. When Swimming and Physiology (no animals) were connected 1.975 hits were found, out of which 833 (557 advanced, 110 intermediate) appeared during 1990 – 2006. When the subdivisions were added to the searches the number of papers remained at reasonably low levels to enable content analysis. RCT was found in 61 papers, none with population based sampling. Materials concerning data to be utilised by practitioners in sports coaching and fitness training were well represented in all subdivisions.

DISCUSSION
The major finding was that all subdivisions of swimming physiology included studies that could be considered valid for sports coaching and fitness training. Previous findings of Keskinen (1991) reported 539 items (peer reviewed, books chapters and books) on Swimming Physiology through the years 1893 – 1990. Clarys (1996) reported that by the mid 1990's there were 685 peer reviewed papers on Swimming out of which 18 % were on Swimming Physiology. When these data are connected to the present one, an expansion of scientific approaches in swimming literature can be observed.

CONCLUSIONS
The body of knowledge for the improvement of sports coaching and fitness training in Swimming is large and well represented in all subdivisions of Swimming Physiology.

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ENERGETICS IN COMPETITIVE SWIMMING AND ITS APPLICATION FOR TRAINING.

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INTRODUCTION
Competitive swimming events consist of different distances from 50m to 1500m. The exercise intensity and the relative importance of aerobic and anaerobic energy processes vary depending on the exercise time (and thus swimming distance). Therefore, determining time dependent metabolic profile would provide important information for developing effective training program.

TIME DEPENDENT METABOLIC PROFILE
To determine the time dependent metabolic profile of arm stroke (A), leg kick (K) as well as whole body (S) swimming, the accumulated O_2 uptake (AOU) and the accumulated O_2 deficit (AOD) were determined at six different water flow rates in a swimming flume, which were estimated to cause exhaustion in 15 s, 30 s, 1 min, 2-3 min, 4-5 min, and 8-10 min, with each stroke. As the results, the AOU increased linearly with exercise time in all strokes, and the increased rate of AOU in A and K corresponded to 70, and 80% in S, respectively. The AOD in A and S significantly increased until 2-3min of exercise time, while the AOD in K more rapidly increased and the AOD

at 30 s was not significantly different from those at 1 min and 2-3 min. The relative importance of anaerobic energy process in three strokes decreased from 78-85% for 15 s to 50 % for 1 min, 30% for 2-3 min, 5% for 8-10 min duration, and it was greater in K than those in A and S until 30 s duration. These findings suggest that the coach should design specific training programs to improve the metabolic capacity for each stroke, and those results concerning time dependent metabolic profile in A, K, and S, gives helpful information to plan training successfully.

ENERGETICS IN SUPRAMAXIMAL SWIMMING UNDER HYPOXIC CONDITIONS

The changes in aerobic and anaerobic energy release in supra-maximal swimming lasting 2-3 min were determined under different levels of hypobaric hypoxic condition (a normal condition; 999hPa, 800 m; 912hPa, 1600 m; 836hPa, and 2400 m above sea level; 751hPa). All measurements were done in a chamber where the atmospheric pressure could be regulated. The water flow rate of the supramaximal swimming decreased with decrease in atmospheric pressure. However, when these water flow rates were expressed as percentage of VO_2max determined in each condition, no significant differences were observed among conditions. Mean oxygen uptake determined every 30 s also decreased with effective altitude. Conversely, no significant differences were observed in mean AOD determined every 30 s. Consequently, mean maximal AOD were not significantly different among conditions, either. These results suggest that during supramaximal swimming, rate of aerobic energy release diminished with increase in hypobaric hypoxia, while not only AOD but also rate of anaerobic energy release throughout the exercise were unaffected despite the decreased O_2 demand caused by diminished exercise intensity due to hypobaric hypoxia.

ALTITUDE TRAINING – AEROBIC OR ANAEROBIC?

Training at altitude has been primarily performed for the purpose of improving O_2 transport system, i.e. maximal aerobic power (VO_2max). On the other hand, several studies recently reported that maximal accumulated O_2 deficit (MAOD) and buffering capacity increased after altitude training, and a new possibility that the altitude training may also improve effectively anaerobic energy releasing system was suggested. Therefore, to examine the effects of altitude training on metabolic capacity, two groups (normal group; N and hypoxic group; H) had high-intensity-training 2 times/day, 5 days/week, for 3 weeks under a normal or hypobaric hypoxic condition. Before and after the training period, VO_2max and MAOD were determined. After the training, VO_2max significantly increased in both N and H, and no significant difference was observed in the increase ratio of VO_2max between N (12%) and H (12%). MAOD also significantly increased in both groups, however, the increase ratio of MAOD was significantly higher in H (29%) than N (14%) (P<0.05). These results suggest that the high-intensity training could contribute to induce a large improvement of metabolic capacity in both conditions but that the hypoxic training would be favorable for the improvement of the ability to supply anaerobic energy such as MAOD rather than VO_2max.

CONCLUSION

We conclude that metabolic capacity can be improved more

effectively if you understand time dependent metabolic profile and you can tax an appropriate training stimulus to the aimed energy system.

BIOPHYSICS IN SWIMMING.

Pendergast DR[1], Capelli[2] C, Craig Jr AB[3], di Prampero PE[2], Minetti A[4], Mollendorf J[1], Termin II A[1], Zamparo P[2]

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INTRODUCTION

Swimming performance is judged by the time to cover specific distances (50m to 1500m) or velocity (v = d/t). The velocity can be quantitatively analyzed: 1) as a function of the stroke rate (SR) and the distance the body travels per stroke (d/S) that are determined by biomechanics (1) and 2) the energy cost to swim at that velocity (Cs) and the time dependent maximal metabolic power (2). These two factors have to balance and together they explain performance; and they can be affected by training to improve performance (3).

DEVELOPMENT OF THE TOPIC

Craig in 1979 showed that there are specific characteristics of the relationship between v, SR and d/S for each competitive stroke and that these characteristics related these to swimming performance. Termin has demonstrated that the SR-v relationship can be "shifted" (increased 16% d/S_{max} and 8% SR_{max} at v_{max}) by biomechanical training, independent of strength training, and these changes result in improved performance. The biomechanical factors influence drag and efficiency, that are interrelated, and they in-turn determine the metabolic requirements. Drag forces can be evaluated during actual swimming or while being towed. It is comprised of friction, pressure, and wave retarding forces, and at competitive v of 2.2 m/s are ~ 55, 24 and 23% respectively. Drag reduction can be achieved by training and to a lesser extent by special swim suits. Efficiency and the work/time determine the Cs. They are influenced by drag (Wd), water accelerated away from the swimmer (Wk) and acceleration and deceleration of the limbs (Wint), which in-turn are influenced by SR-v relationships (4). The Cs and v determine the metabolic power required to swim at that velocity (3). The total power increases as expressed by $E_{tot} = kv^{1.83}$, is highly variable among swimmers, and decreases with training (3). $E_{tot} = E_{an} + kV_{O2max} t_p – kV_{O2max} \tau (1- e^{-(t_p/\tau)})$, where E_{an} = anaerobic (rate of blood lactate increase), V_{O2max} = maximal oxygen consumption, k = O_2 equavilent, τ = time constant for V_{O2max}, t_p = performance time (3). At competitive velocities Cs was least in front crawl and greater in backcrawl, butterfly and breaststroke, respectively, at competitive velocities and are associated with the SR-v curves. For most strokes in longer distance races (v = 1.6 m/s) the division of aerobic (E_{ae}), anaerobic lactic acid (E_{anla}) and anaerobic alactic acid (E_{analac}) sources are 37.8, 43.0, and 19.3%; while for shorter distances (v = 2.0 m/s) they are 19.4, 54.2, and 26.4%, respectively (2). V_{O2max} in over-distance trained (moderate v) swimmers is low and not very variable, while high velocity training

increases it 48%, along with 35% in E_{anla}, and resulted in a 27% increase in v_{max}.

CONCLUSION.
The biophysics of swimming can be quantified as v $_{max}$ = SR x d/s and Cs x (Eae + Eanla + Eanala) (Etot). These biomechanical and metabolic factors are greatly variable and each component is changed by training, even in elite swimmers.

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ANALYSIS OF SWIMMING TECHNIQUE: STATE OF THE ART: APPLICATIONS AND IMPLICATIONS.

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INTRODUCTION
Methods of analysing motion have advanced greatly in recent years due to improvement in technology as well as application of scientific approaches. However, analysis of swimming continues to be very challenging compared to many other sport activities due to the fact that swimming is performed at the interface of two media. This paper provides an overview of some of the methods currently used to provide feedback for swimmers and coaches as well as to address scientific questions to understand more about how swimming performance is optimised. The presentation includes methods of collecting data, analysing data, and presenting results for different levels of analysis including qualitative analysis and simple quantitative analysis for immediate feedback, two-dimensional (2D) and three-dimensional (3D) quantitative analysis of kinematics, and deriving forces from the whole body centre of mass. Examples of specific applications and implications are described.

QUALITATIVE ANALYSIS AND SIMPLE QUANTITATIVE ANALYSIS FOR IMMEDIATE FEEDBACK
Various programs provide immediate feedback to swimmers and coaches. The program at the Centre for Aquatics Research and Education (CARE) features outstanding under-water and above-water video equipment controlled from poolside. The data are replayed as digital 'avi' movies in slow and stopped motion on large plasma screens. Other centres, for example, the Centre for Aquatics Research at the University of Granada, and Katholieke Universiteit Leuven, have developed sophisti-

cated automated reporting systems. Several portable systems for quantifying fractional race times and distances of all swimmers in a competition have been developed, for example, the 'Australian' system by Mason and Cossor at the Australian Institute of Sport.

TWO-DIMENSIONAL (2D) AND THREE-DIMENSIONAL (3D) QUANTITATIVE ANALYSIS FOR RESEARCH
Staff and postgraduate students at CARE regularly conduct 2D and 3D data collection and analysis. 2D approaches include the quantification of passive drag and added mass from digitised video data of subjects performing inclined glides, and quantification of movement rhythms and inter-joint coordination in various modes of swimming. 3D approaches are being used to quantify body roll and fine changes in temporal and spatial movement patterns across conditions such as swim speeds, stages of a simulated race, and preferred race distance.

DERIVING FORCES FROM THE WHOLE BODY CENTRE OF MASS
Researchers at CARE have developed a PC version of Jensen's 'elliptical zone' digitising program to yield accurate body segment parameter data. This enables the centre of mass of a swimmer to be calculated accurately so that derived net forces provide an indication of the interplay between propulsion and resistance. This is leading to an improved understanding of how propulsive and resistive forces are produced and how swimming technique can be optimised.

TECHNOLOGY APPLIED TO OPTIMISE TRAINING FOR IMPROVEMENT OF FRONT-CRAWL SWIMMING PERFORMANCE.

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Peak performances in sport require the full deployment of all powers an athlete possesses. The development of those powers require years of hard training. It may be argued that training-time will be especially efficient when devoted to the enhancement of those performance factors that are weak links in the individual performance chain. Developments of measurement technology (with special reference to the MAD-system) have aided the sport scientist in identifying several factors as determinants of performance. These include drag, propulsion technique, and mechanical power (2). The development of this knowledge provides the modern coach with some guide-lines how to design training programmes. However, it may be argued that training-time will be especially efficient when devoted to the enhancement of those performance factors that are weak links in the *individual* performance chain. This implies that on an *individual* level it is necessary to identify in what phase of the process the performance system first becomes insufficient. Those factors when improved would immediately contribute to overall performance and, consequently, training time allotted to these factors would be well spent.
In the training process it is rather challenging for coaches to determine which training load is sufficient to induce the

required adaptation without risk of overtraining. More insight in the individual relation between training dose and adaptation response is necessary to optimise this training process. Training dose and changes in performance capacity can be modelled (1). In this model performance is a systems output varying over time according to the systems input; the training dose or training impulse (TRIMP), quantified from exercise intensity and volume. The subject is represented by a system with a daily amount of training as input and performance capacity as output.

It is possible to use heart rate recordings as indicator for the training dose while simple time trials can be used to monitor the development of the performance capacity (see Figure 1). A sketch will be given how technological developments leading to instrumented swimming wear could be put to use to optimise the training process.
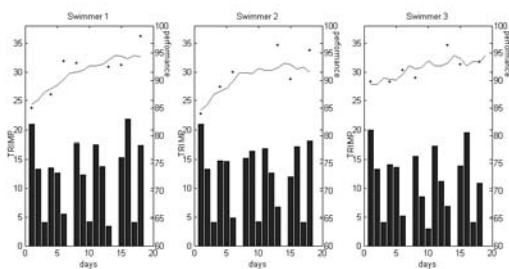
Figure 1: Bars represent TRIMPs; line represents predicted performance; dots represent criterion performance.

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DYNAMOMETRIC SYSTEM FOR THE EVALUATION OF RELAY SWIMMING STARTS.

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INTRODUCTION
A system for the dynamometric evaluation of relay starts in swimming will be presented.

DESCRIPTION
The system is composed by two synchronized force plates. One (Bertec 4060-15) is placed out of the water, simulating a starting platform, with a 10º inclination. The particular location, and fixation, of this force plate was possible due to a special support constructed for this particular purpose.
The second one (Roesler et al., 2003) is placed on the finishing wall of the pool, in a vertical position. The fixation of this second force plate was possible also due to a specific structure conceived for this purpose.
Both force platforms are connected to a PC using the same A/D converter plate (Biopac Systems HLT100C).
Landmarks in the bottom of the pool needed to be changed in order to keep the official distance from the "T" mark to the finishing wall.

RESULTS
The system displayed allow the assessment of variables such as:
(i) double contact time (contact of both swimmers with the starting/finishing wall);
(ii) impulse time;
(iii) vertical component of the platform reaction force;
(iv) horizontal anterior-posterior component of the platform reaction force;
(v) horizontal lateral-medial component of the platform reaction force;
(vi) resultant platform reaction force;
(vii) vertical impulse;
(viii) horizontal anterior-posterior impulse;
(ix) horizontal lateral-medial impulse;
(x) angular momentum at take off.
Results also allow perceiving the effect of moment transfer from the particular actions of the upper limbs in some starting techniques, or the particular effect of single or dual steps forward characteristic of more recent technical solutions for relay starts (2nd, 3rd, and 4th laps).

CONCLUSION
Results provided for such a dynamometrical setup allow swimmers to test their best solutions for relay starts, as well as to train their technique, disposing of immediate feedback about critical variables for the performance in this particular action.

UNDERWATER ELECTROMYOGRAPH SYSTEM AND HIS DIALOG WITH OTHER INSTRUMENTATION.

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INTRODUCTION
The need of an electromyographic (EMG) system that works underwater, and more specifically, in swimming pool conditions, leads to the development of new solution of active electrodes, full compatible with current EMG technology used in Biomechanics labs.

DESCRIPTION
The active electrodes need to have some electrical requisites in conformity with Basmajian and DeLuca (1985) and also, to have capability to measure 25 meters cabled EMG signals, allowing great swimmer's mobility. The active electrode configuration uses, in the core, an AD621BN instrumentation amplifier, with a 100 gain and a CMRR of 110 dB. This IC series warranties a low gain error and low noise values. The cable's length makes the transmission of the signal over 25 meters to became critical, once the signal must be "transported" to the main amplifier, where it will be conditioned and amplified 11 times, in an overall amplification of 1100 in the all system. These two amplifiers stages allow us to achieve quality signals and a proper electrical security (Carvalho et al, 1999), keeping simple the use and maintenance, with great return and protection of investment. The cable electrical parameters reduced the transmission signal problems due to its low impedance. To isolate the active electrode from the water, a special glue was used, that involved all the electronics. The terminal water isolation in the skin was made with special adhesive and some tape. The signals will be acquired by an A/D Biopac module and processed by the ACQ 3.2.5 software. This connectivity to the Biopac allows full dialog with force plates and cameras, either in the perspective of the signal collection as of synchronization.

RESULTS
The EMG survived to the underwater tests and the water invasion of the adhesives only added some no significant noise. The signal treatment involved the following steps: (i) mean signal removal; (ii) band-pass filtering; (iii) rectification; (iv) linear envelope and (v) iEMG calculations.

CONCLUSION
The critical cable distance from the amplifier to the pre-amplifier did not affect the signal quality. The electrode isolation proved to be a good solution to work underwater.

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A KINEMATICAL, IMAGIOLOGICAL, AND ACOUSTICAL BIOFEED-BACK SYSTEM FOR THE TECHNICAL TRAINING IN BREASTSTROKE SWIMMING.

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INTRODUCTION
A system for real time velocimetric feedback, and for immediate disposal of kinematical data, and model, synchronized with dual-media video images, will be presented.

DESCRIPTION
The system is composed by three different unities: (i) a dual-media image setup (Vilas-Boas et al., 1997), upgraded for images in follow up; (ii) a cable speedometer (Lima et al., 2006), and (iii) a FM transmitter/receiver system, adapted for swimming use, and able to deliver real time velocimetric information to the swimmer and coach. The dual-media follow up images setup uses a special chariot to move, along the lateral wall of the pool, a set of two video cameras: one underwater camera (Submergible AC230V), and one over-water (JVC GR-SX1, SVHS). The images of both cameras are mixed (Panasonic Digital AV Mixer WJ-AVE5), edited (Sony Color Triniton TV monitor) and recorded (Panasonic AG-7350). Differences in refraction are corrected using the zoom optics of the over-water camera, and a calibration device. The dual-media images are mixed with the display of a PC with kinematical information provided by the speedometer. This is a device for measuring the rotational velocity of a cylinder over which a fine nylon cable is passing through. This cable is fixed to the swimmer at hip's level. The movement of the cylinder is monitored by a rotating incremental coder connected to a microcontroller (PIC18LF1320, Microchip). A electrical brake motor allow the reduction of the inertia of the all system, keeping the cable straight, and also allows the cable recoil action. The speedometer was also equipped with a audio output, that allow a sound of variable frequency to be sent to the swimmer and coach through AM/FM receivers (Roadstar TRA-2221D) placed bellow the swimmers cap.

RESULTS
Results are v(t) real time curves, synchronized with images, and with corresponding auricular sounds. The software also allows the immediate modelling of a typical stroke cycle, both bimodal or trimodal, displaying mean velocities in noticeable points, mean phase durations and accelerations.

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Lima A. B., Semblano P., Fernandes D., Gonçalves P., Morouço P., Sousa F., Fernandes R., Barbosa T., Correia M.V. Tani G., Vilas-Boas J. P. (2006). A kinematical, imagiological, and acoustical biofeedback system for the technical training in breaststroke swimming. *This Symposium.*

DYNAMOMETRIC SYSTEM FOR THE EVALUATION OF SWIMMING TURNS.

Pereira S[1,2], Roesler H[2], Esteves C[1], Gonçalves P[1], Sousa F[1], Conceição F[1], Machado L[1], Lima A[1,3], Vilar S[1], Fernandes R[1], Vilas-Boas JP[1]

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INTRODUCTION
A system for the dynamometric evaluation of swimming turns will be presented.

DESCRIPTION
The system is composed by one underwater force plate, specifically developed for this purpose, and based on the general characteristics described by Roesler et al. (2003). The force plate is fixed to the ending wall of the pool through a specific structure conceived for this purpose.
The force plate is connected to a PC using a Biopac (Biopac Systems HLC100) A/D converter, operating under control of the Acknowledge software.
Landmarks in the bottom of the pool needed to be changed in order to keep the official distance from the "T" mark to the ending wall.

RESULTS
The system displayed allow the assessment of variables such as:
(i) contact time;
(ii) impulse time;
(iii) horizontal component of the platform reaction force;
(iv) horizontal impulse.
Results also allow perceiving the effect of different turning techniques on the measured parameters, as well as the effects of different variants of one same technique.

CONCLUSION
Results provided for such a dynamometrical setup allow swimmers to test their best solutions for turning actions, as well as to train their technique, disposing of immediate feedback about critical variables for the performance in this particular action.

DEVELOPMENT OF A MULTI-MEDIA SYSTEM FOR KINESIOLOGICAL EVALUATION OF SWIMMING BY EXPERTS IN ANY POOL.

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INTRODUCTION

A breaststroker does not find spontaneously his optimal style. In the past, each swimmer was evaluated in our Centre from video observation using a checklist of faults and a physical profile. To evaluate at international level, a specific digitizing system for movement analysis was developed. However, this was time demanding and the success depended on the expertise of the researchers themselves. The objective of this project is to develop a fast, so-called kinesiological evaluation system, useable by a trained expert in any pool.

METHODS

The movement and physical analysis data of 62 breaststroke swimmers at international level were available. Four style groups (N±15) were composed, based on the maximum waved and cambered body positions in the cycle, being the most typical to derive different propulsion concepts. In addition to an undulating and flat style, two other consisted of much waving and little cambering and vice versa. Each group and two gender groups were sufficiently large to locate movement variables (angles, amplitudes,…) statistically relevant for velocity variation of the body centre of mass and even for swimming velocity (2, 3).

RESULTS

First, the style group is estimated by overlaying the two average stickfigures of the two most typical body positions of the whole population on the two corresponding video pictures. Beforehand, an estimation of the most appropriate style is made from the physical profile (1). Next, faults are quantified by overlaying nine average stick figures of the selected style group, delimiting phases in the cycle. These contain also specifications of performance relevant angles, amplitudes,… (see figure). Immediately after the evaluation, a report is ready to be given to the coach.
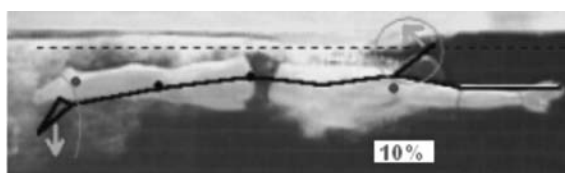
Overlaying 'optimal' stickfigures

DISCUSSION

For the training of future experts, e.g., in short courses, an interactive multi-media package is available. It contains extensively animations of the swimmers and of the water displaced; written documents only are not satisfactory. The content consists of the stroke mechanics (propulsion concepts, balance,…) and of case studies, including follow-ups.

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PROPELLING EFFICIENCY IN SPRINT FRONT CRAWL SWIMMING.

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INTRODUCTION

In swimming, generation of propulsion will *always* lead to a loss of mechanical energy, which is used to give fluid a kinetic energy change. Consequently, not all of the total mechanical power (P_o) generated by the swimmer is available to overcome drag. The propulsive efficiency (e_p) is defined as ratio of the power to overcome drag (P_d) relative to the total mechanical power. Previously, e_p was measured using oxygen uptake measurement techniques that could only be used at slow speeds. In a group of top-level swimmers an average e_p value of 63.5% (range 50 - 77%) was found at a swimming speed of 1.29 m•s^{-1}.
In the present demonstration a new approach to measure e_p at higher speeds is presented and evaluated.

DESCRIPTION

The system to Measure Active Drag (MAD-system) provides fixed push of pads below the water enabling propulsion generation without loss of energy to the water. Therefore, all-out sprints performed on the MAD-system enabled faster swimming than all-out sprints swimming 'free'. Considering that power to overcome drag relates to swimming speed cubed, and assuming equal power output in two 25 m sprints (free and MAD), the ratio of speed cubed sprinting all-out 'free' relative to the speed cubed sprinting all-out on the MAD-system reflects e_p.

RESULTS

For the thirteen elite swimmers e_p values of on average 75% (range 68 – 84%) for an average speed of 1.64 m•s^{-1} were found. This compares reasonably well with the previously reported values.

CONCLUSION

The determination of e_p based on two sprints free and two sprints on the MAD-system, is fast and can be incorporated in a test to evaluate changes in performance factors with training.

EFFECTS OF STROKING PARAMETERS CHANGES ON TIME TO EXHAUSTION.

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INTRODUCTION
Within the last century, swimming performances did improve concomitantly with an increase in stroke length inciting coaches to focus their attention in improving this parameter with training. In this way, using stroke counting, coaches can ask their swimmers to maintain a given velocity on a given distance while decreasing the number of strokes throughout the set. The purpose of this study was to analyze the effects using higher stroke length on the ability to maintain selected swimming velocities.

MATERIAL AND METHODS
Ten trained swimmers performed a maximal 400-m front crawl test to estimate maximal aerobic swimming velocity (MAV). Subjects then performed three sets of four time to exhaustion (TTE): at 95%MAV ($V_{95\%}$), 100%MAV ($V_{100\%}$), 105%MAV ($V_{105\%}$), and 110%MAV ($V_{110\%}$). During the first set (S_1), individual stroke frequency (SF_1), stroke length (SL_1), and velocity (V_1) were measured. Values recorded at the start and the end of each TTE were compared. In the second set (S_2), V_1 and SF_1 were imposed. During the third set (S_3), V_1 and SF_1 minored by 5% were imposed. The TTE of S_2 and S_3 were expressed in percentage of TTE in S_1.

RESULTS
Values of TTE are presented in Table 1. TTE of S_2 and S_3 were significantly shorter than TTE of S_1 for all intensities ($P<0.05$). TTE of S_2 were significantly longer than those of S_3 ($P<0.05$) except for $V_{95\%}$ and $V_{105\%}$.

	95%MAV	100%MAV	105%MAV	110%MAV
S_2 (%S_1)	51	74	61	69
S_3 (%S_1)	40	41	48	54

SL decreased significantly between the start and the end of each TTE of S_1 ($P<0.05$). SR increased significantly ($V_{95\%}$ and $V_{100\%}$; $P=0.15$) or remained stable throughout the TTE ($V_{105\%}$ and $V_{110\%}$; $P=0.08$).

DISCUSSION
Above the velocity corresponding to maximal lactate steady state can be observed a decrease in SL values from the beginning to the end TTE [1,2]. Indeed, during each TTE of S_1, swimmers attempt to adjust continuously their SR-SL combinations to sustain the imposed velocities. The present study also demonstrates that a use of longer SL than freely chosen does not allow swimmers to sustain each velocity for longer, TTE being more likely to be shortenened. This could be due to a greater development of local muscular fatigue.

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EFFECTS OF FATIGUE ON THE KINEMATIC HANDS SYMETRY IN FREESTYLE.

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INTRODUCTION
Front crawl swimming is characterised by alternative right and left arms strokes. Symmetry could be defined as an exact correspondence between opposite forms. Previous results in swimming reported symmetry for angular values of the upper limb (1) and for the 3-D body angular momentum for the best swimmers (2). In regard to these previous results obtained in fresh conditions, the aim of the study was to investigate the effect of an exhaustive test on the symmetry of right-left hands trajectories.

METHODS
Eight male international swimmers (age 22.5 ± 2.3 yr, height 1.87 ± 0.07 m and weight 79.0 ± 6.5 kg) realized a maximal 25m power test in semi-tethered swimming before (pre) and after (post) an exhaustive test of 4*50m freestyle. Right and left fingertips trajectories were digitized from frontal and sagittal aquatic video views (50Hz) (figure 1). Symetry was evaluated according to Robinson' index (3):

$$SI = \frac{X_R - X_L}{\frac{1}{2}(X_R + X_L)} \times 100$$

where X_R and X_L right-left coordinates.

RESULTS
Results indicated no changes after the exhaustive test with a good spatial symmetry for all the studied points and all the subjects and a temporal asymmetry (F, O, D, I, R) (table 1). Greater duration was observed for the right side or the left one depending the point and/or the subject. Each subject maintained his temporal asymmetry with fatigue.
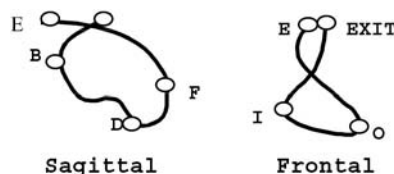
Figure 1: Characteristic points of the fingertip.

Table 1: Temporal SI (%) for the stroke.

Conditions	F	D	I	O	B
pre	10.9	12.4	15.4	21.5	16.4
post	13.9	12	13.5	14.3	27

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≤ 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$_2$net+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: $59,19 \pm 3,15$s), 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≤ 0.05 and r=0.890, p≤ 0.01, respectively).

DISCUSSION
In this group of swimmers, an early catch and a more pro-

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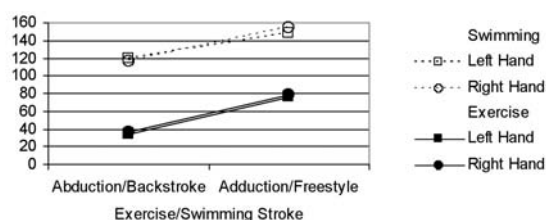
Figure 1: Peak Hand Force Values for Exercise and Swimming.

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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STRUCTURE OF GENERAL AND SPECIFIC SWIMMING ABILITIES IN JUNIOR TOP WATER POLO PLAYERS.

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INTRODUCTION
Motor and tactical technical demands in playing water polo are increasing (1) and are therefore causing the increase in training, starting from the early age in order to prepare the player to achieve top results through a long, quality training process. The task of this research was to establish the most important factors which define the structures of general and specific swimming preparation of junior water polo players, members of Slovenian national team.

METHODS
During season 2004/05, 31 water polo players were tested. Variables were the results of the following eleven swimming tests: crawl 15, 25, 50 1500m ($15m_{crawl}$, $25m_{crawl}$, $50m_{crawl}$, $1500m_{crawl}$), 25m crawl with head up ($25m_{crawlhu}$), 25m crawl with ball ($25m_{crawlB}$), 25m back ($25m_{back}$), specific swimming by using legs 25m, legs crawl and breast kick and mixing with legs ($25m_{legcrawl}$, $25m_{legbre}$, $25m_{mixing}$) and 10x50m crawl ($10x50m_{crawl}$), and the derived variables were: stork index (SI), index of specific swimming efficiency (specefic), index of coordination of crawl technique ($crawl_{armleg}$) and the index of specific coordiantion of leg movement ($legs_{crawlmix}$). All results were subjected to basic descriptive statistics, while the strucutre was defined by applying exploration factor analysis.

RESULTS
Factor analysis has defined four factors which describe a total of 78.068% of joined variability by means of using oblimon criterion, on the statistically significant level of reliability (KMO measure of sampling adequacy – 0.748, Barlett's test of sphericity – F = 2431.76, p =0.000). In the explained variability, the first factor has saturated 35.958%, the second factor 17.449%, the third factor 14.906% and the fourth factor 9.755% of the variance.

DISCUSSION
The results indicate the existence of four various areas of preparation of swimmers in the tested population. The first factor indicates that the speed of swimming, which was achieved both by general and specific water polo techniques, ($25m_{crawl}$-0,894, $25m_{crawlL}$-0,890, $25m_{crawlhu}$-0,845, $50m_{crawl}$-0,770) is the ability where players differ most, the second factor recognises coordination swimming abilities of players ($crawl_{armleg}$ -0,942, $25m_{legcrawl}$- -0,894, $legs_{crawlmix}$ - -0,768), the third indicates specific leg movement ($25m_{legbre}$-0,924, $25m_{mixing}$-0,794), while in the fourth factor swimming efficiency was singled out (SI-0,876, $1500m_{crawl}$- -0,769, $10x50m_{crawl}$- -0,711). The stated structure is a direct consequence of the state and quality of players and their level of training and it enables planning adequate training activities in order to improve both general and specific level of preparation in swimming.

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EFFECT OF FASTSKIN SUITS ON PERFORMANCE DRAG AND ENERGY COST OF SWIMMING.

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INTRODUCTION
Since the Sydney Olympic Games, swimmers may wear in competition new fastskin suits in Lycra covering either a part or the whole body. Fastskin Full Body Suits (FB) have been claimed by manufacturers to reduce passive drag by as much as 10% compared to normal suit (N). However, manufacturer's claims have not been backed by published peer reviewed studies. This study was undertaken to determine the effect of the two most popular Fastskin suits: one covers the whole body with no sleeve, the other covers the legs on swimming performance, drag and energy cost of swimming.

METHODS
Fourteen competitive swimmers swam at maximal effort in a 25m pool for distances of 25m, 50m, 100m, 200m, 400m and 800m when wearing FB, legs only (L) and N. They performed 4 min swims at their 800m pace when wearing FB, L, and N, in the swimming flume of the University of Otago, Dunedin NZ. Oxygen consumption was determined using a metabolic cart. Passive drag measures were made when wearing FB, L, and N at speeds between 1.20 and 2.00 m/s. The order of all suit and performance conditions were randomly assigned. The FB and L suits were purchased from local suppliers and supplied to swimmers according to their fit.

RESULTS
There was a 3.42 ± 0.86% performance benefit (decreased swim time) for all swimming distances when wearing the FB. The gain was significantly lower when wearing L (1.93 ± 0.69%, P <0.01). There was a significant reduction in drag (6.15 ± 7.93% vs 4.73 ± 4.74) and oxygen cost (5.51 ± 3.01% vs 4.04 ± 5.54%) when wearing FB and L compared to N. However, the difference between FB and L were not significant.

DISCUSSION
There appears to be a performance benefit, and drag and oxygen consumption reduction when wearing FB and L compared to N.

EFFECT OF TECHNICAL MISTAKES ON ARM COORDINATION IN BACKSTROKE.

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INTRODUCTION

In crawl, the evolution of the spatio-temporal parameters and the expertise modify the arm coordination (IdC) (1). The particularity of the dorsal position in the backstroke is the apparition of the clearing phase due to a decrease of the shoulder movement. Unlike in front crawl, arm coordination in backstroke is always in catch-up mode (2). Common technical mistakes observed in non-expert backstroke swimmers could disturb this coordination. The aim of the study was to quantify the influence of two mistakes (entry of the hand outside of the shoulder axis and head flexion on the thorax) on the arm coordination in backstroke according to the velocity increase.

METHODS

Sixteen national swimmers simulated three mistakes observed in non-expert swimmers (the entry of the hand outside of the shoulder axis, the head flexion on the thorax and their combination), which were compared to their traditional coordination at four race paces (400, 200, 100 and 50-m). Two underwater video cameras (frontal view and lateral view, 50Hz) were video timed, synchronised and genlocked. Velocity, stroke rate, stroke length, the relative duration of six arm stroke phases (entry and catch, pull, push, hand lag time at the thigh, clearing and recovery) and IdC (adapted from crawl, [1]) were calculated from video analysis.

RESULTS

With the increase of paces, velocity, stroke rate, pull phase, push phase, IdC increased and stroke length, entry and catch phase, clearing phase and recovery phase increased for all behaviours. Compared to the traditional coordination (IdC=-14.3%) and the coordination where head flexed on the thorax (IdC=-12.3%), a smaller catch-up mode occurred when the entry of the hand was outside of the shoulder axis (IdC=-10.6%) and when the two mistakes were combined (IdC=-9.9%). These coordination differences were due to a smaller relative duration of the entry and catch phase (8% *vs.* 14.5%) and to longer relative duration of the push (19% *vs.* 16.5%) and clearing phases (18% *vs.* 15.5%) occurred when the entry of the hand was outside of the shoulder axis and when the two mistakes were combined.

DISCUSSION

For each behaviour, the negative values of the IdC confirmed a catch-up coordination in backstroke, which was influenced by the mistakes adopted by swimmers. Thus, coach should monitor the common mistakes observed in non-expert backstroke swimmers to prevent coordination modifications disturbing propulsion efficiency.

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THE CONTRIBUTION OF THE AXILLARY ARCH TO THE OVERHEAD KINESIOLOGY OF THE SHOULDER.

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INTRODUCTION

The Axillary Arch (AA) bridges the fossa axillaris from the M. latissimus dorsi to the humeral insertion of the M. pectoralis major and the surrounding fascia of the M. bicep brachii. The AA can be muscular or tendineous. The AA is often ignored in surgery and totally ignored in overhead sports, including swimming. Although the incidence of an AA varies between studies and races, there is sufficient evidence to assume that its frequency and its Axillary location will not only create compression, but influence the overhead motion of the shoulder girdle also. It needs to be emphasised that whatever knowledge we have concerning the presence of an AA, is based only on anatomical reasoning and theoretical deduction but never in ad-hoc, in-vivo dynamic circumstances within healthy population e.g. overhead athletes (swimmers and throwers).

METHODS

Twenty two subjects were found to participate in this study, with an AA. A similar amount of subjects were chosen at random without an AA.
Functional testing consisted of hand held dynamometry, abduction shoulder strength and endurance, throwing precision and pulling force, joint position sense, musculo-skeletal exercise assessment and Doppler blood flow measurements.

DISCUSSION

This anatomic variant has been subject of over 50 studies with an incidence within Caucasian populations of in-vivo subjects and cadavers ranges from 6 to 12% (range 0.25% up to 27%). The AA has received such an interest that it may be considered as one of the most popular variants of the human body. The AA itself is very variable (its name, its origin, its course, its insertion, its type of tissue, its innervations, its dimensions, its incidence and last but not least, for its assumed function and influence of the theoretically cadaver based assumptions against its effective kinesiological influences in-vivo. According to cadaveric, neurosurgical and medico-diagnostic evidence the AA is assumed to create symptoms similar to those of shoulder instability and entrapment or obstruction type syndromes, e.g. Thoracic Outlet Syndrome (Biom. & Med. In Swimming Atlanta 1996 – FINA conf. Glyfada 1997).
Results indicated that a significant (p<0.05) influence of the AA on strength, endurance and motor control increase in female athletes in particular, associated with a minor increase of paresthetics. For all these parameters no significant difference occurred in men. As for throwing (pulling) and proprioceptive joint position sense, the data suggest a clear (p<0.05) increase of impact forces suggesting an increase of the shoulder stabilisation but a decrease of proprioception both in men and women.
The clinical relevance of these findings is opposed to the majority of anatomical assumptions of compression and instable shoulder.

PEAK OXYGEN UPTAKE IN FEMALE SWIMMERS AND PUPILS.

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INTRODUCTION
Knowledge of metabolic and functional responses during exercise and sport, in normal and pathologic adults, has increased a lot but we still have some questions related to physical training in children and adolescents. The aim of the present study is: a) to analyse the VO_{2peak} behavior (absolute and relative), among different female age-groups; b) to compare the VO_{2peak} values (absolute and relative), between swimmers (Sw) and pupils (Pu) for the same age-group.

METHODS
Sample: 74 female volunteers served as subjects in this study, ranging in age from seven through 17 years (34Sw e 40Pu), arranged in age-groups from 7-10, 11-14 and 15-17 years. Anthropometrical data: Stature (S); Body Mass (BM) and Sum of seven Skinfolds Sum (SKF). The VO_{2peak} values were attained through the VO2000® gas analysis system and Inbrasport ATL® treadmill, using adapted Bruce protocol. Multivariate analysis of variance – MANOVA was used to compare the VO_{2peak} mean values absolute and relative between Sw and Pu, and their respective age-groups ($p<0.05$).

RESULTS
The mean values and standard deviation of anthropometrical, absolute and relative VO_{2peak} data of the Sw and Pu are presented on Table 1.

Table 1: Anthropometrical, absolute and relative VO2peak data.

	N	S (cm)	BM (kg)	SKF (mm)	VO_{2peak} (l.min^{-1})	VO_{2peak} (ml.kg^{-1}.min^{-1})
Sw1	13	134.61 ± 7.83	31.76 ± 8.49	76.11 ± 48.72	1.27 ± 0.30*	37.83 ± 7.10
Sw2	12	157.88 ± 7.66	52.03 ± 6.98	82.54 ± 23.45	2.21 ± 0.40*	42.13 ± 6.36
Sw3	09	161.41 ± 6.91	55.58 ± 2.12	106.42 ± 28.86	2.42 ± 0.45*	43.53 ± 6.69
Pu4	12	130.82 ± 8.71	27.97 ± 6.39	66.41 ± 37.44	0.96 ± 0.34	33.40 ± 6.85
Pu5	14	151.51 ± 8.92	42.04 ± 11.22	89.98 ± 35.01	1.36 ± 0.36	33.61 ± 5.07
Pu6	14	161.54 ± 3.50	59.91 ± 10.58	157.66 ± 43.00	1.82 ± 0.32	30.74 ± 3.99

DISCUSSION
Statistical significant differences in absolute VO_{2peak} between Sw1 and Sw2, and Sw1 and Sw3 were identified, but not the same between Sw2 and Sw3 ($p<0.05$). Statistical significant differences in relative VO_{2peak} were not observed among all age-groups of the Sw. Statistical significant differences in absolute VO_{2peak} were identified among all age-groups, but in relative VO_{2peak} were not observed among all age-groups of the Pu. These findings point that the absolute VO_{2peak} rise among all age-groups is result of natural subjects's development, but, above all, the swimming training effect.

EXPERIMENTING WITH VARIOUS STYLES TO OPTIMIZE THE PERFORMANCE PER CRAWL EVENT.

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INTRODUCTION
To discover their fastest style per event, swimmers have to experiment with their style. The subject in this study was a right leg-amputated world record holder. Based on the hip velocity variation and by visualising the water displaced by the arm action, interpretations about propulsion were made.

METHODS
Underwater side view recordings were made with a fixed camera. From a movement analysis, paths and positions of the hand were obtained at specific arm positions delimiting phases: entry, glide, downward press, backward pull and push, exit and recovery (see figure). In addition, the hip velocity variation was calculated. Because in crawl this velocity is almost equal to the velocity of the body centre of mass, it can be used to estimate if propulsion is generated: when the velocity does not decrease. The water displaced was visualised using a tape with dye attached on the hand palm. From the three arm sweeps (down-, in- and out-upward), separate clouds were visible. They were coloured differently on still pictures, taken every 0.12 second (using Photoshop). The direction of the flows was indicated by arrows.
Four crawl style changes were analysed: a glide stroke with high elbow, a rotating arm action, a longer arm lever and a shorter arm lever than usual.

RESULTS

In all styles, the hip velocity remains equal or increases during an unusual down- inward (almost horizontal) left leg kick, combined with the left arm entry. Considering that no propulsive actions by the arms can be generated meanwhile, this unusual kick is propulsive. During the normal kick, combined with a right arm gliding, no propulsion is generated. Although the down-inward left leg kick hinders the body roll to the left side, he breathes to the right.
In the 2 arms glide stroke with high elbow, the velocity increases during a down-forward hand movement, relative to a fixed background (while no other propulsive actions by the other arm and the kick can be generated). Thus, the hand and forearm generate propulsive lift force. As expected, this style was the best for the 200m event and the rotating arm action style for the 50m event. In this last style the water was displaced best backwards (see figure). In the style with a long arm lever style, more water mass was displaced, but consecutively up-, down- and upward. In the style with a short arm lever the water is displaced close to the trunk in the body's turbulence.
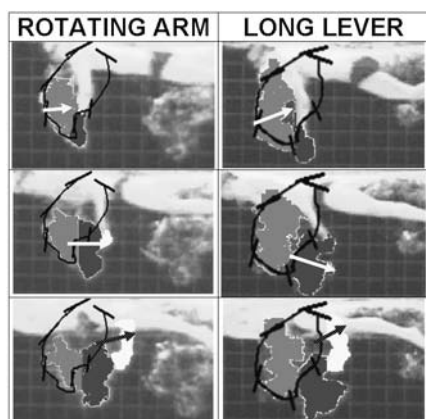
Water displaced by the arm

DISCUSSION

Some technique changes could explain performance improvements: e.g., by using a more vertical forearm position in his rotating action style in the 50m event; by breathing at the left and avoiding a glide of the right arm. Throughout this study, his performances were improving although the training quantity was very limited, indicating the value of experimenting and reasoning about ones own technique.

SIMULTANEOUS RECORDINGS OF VELOCITY AND VIDEO DURING SWIMMING.

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INTRODUCTION

Underwater videos of swimmers synchronized with recordings of instantaneous velocity displayed on the same computer screen reveal information about the biomechanics of swimming that can't be appreciated using either alone.
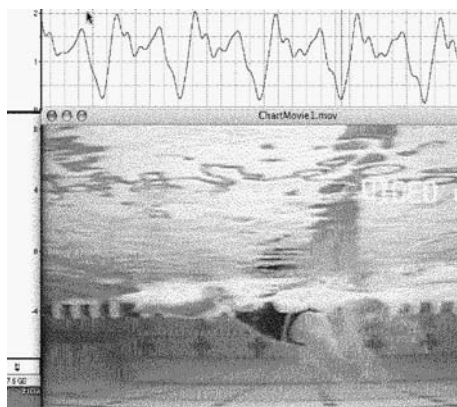
Figure 1.

METHODS

Velocity is measured by attaching a fine non-stretchable line to the back of a belt around the swimmer's waist. The line passes over a DC generator located at the side of the pool, and the voltage output is recorded. Four underwater video cameras are spaced along the side and one at the end of the pool. The videos are recorded sequentially on the same computer screen. The records can be viewed during the swim and are available for immediate review afterwards.

RESULTS

When the swimmers pushes from the wall or enters the water from a dive, velocity begins to decrease immediately and exponentially. The constants for these curves can be calculated at once. The transition from coasting to swimming is accomplished in several different ways. Most swimmers slow to speeds less than their subsequent swimming velocity. Corrective measures based on real time data can be promptly suggested. Each of the competitive strokes shows specific patterns. Common to all are periods of acceleration and deceleration. For example, in breaststroke (see above) the initial arm action accelerates the swimmer. As the lower extremities are flexed in preparation for the kick, there is increased drag and rapid deceleration. The greatest acceleration is associated with the kick. As the swimmer increases stroke rate and the velocity, the timing of these first three phrases of the stroke remain quite constant. The major changes are shortening the period of coasting and deceleration after the kick and before the next arm action. The patterns of movement associated with velocity in the butterfly stroke are quite variable. The major differences are seen in the timing of the arm acceleration and the kick that follows. These variations are also seen in some swimmers in sequential strokes. In the front crawl stroke the patterns of motion and the resulting changes of velocity are very individual. Both the arm and leg movements produce propulsion. Although it is possible to indicate parts of the stroke that may compromise velocity, there is no "one way" to swim. Backstrokers show the most constant speed. Although leg movements increase velocity they sometimes cause major decelerations during the stroke.

CONCLUSION

Simultaneous recordings of velocity and video and the ability to review the record instantly provide the athlete and the coach with a new and objective tool with which to study swimming biomechanics.

FREESTYLE RACE SUCCESS IN SWIMMERS WITH INTELLECTUAL DISABILITY.

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INTRODUCTION

Race speed differences among Olympic and Paralympic swimmers with an intellectual disability (ID) are determined by physical aptitude, fitness (training) use of correct techniques (knowledge) and adapting optimal race patterns (experience).

Potential participants must show impaired intellectual functioning and limitations in adaptive behaviour according to criteria set by the WHO and the American Association of Mental Retardation. Sport specific behavioral characteristics such as motivation and ability to deal with stress (experience) might be reflected in deviating race speed or arm movement patterns. In the 100-m freestyle race almost all Paralympic competitors with a loco-motor disability use similar speed and arm stroking race patterns. The question at hand is therefore do highly trained and experienced swimmers with ID also generally adapt these patterns.

METHODS
Video race analysis data was collected at the 2004 Global Games World championships for swimmers with ID and from the 2000 Sydney Paralympic Games finalists including swimmers with ID, loco-motor disability (2 classes) and visual impairment (3 classes). Further reference data was available from the 2000 Sydney Olympic Games, the 2000 Australian Olympic trails, the 2005 European indoor championships and the 2005 Scandinavian youth championships. In total data on Clean Speed (CSS), Stroke Rate (SR) and Stroke Length (SL) was available for 4 100-m freestyle race segments in 81 male competitors. Descriptive statistics, ANOVA, Cluster analysis and Spearman correlations were calculated. Race speed and arm movement patterns were defined by the relative changes between race segments.

RESULTS AND DISCUSSION
Analysis of the relative within race speed changes resulted in only one large race speed cluster (n=72). Eight additional clusters were formed containing 9 extra swimmers considered outliers and these were temporarily set aside. Five groups were then formed: 1) loco-motor impaired (M = 58.95s; ±2.33, n=16), 2) visually impaired (M=58.21s; ±1.24, n=16), 3) ID swimmers (M=57.73s ±1.79, n=11), 4) International Able Bodied (AB) swimmers (M=48.68s ±0.92, n=21) and 5) youth International AB swimmers (M=52.69s = 0.99, n=8). Within race speed changes between 4 segments were -3.2% (±2.45), -4.3% (±2.41), and -4.6% (±2.53) as the race progressed. Only ID swimmers lost significantly more speed in the middle of the race than International AB participants (F=3.17, p< .019). A decreased loss of speed between segments 2 and 3 was significantly related to race success (.58). Within race changes in SR were related to changes in CSS (.36, .54 and .33). Less reduction of SR resulted in less reduction of swimming speed. No similar relationship was found for SL. Of the 9 swimmers not fitting the cluster, 3 were ID swimmers, 2 were youth Internationals and 3 were AB elite. While 6 of these swimmers were observed in short course races only 33% of all swimmers were analyzed in short course events. The unusual race patterns of the 3 ID swimmers not included in the main cluster as well as the more conform patterns of the 3 other ID short course finalists were verified during preliminary heat swims. This disproportion looks therefore to be a trait of short course races rather than a feature of ID swimmers.

THE STRUCTURE OF EVALUATION INDICATORS OF VERTICAL SWIMMING WORK ABILITY OF TOP WATER POLO PLAYERS.

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INTRODUCTION
At the senior top-performance level, a water polo player spends 45-55% up to 66.9% in the vertical swimming position in which he executes different tactical and technical tasks (1, 3). The data generally indicate the vertical swimming position to be the dominant one in the game. This brings about the necessity to define a simple, easy-to-apply and reliable method for assessing the level of basic and competitive fitness of water polo players in the vertical swimming position.

METHODS
The sample of water polo players (SCG_{WP}) was made of 35 members of the SCG under-20 and B-national team (Age=19.3±2.6 years; BH=1.914±0.048 m; BM=88.2±7.5 kg). Each subject has been tested four times in different training sessions with four different weights (one weight per session - 12, 14, 16 and 18 kg). The task was to stay in the vertical swimming position as long as possible by the only use of the egg-beater kick, while with their hands they performed – semi-circular horizontal movement ("horizontal eight"), until full exhaustion and stopping the trial (all – out trial). On the basis of raw data obtained through testing for each subject the function of dependence Power-Time equation has been calculated applying the general equation $y = a \cdot b^x$. All calculated data are presented in absolute terms - in kg of weight mass, for the following nine time intervals (three different time intervals per energetic system): 5, 10 and 15 s - anaerobic alactic, 30, 60 and 120 s - anaerobic lactic, 300, 600 and 1800 s - aerobic energetic system (2). All data have been treated with the descriptive statistical method and multivariant statistics (Factorial analysis).

RESULTS
On the average, the results showed that the players were able to sustain vertical position for the following times and weights: 5, 10, 15 s – 36.43, 30.87 and 28.08 kg; 30, 60, 120 s – 23.95, 20.52 and 17.64 kg; 300, 600, 1800 s - 14.53, 12.59 and 10.11 kg, respectively. The equation function of the model yielded: Power (kg) = 50.739 · time^{-2179}. Kaiser-Meyer-Olkin measure of sampling adequacy has shown the reliability of the measurement method to be at 0.748 (74.8%), at a statistically significant level, F_{ratio} = 2431.75, and p = 0.000. Factorial analyses extracted two factors, the first factor explaining 63.31%, and the second 36.15% of total variance of vertical swimming work ability in players. The former is best represented by the variable which described vertical swimming ability for 30 s, and the latter by the variable for 300 s.

DISCUSSION
These results draw upon the conclusion that in the context of vertical swimming work ability of top water-polo players, the basic evaluation should be carried out in relation to anaerobic lactic load realized within 30 s (23.95±3.90 kg), and aerobic load realized within 300s (14.53±1.70 kg).

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ASSESSMENT OF TIME LIMIT AT LOWEST SPEED CORRESPONDING TO MAXIMAL OXYGEN CONSUMPTION IN THE FOUR COMPETITIVE SWIMMING STROKES.

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INTRODUCTION
Time limit at the minimum velocity that elicits maximal oxygen consumption (TLim-v$\dot{V}O_2$max) was studied both in flume (Billat et al., 1996) and in normal swimming conditions (Fernandes et al., 2003). While no studies have been carried out based on other swimming techniques than freestyle, the purpose of this experiment was to characterize, and compare, TLim-v$\dot{V}O_2$max in the four competitive strokes, as well as to observe its relationships with two major performance determinants: $\dot{V}O_2$max and anaerobic threshold (AnT).

METHODS
Twenty-three elite swimmers (15 males of 19.4±2.1 yy, 178.1±6.2 cm and 71.8±7.4 kg, and 8 females of 17.2±1.4 yy, 166.0±3.7 cm and 59.7±4.3 kg) performed, in their best technique, an intermittent incremental protocol for v$\dot{V}O_2$max assessment (Fernandes et al., 2003). Forty-eight hours later, subjects swam until exhaustion at their pre-determined velocity, to assess Tlim-v$\dot{V}O_2$max. $\dot{V}O_2$ was measured breath by breath by a portable gas analyzer (K4 b[2], Cosmed, Italy) connected to the swimmers by a respiratory snorkel. AnT was assessed individually (YSI 1500L Sport, USA) from the [La-]/$\dot{V}O_2$ curve (Machado et al., this vol.).

RESULTS
Mean ± SD values for Tlim-v$\dot{V}O_2$max were 238.8±39.0, 246.1±51.9, 277.6±85.6 and 331.4±82.7sec in crawl, backstroke, butterfly, and breaststroke, respectively. While no significant differences were observed between strokes in TLim-v$\dot{V}O_2$max (One-way Anova, p<0.05), pooled data were correlated with AnT. Non-significant interrelationships were found between Tlim-v$\dot{V}O_2$max and $\dot{V}O_2$max (ml/kg/min) and AnT (mmol/l). However, moderate inverse interrelationships were observed between Tlim-v$\dot{V}O_2$max and v$\dot{V}O_2$max (r=-0.63, p=0.001) and v@AnT (r=-0.52, p=0.012, Figure 1).
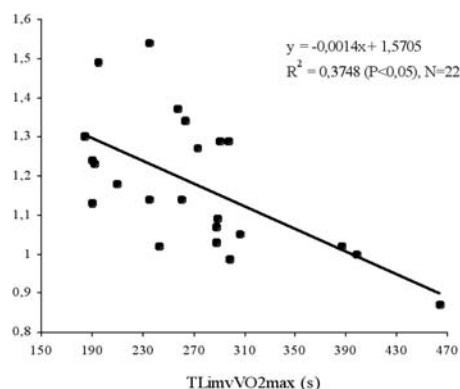
Figure 1. Relationship between Tlim-v$\dot{V}O2$max and v@AnT.

DISCUSSION
The inverse interrelationship between the parameters confirms previous findings obtained in national level freestyle swimmers (Fernandes et al., 2003), and point out that the higher the swimming velocities commonly related to aerobic proficiency, the lower the TLim- v$\dot{V}O_2$max. Moreover, this latter variable did not differ between swimming strokes, pointing out that the phenomenon is similar in all four strokes.

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LACTATE AND HEART RATE RESPONSES DURING SWIMMING AT 95% AND 100% OF THE CRITICAL VELOCITY IN CHILDREN AND YOUNG SWIMMERS.

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INTRODUCTION
Metabolic responses during swimming at critical velocity (CV) have been previously reported (2). However, CV may represent a different exercise domain for children and young swimmers compared to adults (1). The purpose of the present study was to compare the metabolic responses of children and young swimmers when swimming at 95% and 100% of the CV.

METHODS
Seven young swimmers and eight children (x±SD, age:16.0±1.7 vs. 11.5±0.6years, height:177±6 vs. 149±5cm,

body weight:68.9±5.4 vs. 42.9±5.8kg) participated in the study. The CV was calculated from performance time on distances of 50-100-200-400m. Lactate and heart rate responses of each swimmer were examined during a series of 4x400m (young) or 4x300m (children) which were performed with a velocity corresponding to 95% (V95) and 100% (V100) of CV in two different days. The resting interval was kept as short as possible (35-45s) to allow for blood sampling after each repetition. Heart rate was continuously recorded during each trial (Polar xTrainer-plus).

RESULTS
The CV of young swimmers was higher compared to children (1.34±0.04 vs. 1.17±0.04 m/s, $p<0.05$). In young swimmers, blood lactate was higher at V100 compared to V95 (5.95±0.95 vs. 3.91±1.11mmol/l, $p<0.05$) increased at V100 after the third and fourth 400m repetition compared to the first (1st:5.55±0.65 vs. 3rd:7.27±1.01 and 4th: 8.02±1.47 mmol/l, $p<0.05$) but remained unchanged at V95 (1st: 3.80±0.91, 2nd:4.41±1.08, 3rd:4.52±0.94, 4th:4.61±1.03 mmol/l, $p>0.05$). In children, blood lactate was unchanged after each 300m repetition in both trials (V95; 1st:3.27±1.31, 2nd:3.70±1.67, 3rd:3.48±1.64, 4th:3.74±1.82 mmol/l and V100; 1st:4.56±1.32, 2nd:5.49±1.89, 3rd:5.15±1.35, 4th:5.21±1.68 mmol/l, $p>0.05$). Heart rate was higher in V100 compared to V95 trial (184±8 vs. 173±8 b/min, $p<0.05$) and no difference was observed between groups ($p>0.05$).

DISCUSSION
The present findings indicate that swimming at critical velocity will induce an increased blood lactate concentration over time in young swimmers. However, this was not observed in children swimmers, and it may be attributed to different energetic responses or altered rates of lactate removal during childhood compared to puberty.

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UNDERWATER UNDULATORY SWIMMING: STUDY OF FREQUENCY, AMPLITUDE AND PHASE CHARACTERISTICS OF THE 'BODY WAVE'.

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INTRODUCTION
Underwater undulatory swimming (UUS) consists of timed vertical oscillations of body segments to produce efficient propulsion by a 'body wave' mechanism (1). The characteristics of the body wave have been previously studied by Sanders in butterfly (2) and in breaststroke (3). The purpose of this study was to investigate the body wave characteristics of UUS so that we can understand something about its flow characteristics.

METHODS
Subjects: Twenty international and national ranked swimmers were videotaped performing UUS for a 15m sprint after a water start. The distance was covered in the horizontal direction and at approximately one meter in depth. *Instrumentation:* One camera (S-VHS and 50 Hz) with its optical axis perpendicular to the line of motion of the swimmer recorded each trial through an underwater window. A symmetrical 13 point model was digitized after each video-capture. Coordinates of CM were determined. All the kick durations were normalized to percentiles of a total kick cycle. The amplitude and frequency of waveforms, comprising the vertical undulations of the body parts and the phase relationships between them, were determined by Fourier analysis. *Variables:* Are described and their results included in the next table 1.

TABLE 1	Average	S.D.
CM velocity (ms^{-1})	1.63	0,17
Kick freq. (Hz)	2.17	0,32
Kick length (m/cyc)	0.76	0,13
Kick Index ($m^2 \cdot cyc^{-1}s^{-1}$)	1.25	0,32
Fourier amplitude H1 Shoulder	0.015	0,003
Range Vertical Motion Shoulder (m)	0.068	0,016
Fourier amplitude H1 Hip	0.029	0,007
Range Vertical Motion Hip (m)	0.136	0,031
Fourier amplitude H1 Knee	0.056	0,013
Range Vertical Motion Knee (m)	0.239	0,056
Fourier amplitude H1 Ankle	0.099	0,020
Range Vertical Motion Ankle (m)	0.414	0,082
Fourier amplitude H1 CM	0.007	0,004
Range Vertical Motion CM (m)	0.041	0,021
Power Contrib. of H1 (%) - Shoulder	94.34	5,63
Power Contrib. of H1 (%) - Hip	96.88	3,15
Power Contrib. of H1 (%) - Knee	96.77	1,84
Power Contrib. of H1 (%) - Ankle	98.94	0,67
Power Contrib. of H1 (%) - CM	80.40	22,5

RESULTS
The range of motion produced by the calculated waveforms was about four times that of the Fourier amplitudes presented. Mean vertical velocity range 0,39 m/s (-0,19 to +0.20) was higher than the mean horizontal velocity range 0.28 m/s (1,52 to 1,80) in UUS obtained in previous studies. Peak positive (upward) and negative (downward) average vertical velocities of shoulder, hip, knee and ankle were sequentially obtained during the kick-cycle. Peak vertical velocities of the ankle were obtained at about the same instant as CM horizontal velocities.

DISCUSSION
The differences between UUS and butterfly swimming in the range of motion are evident from comparison of our data with the data published by Sanders (2) where the range of vertical motion of the shoulders in butterfly swimming was about five times that of UUS, while the hip and CM were similar to results obtained in our study. This raises the possibility that energy is transmitted along the whole body in butterfly swimming but mainly from the hips in USS as was expected.

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COMPETITIVE SWIMMING AND GLOSSOPHARYNGEAL INSUFFLA-TION TRAINING- EFFECTS ON LUNG VOLUMES AND BUOYANCY?

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INTRODUCTION
In order to optimize performance in competitive swimming it is of great importance to reduce passive and active drag, which is partially associated to the swimmers buoyancy (1). This, in turn, depends on body composition, by means of density related to relative distribution of fat, bone and muscles, together with air in the lungs and other cavities (2).
The purpose of this study was to investigate whether glossopharyngeal insufflation training (GIT) could increase lung volumes and assist the buoyancy. GIT is a technique where small volumes of air are pressed down into the lungs with the tongue and glossopharyngeal muscles on top of the already maximally inhaled lung (3).

METHODS
Ten female (FM) and 16 male (M) nationally and internationally ranked swimmers trained GIT 4 times/week for 5 weeks, additional to their regular swim training program. The subjects performed 8-15 repetitions of GIT during 20 minutes in a sitting or supine position. Baseline- and post tests included vital capacity (VC), residual lung volume (RV) chest expansion circumference, hydrostatic weights (maximally inhaled and exhaled) and body composition based on skinfold measurements.

RESULTS AND DISCUSSION
After the 5 weeks of GIT vital capacity (FM) and chest circumference (FM and M) were significantly increased and hydrostatic weight (maximally inhaled) was significantly reduced (FM and M). For both genders no differences were found in body composition.

Gender	Chest wall at C4 (cm)	VC (l)	Hydrostat weight inh. (kg)
M	+ 0.95	Ns	- 0.34
FM	+ 0.72	+ 0.12	- 0.17

These findings showed, in spite of a relatively short training period, that the buoyancy of the elite swimmers can be improved by GIT. It may be reasonable to speculate that extended GIT periods can influence the buoyancy even more and, in turn, lead to faster swimming.

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MAGNITUDE OF THE EFFECT OF AN INSTRUCTIONAL INTERVENTION ON SWIMMING TECHNIQUE AND PERFORMANCE.

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INTRODUCTION
In competitive swim programs, training distance is often given priority at the expense of technique instruction. The lack of emphasis on technique may be related to a misperception about the potential impact on performance. The purpose of this study was to determine the magnitude of the effect of an instructional intervention on technique (as measured by the active drag coefficient, C_d) and performance (swimming velocity, SV).

METHOD
The subjects were 18 competitive swimmers (12 males and 6 females) between the ages of 12 and 15. They were pretested with Aquanex+Video. The instrumentation and testing protocol were previously described and validated (1). After the pretest, a one-week intervention included three classroom and five poolside instructional sessions. The treatment included technique feedback with specific visual and kinesthetic cues designed to improve the C_d and SV. The subjects were then post tested.

RESULTS
There was an overall significant improvement in both C_d and SV. The C_d decreased by $.31\sigma$ ($p<.05$) and the SV increased by $.26\sigma$ ($p<.05$).
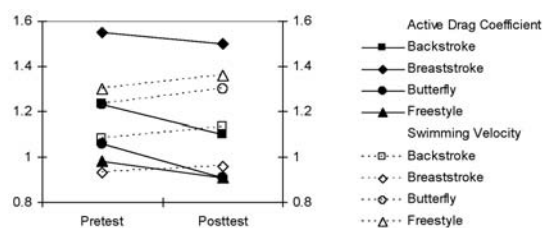
Figure 1. Changes in Active Drag Coefficient and Swimming Velocity with Instructional Intervention.

DISCUSSION

A one-week instructional intervention significantly improved both technique and performance. The magnitude of the effect compares favorably with differences previously found (1) between faster and slower performance levels in C_d (.46σ) and SV (.65σ). The results demonstrate that even a relatively short duration of carefully targeted instruction can make a meaningful improvement in technique and performance and will hopefully encourage coaches to reconsider training time allocation.

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MIXED-MODEL ANALYSIS OF THE RELATIONSHIPS BETWEEN TRAINING LOADS AND HEART RATE VARIABILITY IN ELITE SWIMMERS.

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INTRODUCTION

Heart rate variability (HRV) analysis is a well recognized method to assess autonomic nervous system perturbations and was shown to be influenced by the fitness and the fatigue in endurance athletes (Pichot et al., 2000). The relationships between HRV and training loads were shown to be highly individualized (Pichot et al., 2000), and depends of several factors including gender (G), training level (L) and specialty (S) (Aubert et al., 2003). When only few repeated measurements are available for several subjects characterized by a large inter individual variability, mixed models provide an attractive solution (Avalos et al., 2003). Instead of constructing a personalized model for each subject, a model of common behavior is constructed, allowing parameters to vary from one individual to another, to take into account the heterogeneity between subjects. The aims of this study were, first, to test the hypotheses about the mean structure of the covariates: evolution through time (T), G, and S; second, to model the relationships between training loads and HRV over 1 to 3 whole seasons.

METHOD

Twenty one national and international level french swimmers were studied (11 females, 10 males), (20±3 yr, 179±6 cm, and 65±11 kg, respectively. Heart rate variability was monitored during 1 to 3 years twice a month. The mean number of recording per subject was 23±12. each test lasted 12 min, in supine position. the rr interval (time between two r waves of the recorded cardiac electric activity) was measured with a polar s810 hr monitor (Polar®, Kempele, Finland). Fast Fourier Transform (FFT) was then applied to calculate the spectral power using nevrokard hrv software (Nevrokard® Medistar, Ljubljana, Slovenia). peaks are extracted from the spectrum and determined on low frequency (LF between 0.04 hz and 0.15 hz) and high frequency (HF between 0.15 hz and 0.5 hz). This allows us the determination of LF and HF powers, total power (TP) and computing the LF/HF ratio. The content of three specific training loads, low-intensity (li), high intensity (hi), strength training (st) and the total training load (tl) were linked to hrv using the mixed model.

RESULTS

TP and LF were higher for men (8227±1857 vs. 18687±2888 ms^2; 1857±2269 vs. 3885±2888 ms^2) respectively (p≤ 0.01). L was linked to TP, LF and HF by an inverted -U- shape relationship (P <0.001). The mixed model described a significant relationship between training and HRV both for all individuals and for group of swimmers, p≤ 0.0001.

DISCUSSION

It could be interesting to model the individuals training loads HRV relationships in order to control the training impact on autonomic nervous system.

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EMG-MODEL OF THE BACKSTROKE START TECHNIQUE.

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INTRODUCTION

Cossor and Mason (2001) proved that the underwater speed during the glide phase of the start exerted a significant influence on the position within the starter field, and also with the total race time in the 100m backstroke swimming. It is assumed that also the overwater phase is a key factor of the sprint performance. Thus, the study aims at a 2-phase model that contains not only kinematic and dynamic parameters [Krueger et al., in this volume], but also describes the time pattern and the activity level of the muscles that generate and transmit the forces and fix the body while executing the different movements during the backstroke start.

METHODS

7 male backstroke sprinters of the German national team performed 4 backstroke starts. The over all start time at 7.5 m was measured by high speed video analysis (125 Hz). EMG-data were recorded by a water protected 8-channel EMG (BIOVISION, GER) from eight Hz, 6th-order, and at 400.0 Hz, 1st-order, and then normalized with respect to the maximum muscle activity during the overwater and underwater phase. The durations of the overwater phase and of the underwater phase were normalized separately in order to allow intraindividual and interindividual comparisons of the patterns of the muscle activities.
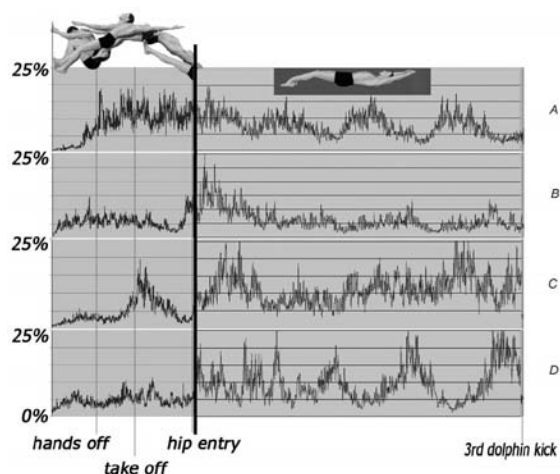
RESULTS

The EMG patterns of four selected muscles show that the start movement during the overwater static phase is initiated by the (a) M. deltoideus that was very active to fix the body in a high start position close to the wall. After pushing the hands off the wall this muscle also helps to bring the shoulder backward into the take off position. M. semitendinosus (d) showed maximum activity during the explosive extension of the legs at the take off, and (b) M. erector spinae contributed especially to form the bow of the body during the water entry. In the underwater glide phase the cyclic propulsion movement of the dolphin kick is characterized by high muscle activities of the (a) M. deltoideus and (c) M. rectus femoris during the up and down sweep, and by time lagged activities of the M. semitendinosus. The EMG recordings in the 7 swimmers indicate a high repetition constancy and a high reproducibility of the identified patterns of muscle activity during the backstroke start. The great similarities in the myographic behavior of the movement specific propulsion and equilibrium muscles allowed to form a representative 2-phase model of the muscle participation in the separate overwater und underwater movements of the backstroke start.

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SUPPORT SCULL TECHNIQUES OF ELITE SYNCHRONIZED SWIMMERS.

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INTRODUCTION

In synchronized swimming, the support scull is a fundamental skill that is used in the vertical position and vertical variation positions. Since coaches require practical data and information on the relative effectiveness of techniques, the present study investigated support scull techniques in synchronized swimming based on three-dimensional motion analysis.

METHODS

Subjects comprised 10 female skilled synchronized swimmers. Swimmers maintained a stationary vertical position (Fig. 1) under two load conditions: no load; and a 1.5-kg load attached to the waist. Two underwater video cameras were synchronized by means of a frame counter. Videotapes were manually digitized and three-dimensional coordinates were obtained using a three-dimensional direct linear transformation method. Upper arm angle, elbow flexion angles, wrist angles of flexion, extension, radial and ulnar deviation, scull range, sculling time and velocity during one scull cycle, changes in attack angle of the hand relative to the direction of motion and the paths of the fingertips and wrists were analyzed.
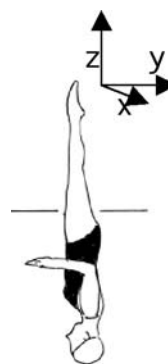
Figure 1: Support Scull in vertical position

RESULTS AND DISCUSSION

The ranges of upper arm angles were smaller in more advanced swimmers. This result showed the same characteristics as the flat scull in the back layout position (1). It can therefore be said that holding the upper arms and elbows stationary is a pointer in both support scull and flat scull techniques. Furthermore, this finding indicates that support scull is a lever movement made from the elbow. In the present study, elbow flexion angles were 145º outside and 100º inside. With a 1.5-kg load, the elbow angles were smaller at the outside. This shows that the forearms push the water toward the pool bottom at their outside. With no load, the paths of the fingertips and wrists of most swimmers drew a sideways figure-of-eight. Support scull produces propulsive force by generating drag force at the outside transition phase and lift force at the horizontal sculling phases. With a 1.5-kg load, fingertips and wrists drew a sideways figure-of-eight with a large circle at the outside, and some swimmers traced a slanting sharp-pointed ellipse (Fig. 2). These results indicate that as load increases, the drag force contributes to producing a propulsive force.
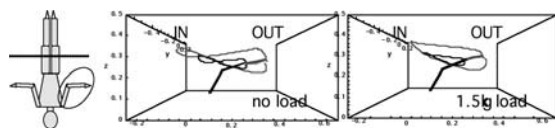
Figure 2: Path of right middle fingertip and right wrist for an Olympic swimmer under no load and 1.5-Kg load conditions. Locus with no load is a slanting sideways figure-of-eight. Locus with a 1.5-Kg weight is a slanting sharp-pointed ellipse.

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ESTIMATION OF ARM JOINT ANGULAR DISPLACEMENTS IN FRONT CRAWL SWIMMING USING ACCELEROMETER.

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INTRODUCTION

It is important to feedback the swimmers' motion in the training to improve their performance. The measurement by an accelerometer would have the possibility to be more suitable for swimming motion. The acceleration of the front crawl swimmer's wrist is mainly affected by the shoulder extension and the elbow flexion [1]. The purpose of this study was to estimate the arm joint angular displacements, such as shoulder extension and elbow flexion angle, in front crawl swimming using an accelerometer attached on swimmer's wrist.

METHODS

The acceleration of the wrist was identified mathematically using the formulated angles of the arm joints. A well-trained swimmer as the subject performed front crawl swimming with three different velocities. The acceleration of the wrist was measured by an accelerometer. The shoulder extension and the elbow flexion angles were estimated from the measured acceleration by corresponding to the acceleration calculated mathematically.

RESULTS

The estimated angles were compared with the angles measured by the videography (Fig. 1). The estimated shoulder extension angles were well-corresponded to the measured. The estimations of the elbow flexion angles were acceptable, although it was observed that there were the differences of the value and the timing at the maximal flexion.
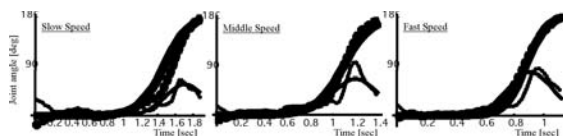
Fig.1: The comparison of the angular displacement between the esti-

mated from the acceleration (solid) and the measured by videography (dotted) of the shoulder extension (thick) and the elbow flexion (thin).

DISCUSSION

The results of the estimation were desirable, even though it was only the acceleration of the wrist to be used in this study. The feedback of the joint angular displacement would be effective for swimmers and coaches to improve their performance. It was suggested that the measurement by the accelerometer had the possibility of the practical use as the methodology to measure swimming motion.

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THE PROBLEM OF PEAKING IN VIEW OF EVIDENCES FROM THE ATHENS OLYMPIC GAMES.

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INTRODUCTION

Peaking as an obtaining the best athletic record at a particular moment is of primary importance for any athlete. This problem was mostly considered with regard to pre-event tapering and this approach is criticized here. The present study was purposed to examine the achievement of peak-performance by world-class swimmers and to evaluate effects of several factors determining peaking in the Athens Olympic Games.

METHODS

Data on 301 Olympic swimmers who competed in 424 events were used to analyze the relative swimming performance gain (RSPG%; the relative differences between the entry swimming results obtained in national trials or another competition, and in the Olympic competition expressed in %). RSPG% was described with respect to 24 National, stroke-type, swimming distance, swimmer's rank, gender, mode of selection and duration of the final stage preparation (FSP) prior the Olympics. Analysis of variance (ANOVA) and cluster linear regression were performed to estimate the effect of these factors on RSPG%.

RESULTS

The average RSPG% gain equaled 0.58% ($SD = 1.13\%$) indicating performance decline, embracing 68.2% of all the swimming events. Only two categories of competitors, medal winners and swimmers ranked 4-8, surpassed their previous entry time on average by 0.35% and 0.12%, respectively. One-way ANOVA considering nations with "tough selection" vs. "liberal selection", revealed significant superiority ($p = .04$) of the swimmers who were selected rigorously over swimmers selected liberally.

DISCUSSION

The results suggest that the marked tendency of performance decline was determined by:

(a) *emotional strain and anxiety during the FSP and Olympic competitions*; factors such as the media, social commitments, expectations of sport administration, anticipated bonuses etc. increase dramatically the incidence of emotional stress;

(b) *hormonal and metabolic changes induced by emotional and physical stress*; the low Testosterone/Cortisol ratio indicates high level of emotional stress that can replace physical stress a days prior the competition; beside of that increased catecholamines' excretion reinforces anaerobic metabolism and modifies aerobic/anaerobic interaction;

(c) *training insufficiency during the FSP*; the mentioned hormonal perturbations shift metabolic reactions into a direction of anaerobic prevalence and shortening of the aerobic and anabolic training residuals.

A FUNDAMENTAL RESEARCH ON CONFIGURATIONS OF HANDS CONCERNING SYNCHRONIZED SWIMMING.

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INTRODUCTION

Sculling operation in synchronized swimming performs that hands stroke should draw like a shape of egg or that of the letter of 8. However in regard to the configurations of a hand, specific shapes do not exist among coaches or players definitively. The empirical ones only exist among each player. Aerodynamic specifications of hand configurations were measured in steady state as a fundamental study in this research. One of the best configurations is proposed which can generate the largest buoyancy due to those results.
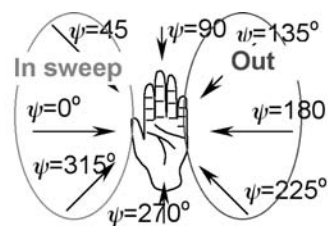
Fig 1. The sweepback angle ψ defined by Shleihauf (1), inflow entering into a hand.
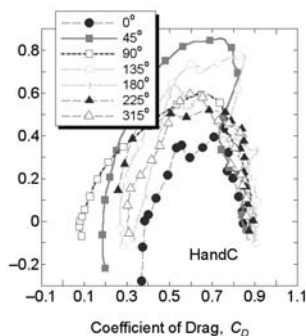
Fig 2. Polar curves of Hand C.

METHODS

Six replicas of a hand were produced as experimental objects, whose configurations were actually adopted from hands of female synchronized players. These configurations were as follows: A: Flat type without finger gaps, B: Round cup type with finger gaps, C: Cup type without finger gaps and with the fingers rectilinear, D: Round cup type without finger gaps, E: Bent back type without finger gaps and F: Flat shape with longer nails without finger gaps. In the operation of support sculling, players bend their elbows perpendicularly to the body and sweep forearms inside and outside. It is possible for these actions to be corresponded to the sweepback angles ψ shown in Fig. 1. Based on the angles ψ, aerodynamic experiments were performed on angle of attack α of hand from 0° to 90° in order to acquire specifications using 3 components load cell in a wind tunnel. Acquired C_D, coefficient of drag, and C_L, coefficient of lift were drawn as polar curves. The farthest point from the origin to the point on the curves shows the maximal point of resultant force composed of lift and drag, which was described by the author[2].

RESULTS & DISCUSSIONS

As sculling technique utilize lift force most, the farthest point from the origin with angle of attack α less than 60 degrees was designated as the best configuration of the hand. The polar curves shown in Fig. 2 are the specification of Hand C in respective sweepback angles. The best lift-drag resultant force is obtained in each sweepback angles compared with the other configurations.

Especially, it is found that the largest force is generated in ψ=45º and 135º.

CONCLUSION

In synchronized swimming, the hand configurations were inspected which produces the largest lift-drag resultant force. As a result, the most optimal configuration for sculling is found to be a cup type without finger gaps and with the fingers rectilinear.

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ANALYSIS OF SCULLING PROPULSION MECHANISM USING TWO-COMPONENTS PARTICLE IMAGE VELOCIMETRY.

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INTRODUCTION

There have been many studies attempted to determine the propulsive force during human swimming. However, most of them were based on quasi-steady analysis. The actual flow field around the swimming human body is unsteady condition. Thus, unsteady effects have to be taken into account (1). The purpose of this study was to analyze the propulsion mechanism of sculling motion in human swimming using Two Components Particle Image Velocimetry (2C-PIV).

METHODS

A swimming flume was used in this study. The tracer particles (50 μm) were mixed in water for PIV measurement. YAG laser was spread like a sheet and illuminated the particles at the test section. The subject was instructed to keep the position against the flow (0.5 m/s) by sculling motion in prone position. Time sequential images of unsteady flow field around the left hand were captured by CCD camera (15 Hz) and were stored in personal computer. The velocity vectors of particles and vorticity were calculated by MATLAB software (The Math Work Inc. USA).

RESULTS

One example of velocity vectors-vorticity map during sculling was shown (Fig. 1). A pair of vortices was observed at the shift phase from the end of out-scull to the in-scull. Velocity vectors (jet flow) were confirmed to the direction of the flow between a pair of vortices. Similar vortex pairs and jet flow were confirmed at the opposite phase (from in to out-scull phase). Moreover, circulation of vortex ring was 0.07 m²/s. The theoretical value of jet flow from circulation of vortex ring was 0.49 m/s, and the experimental value of jet flow was 0.50 m/s.
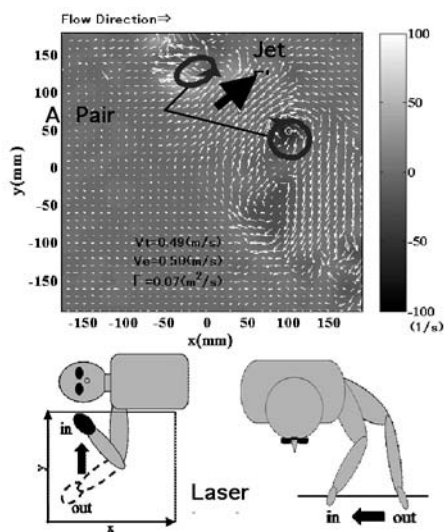
Fig.1 Example result of velocity vectors-vorticity map of the shift phase (out to in-scull: above) and the illustrations of the sculling hand movement (underside view: left bottom, front view: right bottom).

DISCUSSION

The subject seemed to propel against the flow direction creating vortices by sculling motion. It was thought that the swimmer created a higher propulsive force by making vortices. Moreover, the flow field around the hand at the sculling was similar to the phenomenon such as "delayed stall" that has been observed in fly's flight mechanism. The "delayed stall" is the phenomenon that the lift force increases by generating the vortex (leading-edge vortex) with the major part of stroke movement that repeats the reverse of wing. Therefore, it was suggested that the swimmer might be increased the lift force after change direction by sculling motion.

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LOWER LIMB MUSCLES ACTIVITIES OF THE DEEP-WATER RUNNING AND INTERVENTION EFFECTS ON BALANCE ABILITY IN THE ELDERLY.

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INTRODUCTION

Upright-floating situation in the water environment (the feet apart from the floor of the swimming pool) is difficult to experience in any other exercise environment. The typical form of upright-floating (UF) exercise in water is deep-water running (DWR). The advantages of this exercise were to reduce impact stress for lower limb joints and to maintain aerobic fitness (Reilly et al., 2003). However, there was no study investigated the lower limb muscles activities during DWR and the effects for the elderly. The purpose of this study was to investigate two lower limb muscles activities during DWR, and the intervention effects of UF exercise on the balance ability in elderly.

METHODS

Exp. 1: Nine healthy young males (mean age = 25.0 ± 0.5yrs) underwent the DWR and the water walking (WW) on their normal speed. The lower limb muscles activities of rectus femoris (RF) and biceps femoris (BF) were measured by surface electromyography (with a time constant 0.03sec, 2kHz sampling rate and 500Hz hi-cut filter) during exercise. The exercises were assessed with a digital video camera synchronized to the EMG. This allowed coverage of one cycle at a 30Hz frame rate. The mean electromyogram (mEMG) during one cycle was calculated, and compared between DWR and WW.

Exp. 2: The 12 weeks exercise intervention was conducted to fourteen elderly people (mean age = 60.8 ± 5.3yrs). The subjects participated 60 minutes water exercise program including 30 minutes of divided into two groups in one session, once a week, for 12 weeks. Two groups were a normal water (NW, n = 7) exercise and an UF (n = 7) exercise group. Body-sway tests (30sec, eyes open) as a static balance ability and tandem walk tests (times of 10-steps) as a dynamic balance ability were measured before and after 12 weeks intervention.

RESULTS

Exp. 1: The mEMG of the BF during the DWR was significantly higher ($p < 0.05$) than that in the WW. There was no difference in the mEMG of the RF between groups.

Exp. 2: UF improved body-sway area ($p = 0.09$) and tandem walk time ($p < 0.05$) after 12 weeks, while NW decline body-sway distance ($p < 0.05$).

DISCUSSION

The DWR could improve strength of hamstrings because the mEMG of the BF was higher than that in the WW. It was considered that the high stimulus of the BF during DWR affected the improvement of the balance ability in UF. From the result

of the balance ability improvement in Exp. 2, UF exercise in the water might be useful for the elderly to prevent the fall accidents.

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KINEMATICS AND DYNAMICS OF THE BACKSTROKE START TECHNIQUE.

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INTRODUCTION
The backstroke swim start has been estimated to contribute up to 30% of the total race performance in the 50 m backstroke sprint (Lyttle & Benjavunatra, 2004). Despite its importance there is a lack of complex biomechanical analysis of this starting technique based on kinematic, dynamic and electromyographic data.

METHODS
Nine male backstroke sprinters, all members of the German national team in swimming, performed four backstroke starts over a distance of 7.5 m. The over all start time was recorded by high speed video analysis (125 Hz), and split into reaction time (signal until hands off), wall time (signal until take off), flight time (take off until hip entry), and glide time (hip entry until head passing 7.5 m). Kinematic parameters were calculated by videographic motion analysis (SIMI-Motion, Ger). Dynamic data were measured as 3-dimensional ground reaction forces by a water proof force plate (KISTLER, Ger) mounted to the pool wall.

RESULTS
In a first step, kinematic parameters of the whole body movement during the different phases of the backstroke start of all 9 swimmers were measured. In the elite swimmers the correlation of the resultant take off force and the final over all start time (7.5 m) turns out to be significant (r=-.83, p<.01; n=9). Likewise a significant correlation could be found between the take off force and the official start times (head passing 7.5 m) of 8 out of the 9 investigated athletes in the German national championships 2005 (r=-.74; p<.05, n=8). Correlations were found between the times of hands off and take off (r=.712, p<.05, [n=9]) and hands off and hip entry (r=.929, p<.01, [n=9]). Other start parameters (wall and flight time, take off velocity and underwater speed) did not show significant relations with the over all start time at 7.5 m. Table 1 shows the kinematical and dynamical data of the 9 athletes during the backstroke start.

Athletes	Body weight [kg]	F_{RMax2} [N]	Hands off [s]	Take off [s]	Hip entry [s]	Start time (7.5m;s)	v take off [mñs^{-1}]	Best time 50m [s]
T.H.	82.00	1,043.390	0.440	0.772	1.068	3.340	4.72	24.02
R.K.	88.00	1,066.750	0.413	0.747	0.949	3.013	4.18	26.08
T.E.	71.00	742.326	0.482	0.821	1.099	3.688	3.75	26.89
J.G.	70.00	710.362	0.428	0.665	1.027	3.693	2.73	28.40
T.R.	75.00	922.092	0.474	0.770	1.098	3.590	2.95	24.80
R.P.	78.00	1,018.050	0.590	0.874	1.194	3.522	2.74	28.10
H.M.	73.00	1,055.554	0.532	0.760	1.168	2.724	2.92	26.16
M.C.	80.00	983.946	0.453	0.673	1.037	3.233	3.56	25.53
S.D.	90.00	1,243.886	0.491	0.783	1.084	2.767	3.50	25.14
Mean	78.55	976.26	0.478	0.763	1.080	3.285	3.45	26.12
SD	±7.14	±166.12	±0.055	±0.065	±0.074	±0.378	±0.69	±1.47

DISCUSSION
The influence of the kinematic and dynamic parameters of the overwater phase (wall and flight activity) of the backstroke start technique is clearly shown by the analysis. High correlations occure between the absolute (resultant) force at the time of take off from the wall and the over all start time at 7.5 m.

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THE APPLICATION OF COMPUTATIONAL FLUID DYNAMICS FOR TECHNIQUE PRESCRIPTION IN UNDERWATER KICKING.

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INTRODUCTION
It has long been accepted that understanding fluid flow patterns in swimming should lead to performance enhancements. Computational Fluid Dynamics (CFD) was developed to model any flow field provided the geometry of the object is known and some initial flow conditions are prescribed. This can provide answers into problems which have been unobtainable using physical testing techniques. The current study seeks to discriminate between the active drag and propulsion generated in underwater dolphin kicking with the goal of prescribing an optimal underwater kick profile. Secondly, this paper will demonstrate the potential benefits of using CFD to model technique changes.

METHODS
An elite swimmer was scanned using a whole body 3D scanner (see Fig.1). A 2D kinematics analysis was conducted of the swimmer performing high amplitude, low frequency dolphin kicks and low amplitude, high frequency dolphin kicks underwater. These kicking strategies were similar to those used in current competition by world class swimmers. The CFD model was developed around this input data and the model validated by comparing with static towing trials. Changes were also made to the input kinematics (ankle plantar flexion angle) to demonstrate the practical applicability of the CFD model.

Figure 1. Laser scanned image of the swimmer.

RESULTS

One of the major benefits of the CFD modeling procedure is that it allows the user to modify the inputs into the model to determine how variance in the inputs affect the resultant flow conditions. Hence, the CFD model was rerun over a range of velocities to ascertain any differences in drag and propulsion at various kicking velocities (see Table 1). The CFD analyses allows the resistive and propulsive values to be compared for each segment at any point in time to allow for more effective technique prescription.

Table 1. Momentum (Ns) reduction in
swimmer through an average second of kicking.

	Large Kick			Small Kick		
	2.40 m/s	2.18 m/s	1.50 m/s	2.40 m/s	2.18 m/s	1.50 m/s
Total per second	103.5	81.6	22.3	103.5	85.0	26.5

DISCUSSION

The results demonstrated an advantage in using the large, slow kick over the small, fast kick over the velocity range that underwater dolphin kicks are used. Further analysis of the effect of ankle plantar flexion in generating thrust demonstrated that increasing ankle flexibility, increases the efficiency of the kick by approximately 1Ns per degree of increased flexion. This highlights potential benefits of using CFD models in technique prescription.

MATHEMATICAL MODELLING OF THE SLOW COMPONENT OF OXYGEN UPTAKE KINETICS IN FRONT CRAWL SWIMMING.

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INTRODUCTION

Åstrand and Saltin (1961) observed the slow component of oxygen uptake kinetics ($\dot{V}O_{2kin}$) during high intensity exercises in cycle ergometer. This paper aims to present a mathematical model to characterise the slow component of $\dot{V}O_{2kin}$ in front crawl swimming.

METHODS

Maximal $\dot{V}O_2$ ($\dot{V}O_{2max}$) was determined through direct ventilatory oxymetry, using a portable gas analyser (K4 b[2], Cosmed, Italy) connected to the swimmers by a respiratory snorkel. The swimmers swam at previously determined speed corresponding to $\dot{V}O_{2max}$ until exhaustion (Fernandes et al., 2003). The following equation describing the mathematical model for the $\dot{V}O_{2kin}$ was used:

$$\dot{V}O_2(t) = \dot{V}_b \quad \text{(basal } \dot{V}O_2)$$
$$+ A_0 \times (1 - e^{-(t/\tau 0)}) \text{ (phase 1: cardiodynamic component)}$$
$$+ A_1 \times (1 - e^{-(t-TD1)/\tau 1}) \quad \text{(phase 2: fast component)}$$
$$+ A_2 \times (1 - e^{-(t-TD2)/\tau 2}) \quad \text{(phase 3: slow component)},$$

where t is the time, A_i represents the various components amplitudes, TD_i are the times for the onset of the different components, and τ_i stands for the transition period needed for the component to attain the steady state, during which physiological adaptations adjust to meet the increased metabolic demand (Markovitz et al., 2004). For the adjustment of this function to the data points it was used a nonlinear least squares method implemented in the MatLab program, using the routine LSQCURVEFIT.

RESULTS

The figure shows an example for the fit of the mathematical model to the collected data, where the $\dot{V}O_{2kin}$ has been normalized to the body mass. The fast component stars at 7s and the slow component at 95s.
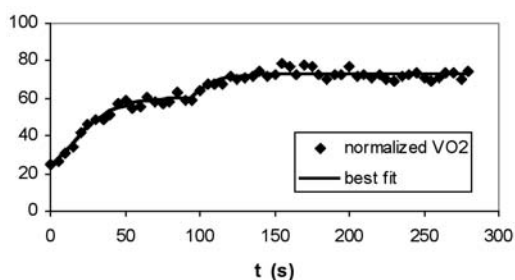
DISCUSSION

The main conclusion of this work is that this method seems to model in an adequate way the slow component of $\dot{V}O_2$ in swimming, discriminating it from the other components.

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EFFECT OF SWIMMING TRAINING ON LEFT VENTRICULAR DIMENSIONS AND FUNCTION IN YOUNG BOYS.

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INTRODUCTION
It is well established that the heart adapts to an increased hemodynamic load following the specificity of the exercise training: a volume load leads to eccentric left ventricular hypertrophy (LV) and a pressure load is associated with a thickening of the ventricular wall and unchanged internal dimension with an increase in relative wall thickness - concentric LV hypertrophy. The purpose of this study was to determine the effect of swimming training on LV cardiac morphology and function of young boys.

METHODS
Cardiac dimensions and function were determined by two dimensional M mode and Doppler echocardiography in twelve swimmers ($15,88 \pm 0,22$ years) (SA) and in twelve active boys with matching age as a control group (CG). Echocardiographic data were expressed in absolute units and then scaled allometrically for individual differences in anthropometrical data - body mass (BM), height (H), body surface area (BSA), body fat percentage (%BF) and fat free mass (FFM).

RESULTS
Fifty percent of SA exhibited end–diastolic LV internal chamber dimension (LVIDd) above normal (> 54 mm). CG displayed significantly greater mean values for relative end–diastolic wall thickness (RWTd) ($p < 0.01$) but both groups showed LV eccentric enlargement (RWTd < 0.44). Absolute LVIDd and end–systolic LV internal chamber dimension (LVIDs) were significantly larger in SA than in CG ($p < 0.05$). After allometric correction for dimensional characteristics, SA maintained higher LVIDd and LVIDs ($p < 0.05$). When scaled for $BMS^{1.5}$, LV mass was also greater ($p < 0.05$) in SA. On the other hand, posterior wall thickness (PWT) and septal wall thickness (ST), when scaled for H and $BSA^{0.5}$, were significantly greater on the CG than in SA. In accordance with structural differences, absolute and relative LV systolic functions were significantly greater ($p < 0.01$) in SA, namely LV end–systolic volume, systolic volume SV and cardiac output as well as LV diastolic function (LV end–diastolic volume).

DISCUSSION
This study supports the influence of systematic swimming training on the diastolic function in 15/16 years old boys. As showed by parameters measured, adaptation to exercise mode induced a typical "athlete's heart" with dominance of volume and diameter (eccentric LV hypertrophy) and mild changes in LV mass.

STROKE PERFORMANCE DURING FRONT CRAWL SWIMMING AT THE LOWEST SPEED CORRESPONDING TO MAXIMAL OXYGEN CONSUMPTION.

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INTRODUCTION
Time Limit is a concept that has been used to diagnose effects of swimming training and performance. It is the time duration a swimmer can perform at lowest speed corresponding to maximal oxygen uptake ($TLim\text{-}vVO_2max$). While the technical performance during this specific test has not, to our knowledge, been previously explored, the aim of the present study was to analyze stroke rate (SR) and stroke length (SL) during the $TLim\text{-}vVO_2max$ freestyle test.

METHODS
Ten swimmers from the National Portuguese Swimming Team (17.78 ± 1.60 yy of age, body mass of 66.32 ± 10.49 kg, stature of 172.40 ± 10.04 cm) performed an intermittent incremental test consisting of a set of 200-m swims. vVO_2max was assessed from the swimming velocity versus oxygen consumption relationships. After a minimum of 24 hours rest, continuous swimming at a speed corresponding to vVO_2max was performed until exhaustion to determine $TLim\text{-}vVO_2max$ (cf. Fernandes et al., 2003). SR and SL were analyzed from underwater video recordings for each 25-m lap throughout the test.

RESULTS
With the given speed, SR was noticed to increase and SL was noticed to decrease significantly. The progression of change in both SR and SL was systematic throughout the swim. Swimming distance during the $TLim\text{-}vVO_2max$ effort varied between 200 and 400 m (mean value of 216.61 ± 61.98 s).

DISCUSSION
The major finding was that there is an increase in SR and a decrease in SL during the course of the $TLim\text{-}vVO_2max$ effort. High speed swimming seems to overload human neuromuscular apparatus and thus deteriorate stroke performance during the event (Keskinen and Komi, 1993; Laffite et al., 2004). In the present situation swimmers were subjected to a highly strenuous experiment where the given speed well exceeded the swimmers' capacity for long lasting performance, i.e. anaerobic threshold. While the test finally ended upon exhaustion, the observed changes within the interrelationships between SR and SL can be considered a sign of specific fatigue occurring during the course of the test. The present study warrants the question whether one could be able to maintain performing despite fatigue by trying to maintain their stroking technique.

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A KINETIC ANALYSIS AND RECOMMENDATIONS FOR ELITE SWIMMERS PERFORMING THE SPRINT START.

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INTRODUCTION
The start is of paramount importance in elite competitive sprint swimming performance. The important aspects of a start include: entry into the water, underwater streamlining, underwater propulsion, breakout, and propulsion off the blocks. Propulsion off the blocks is the initiating action upon which all other aspects of the start are to some extent determined. This kinetic analysis investigated on/off the block start characteristics of elite sprint swimmers.

METHODS
A force platform in a start block enabled the following characteristics to be collected and computed in a training environment: 1.Off block time, 2.Maximum horizontal propulsive force, 3.Projection angle of CoG leaving block, 4.Horizontal velocity of CoG leaving block, 5.Average power developed on block, 6.Peak power developed on block, 7.Work done against block, and 8.Time to 5m. The swimmers included Australian National Team members and 2 FINA World record holders.

RESULTS

Swimmer		A	B	C	D1	D2	E1	E2	F
Level		Nat Ch	Nat Ch	W Rec	WR=3		Nat Tm		W Rec
Gender		Male	Male	Female	Female		Female		Female
Stroke		Butterfly	Breast	Breast	Freestyle	Freestyle	Breast	Breast	Freestyle
Major Swim Dist	metres	100	100	50	100		100		100
Start Type		Grab/Track	Grab	Grab	Grab	Grab	Track	Grab	Track	Track
Preferred Start			*	*	*		*		*
Comment on Start		Excellent	Great	Good	Fair		Fair		Poor
1. Leave block tm	sec	0.80	0.85	0.83	0.87	0.82	0.89	0.77	0.89
2. Max Prop Force	newtons/KgBWt	1.67	1.57	1.52	1.43	1.08	1.39	1.14	0.84
3. CoG Proj Ang	deg -ve=down	-1.5	-6.3	-5.7	-15.4	-19.7	-2.5	-2.8	-15.8
4. CoG Horz Vel	m/sec	4.67	4.84	4.57	4.59	4.58	4.14	4.23	4.42
5. Average Power	watts/KgBWt	20.51	20.13	19.17	17.13	17.56	16.35	18.57	16.09
6. Peak Power	watts/KgBWt	89.74	83.78	76.79	67.88	52.04	67.72	54.87	43.74
7. Work Output	joules/KgBWt	16.78	17.85	16.41	15.78	14.85	14.84	14.32	14.57
8. 5m Start time	sec	1.50	1.56	1.60	1.79	1.76	1.96	1.83	1.76

Nat Ch is Holder of Nat Championship, **Nat Tm** is Member of National team,
WR=3 is a FINA World ranking of 3, **W Rec** is Holder of FINA World Record

DISCUSSION
The characteristic that was most closely related to starting ability was peak power generated on the block. Average power and maximum horizontal propulsive force were also closely related to starting ability. Work output against the block was related but not as highly as the previous parameters. Horizontal velocity off the block appeared not to be a good predictor of starting ability as the angle at which the swimmer left the block played an important role in the outcome. A projected CoG angle off the block between 0 and 7 degrees downward appeared acceptable. Time off the block appeared not to be related to starting ability. Similar characteristics but with a completely different force and power profiles were evident for swimmers that utilised both a grab and a sprint start. This indicated that neither the sprint nor grab start was superior in itself, but the start used should be based on individual preference.

FLOW VISUALIZATION OF UNSTEADY FLOW FIELD AROUND A MONOFIN USING PIV.

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INTRODUCTION
It is well known that swimmers wearing with a monofin can swim very fast. The world record of the apnea, which is the one of the categories of fin swimming, is one and half times faster than that of the ordinary crawl swimming. The high speed is related to the high momentum generation of the water. To know the generation of momentum, the characteristics of unsteady flow field have to be investigated. Vortex motion is known to play an essential role on the generation of propulsive force, because a vortex combined with other vortices induces a jet flow or momentum. In the animal locomotion such as insect flight and fish swimming, a certain kind of vortex rings produces the jet flow. So far we have no available methods for determining the flow field, but recently a powerful technique for the measurement of the unsteady flow field, which is called the PIV (Particle Image Velocimetry), has been developed. To investigate the mechanism of the high-speed swimming with a monofin, we adopt this PIV and measure the complex unsteady flow field in detail.

METHODS
A monofin was attached to the device that can carry out a pitching motion of the fin instead of wearing it on swimmers. This is because of the controllability and reproducibility of the experiment. The device has the ability of varying the pitching angle of the fin between –20 deg and +20 deg. We used the flume installed in the Univ. of Tsukuba whose free stream velocities were set from 0 to 1.0 m/s. Unsteady velocity fields were measured in several horizontal and vertical planes illuminated by the YAG laser of the PIV system. A CCD camera takes the images of tracer particles at two subsequent times around the monofin. From the distance of a particle moved for the short time interval, the velocity is determined. In this way we can get the velocity and vorticity fields from the particle image data. Our PIV system can get 15 planes per second and 100 planes at once.

RESULTS & DISCUSSION
Time-sequential variations of the velocity fields were obtained. The generation of vortices is clearly discerned in the velocity field. The orientation of the vortex changes alternatively and a pair of counter-rotating vortices produce momentum in the inverse direction of traveling. According to Newton's second law of motion this momentum increase corresponds to the propulsive force by a fin.
Since we measured the flow field only in planes, the 3-dimensional structure of vortices could not be cleared. However, it is plausible that the generating mechanism of propulsive force may be similar to that generated by flying insects, birds and fish.

CONCLUSIONS
We could visualize the flow field around the fin and detected the vortices shed from the fin. They change their signs alternatively. It is known that the vortex shedding is closely related to the propulsive force of animal locomotion. We concluded that the propulsive mechanism by a fin is very similar to that done by natural lives like birds and fish moving with the propulsive force by generating vortices.

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EFFECTS OF ACUTE MODERATE ALTITUDE EXPOSURE ON PHYSIOLOGICAL AND TECHNICAL PERFORMANCE IN FRONT CRAWL SWIMMING.

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INTRODUCTION
Various external conditions in and outside the water have been shown to affect performance while swimming (Keskinen et al., 1997). The relationship between stroke parameters and physiological responses during swimming at different speeds has been previously studied by Nomura et al. (2002). The effects of acute and chronic altitude exposure on metabolic aspects have also been studied in recent decades. This study aimed to investigate the effects of acute moderate altitude exposure in technical and physiological variables during one repetition 400m standardized trial.

METHODS
Subjects: Eleven swimmers swam two sets 400 meters front crawl twice at sub-maximal speed (92.5% of timed performance). Each subject was assigned at random to one of two groups, and each sub-group executed the protocol first either in Granada town (690m alt.) or in the Altitude Training Centre of Sierra Nevada (2320m alt.) and then after 48 hours they performed it again exchanging the swimming location.
Instrumental: One sagital camera (mini DV) recorded each trial above water to obtain technical performances such as stroke rate (SR) and stroke length (SL) each lap. Blood lactate concentration (BLa), heart rate (HR) and ratings of perceived exertion (RPE, Börg Scale) were registered at the end of each 400m. The swimming speed was fixed by a lane of underwater successive lights connected to a speed controller box (SwimMaster).
Variables: Are described and their results included in the next table.

Table 1 Variables	690 m Mean (S.D.)	2320 m Mean (S.D.)	Dif
BLa (mmol·l^{-1})	6.44 (2.44)	8.81 (2.63)	**
RPE (6-20)	15.00 (2.63)	16.27 (1.10)	*
HR (bpm)	161.27 (15.66)	168.64 (13.66)	*
SR (cic/min)	31.75 (5.49)	32.53 (5.74)	*
SL (m/cic)	2.29 (0.38)	2.23 (0.39)	**

*p<0.05 **p<0.01.

RESULTS
Altitude acute exposure affected all the variables studied. The lactate concentration (+36.6%), the heart rate (4.57%), RPE (+8.48%) and stroke rate (+2.44%) increased while the stroke length (-2.64%) decreased.

DISCUSSION
The major findings of this study demonstrated the effects of acute altitude exposure on both technical and metabolic variables. The behaviour found in the physiological variables is in accordance with other studies involving testing in altitude. Also the technical aspects behaved similarly as it is shown by Nomura et al. (2002). Effects of acute moderate altitude exposure should be taken into account when prescribing intensity in all training sets while swimming in altitude.

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UNSTEADY FLOW MEASUREMENT OF DOLPHIN KICKING WAKE IN SAGITTAL PLANE USING 2C-PIV.

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INTRODUCTION
The flow field around a human body during swimming is very unsteady, though most of the researches were based on quasi-steady flow theory. It has been lately suggested that it is very important to consider the unsteady flow condition to thrust in swimming[1]. We have been applying Particle Image Velocimetry (PIV), which enable us to visualize and analyze unsteady flow in detail, to the human swimming situation[2]. Our aim of the present study was to analyze the dolphin kicking wake of a swimmer in a sagittal plane viewed from the side using Two Components PIV (2C-PIV).

METHODS
Experiments were carried out in a swimming flume (4.6x2.0x1.5 m, IGARASHI Industrial Inc., Japan). One trained male swimmer participated in this study and was instructed to keep its position with dolphin kicking. Unsteady flow fields of dolphin kicking wake in a sagittal plane were measured using 2C-PIV. The tracer particles (50 μm) were admixed to the flume. The sheet-like Nd-YAG laser illuminated the measurement area and two hundreds time-sequential images were captured by CCD camera set at side of the flume at once (15 f/s). The particle velocity vectors were calculated with the cross-correlation analysis from sequential two images. Velocity-vorticity maps were computed by MATLAB software (The Math Works, Inc., USA).

RESULTS & DISCUSSION
The pairs of vortex and jet flow were confirmed in the wake of dolphin kicking (Fig.1: right panel). The value of the jet flow velocity gave good agreement with the value of the induced velocity predicted by assuming that the pair of vortices is the sectional parts of a vortex ring. It was seen that the dolphin kicking motion performed in this study generated the propul-

sive force by generating the vortex ring. However, the mechanism of vortex generation is more complicated. Therefore, further research is needed.
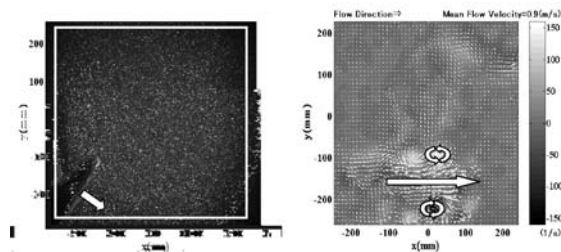
Fig.1 An example image result of downward dolphin kicking motion (tiptoe image, left panel: t=0) and the velocity-vorticity map (right panel: t=134ms). The white rectangle in left panel is corresponding to the right panel. The grey scale indicated in the right column denotes the magnitude of vortices. The white arrows in right panel indicated the orientation of the flow and vortices.

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RED BLOOD CELLS SUSCEPTIBILITY TO PEROXIDATION IN SWIMMERS.

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INTRODUCTION
Moderate physical exercise has been accepted as health beneficial. For intense and sustained exercise, such as that performed by high competition athletes, some controversy about the protective effects still exists. The increase of reactive oxygen species formation associated with the increase in blood flow and viscosity that are triggered by physical exercise may contribute to the accumulation of molecular modifications on red blood cells (RBC), accelerating senescence and removal. The susceptibility of RBC to oxidation is dependent on the composition of plasma membrane lipids and on the enzymatic antioxidant defences. The purpose of our work was to evaluate the influence of training on RBC' susceptibility to peroxidation induced *in vitro* by H_2O_2 (RBC Px) and on RBC' antioxidant enzymes activities.

METHODS
15 high competition male swimmers (S) training between 17

and 23 h/week for at least 5 years, and 16 active men (AM) not involved in any regular sport activity, all between 18 and 25 years old, participated in the study. Nutritional analysis was performed using a 3 days food record and body composition was assessed by DXA. Subjects performed a continuous graded maximal run on treadmill until O_2 uptake stabilization or exhaustion with expired gas analysis and heart rate monitorization. Blood was collected at rest, at fast. RBC Px and the antioxidant enzymes activities, which included superoxide dismutase, catalase, glutathione peroxidase and reductase and methahaemoglobin reductase, were evaluated by photometry.

RESULTS
As expected, swimmers showed higher VO_{2max}, VO_{2AnaT}, FFM and AMM and lower FM%. Food intake was similar between the two groups, with low % of carbohydrate intake (S: 48.3±6.19% and AM: 48.8±4.79%) and high % of fat intake (S: 34.2±5.23% and AM: 33.6±5.32%). Retinol, a-tocoferol and folate intakes were under the RDIs. Swimmers showed lower RBC Px (S: 39.2±4.83% and AM: 46.3±9.54%; p=0.033) and lower methahaemoglobin reductase activity (S: 7.45±2.07 and AM: 9.14±2.29 micramol.min^{-1}.gHb^{-1}; p=0.033).

DISCUSSION
Swimmers showed higher RBC' resistance to oxidation even though antioxidant enzymes were not higher. This beneficial adaptation may result from an accelerated RBC' renewal, leading to more efficient O_2 delivery to tissues and to lower RBC' intracellular oxidant stress. Subjects may benefit from changes in their nutritional habits. High intakes of fat associated with low intakes of fat-soluble vitamins increase susceptibility to oxidation.

THE EFFECT OF SWIMMERS INTERACTION IN DRAG COEFFICIENT FORCE REDUCTION.

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INTRODUCTION
The main purpose of this study was to determine the optimum distance between swimmers in tandem position. The typical approach to study this interaction is to investigate the forces generated or drag coefficients in relation to the distance between two or more swimmers. As an alternative to experimental and costly designs, the present research applied the numerical technique of Computational Fluid Dynamics (CFD) (1).

METHODS
For this purpose, a k-ε turbulent model (1), implanted in a commercial code fluent®, was applied for a fluid flow around

swimmers in tandem (Fig. 1). The simulations have been done for various distances (between 0.5m and 8m) between swimmers and different swimming velocities (1.6m/s to 2.0 m/s for each simulation). Drag coefficients have been calculated for each one of the distances and velocities. As an initial step, three CFD models have been tested and compared with experimental data in the case of fluid flows around cylinder, to choose the best turbulence model to be applied. The drag coefficient of the first swimmer (on the left on figure 1, was considered constant for all distances at the same velocity.

RESULTS
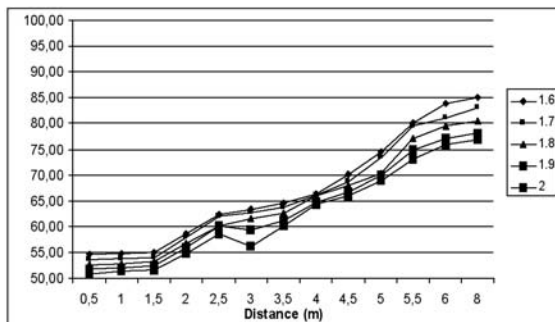
As the distance between swimmers increases from 0.5 m to 8 m, the drag coefficient began to increase slightly.

DISCUSSION
The results of this study were limited to steady flow around swimmers in tandem position. In the presented study, and for 0.5m of distance allowed decreasing in 45% the interaction of the first swimmer. However, the present study serve to establish CFD methodology as a technically reliable and less expensive alternative to experimental testing of swimming propulsion in tandem and allowed to estimate the optimal distance between swimmers in tandem and to evaluate the interaction between swimmers.

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"SWUM" AND "SWUMSUIT" – A MODELING TECHNIQUE OF A SELF-PROPELLED SWIMMER.

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INTRODUCTION
The author proposes a simulation model "SWUM" (SWimming hUman Model) and a simulation software "Swumsuit" (SWimming hUman Model with Synthetic User Interface Tools) as its implementation. This modeling technique is developed to analyze various problems in the mechanics of a self-propelled swimmer. The overview of SWUM and Swumsuit are firstly described. Next, the validity of the model is examined by comparing the simulation results of swimming speed with the actual value for the four modern strokes.
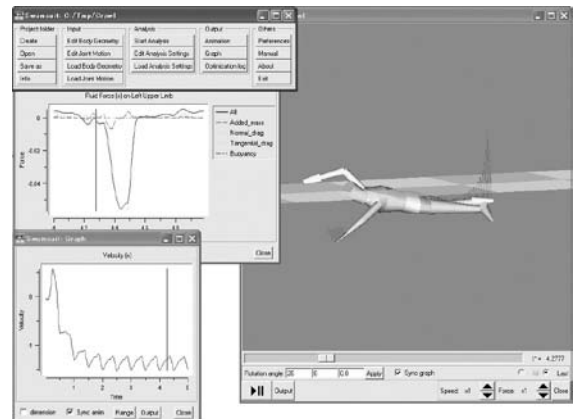
Figure 1. Screenshot of the developed software "Swumsuit"

METHODS
In SWUM, the relative motion of human body is given as joint motions, and the absolute motion for whole human body in six degrees-of-freedom is solved. The swimming speed, rolling, pitching and yawing motions, joint torques and so on are obtained as calculation results. As the external force acting on the human body, unsteady fluid force including the buoyancy and the gravity force are taken into account. The unsteady fluid force is assumed to be obtained from local motion of each body part. This model has been implemented into the software "Swumsuit", whose screenshot is shown as Figure 1.

RESULTS
From movies of model swimming by an athlete swimmer, joint motions for the four modern strokes, that is, front crawl, breast, back, and butterfly strokes, were produced. In the simulation, after several cycles of unsteady motion, steady straight swimming motions were obtained for all strokes. Figure 2 shows the Comparison of nondimensional stroke length during the steady swimming between simulation and actual value for the four modern strokes.
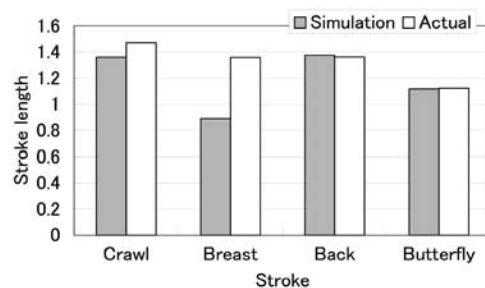
Figure 2. Comparison of nondimensional stroke length between simulation and actual value for four modern strokes.

DISCUSSION

The good agreement between the actual and simulation indicates sufficient validity of SWUM, although the simulation value of the breaststroke is somewhat smaller. With respect to Swumsuit, it can be used by any swimming researcher as a powerful analysis tool, since it can be easily operated through the graphical user interface and it is a free software. All the information about SWUM and Swumsuit, such as description, software itself, manual, and several sample data files, are available at the web site (http://www.swum.org/).

EFFECTS OF SUPINE FLOATING ON CARDIAC AUTONOMIC NERVOUS SYSTEM ACTIVITY AFTER TREADMILL EXERCISE IN WATER.

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INTRODUCTION

In the water, humans have different physical responses compared to land due to influences of physical characteristics of water such as water temperature, water pressure, buoyancy and viscosity. We suggested that supine floating after high and moderate intensity exercise with a cycle ergometer on land could promote the recovery of rectal temperature and an increase in cardiac parasympathetic nervous system activity. The purpose of this study was to determine the effects of supine floating on rectal temperature and cardiac parasympathetic nervous system activity after Treadmill exercise in the water.

METHODS

Six healthy males volunteered for this study. All subjects signed an informed consent form prior to participation in this study. Subjects were placed in a supine position for 30 minutes in both a water condition (W-condition) and control condition (C-condition) after treadmill exercise in the water. And subjects were measured for recovery while sitting for 15 minutes. Walking velocity was 4 km/h. Water temperature was 30 degrees Celsius. Heart rate, blood pressure, rectal temperature, oxygen uptake and cardiac autonomic nervous system activity were measured under these conditions. Cardiac autonomic nervous system activity was calculated using Maximum Entropy Calculation (MemCalc) methodology. Cardiac autonomic nervous system activity was transformed into logarithmic values to obtain a statistically normal distribution.

RESULTS

During supine floating after treadmill exercise in the water, rectal temperature was significantly reduced ($p< 0.05$) under the W-condition, as compared to the C-condition. And log HF was significantly increased ($p< 0.05$) under the W-condition, as compared to the C-condition, during the recovery process. Other indexes showed no significant differences under W-condition, as compared to the C-condition, during the recovery process.

DISCUSSION

The conductive heat transfer coefficient of water is 25 times higher than that of land. Therefore, the W-condition in rectal temperature was significantly reduced as compared to C-condition. The increase in logHF was caused by the bradycardia reflex, which increased central venous pressure, and the arterial baroreceptor, which increased the stroke volume. The increase in logHF continues for recovery while sitting after supine floating. These data suggest that supine floating after treadmill exercise in the water could increase cardiac parasympathetic nervous system activity. Also, the increase in cardiac parasympathetic nervous system activity continues for recovery while sitting after supine floating.

REFERENCE

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ESTIMATION THE LAP-TIME OF 200M FREESTYLE FROM AGE AND THE EVENT TIME.

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INTRODUCTION

This investigation aimed at estimation the lap time of 200m freestyle from age and the event time on national level swimmers.

METHODS

Subjects were 1759 swimmers (men: 908, women: 851) that participated in 200m freestyle of the Japanese national level competitions in 2002. These subjects included from 10 to 22 years old. The lap time in every 50m and the event time were used for analysis. It was obtained permission of these data use to the Japan Swimming Federation Information System Committee. Exponential function approximation of the event time (TIME) by aging (AGE) was carried out. The time constant (TC) was decided as a correlation of TIME and a presumed value became the highest. Furthermore, the linear regression between a lap time (LAP) and TIME for every age was calculated respectively. The linear regression coefficients were smoothed with 3rd order polynomial regression. The estimation formula was as follow:

$$LAP= (a_1AGE^3+a_2AGE^2+a_3AGE+c_1)\ TIME+ (b_1AGE^3+b_2AGE^2+b_3AGE+c_2).$$

RESULTS

The development tendency of TIME by aging could be approximated as following function for men: $46.19\exp\{-(AGE-10)/3.35\}+115.88$ sec. Other hand, the function for women was $31.76\exp\{-(Age-10)/2.76\}+128.01$. The highly correlations between the actual lap time and the estimated lap time from AGE and TIME were 0.944 to 0.990. This estimation formula applicable to international level swimmer with high validity (0.904 to 0.987, n=118 and 86) on condition that the AGE fac-

tor should fix at 22 for over 22 years old male swimmer and/or at 21 for over 21 years old female swimmer.

DISCUSSION
Since three times of TC show 95% saturation of an exponential function, it seems that the competitive time of 200m freestyle reach the maturity about 20 years old for men and/or 18 years old for women. In the 2nd and 3rd LAP, the mesh of estimated lap that consisted of AGE and TIME was distorted reduction-ward during adolescent. It is considered that development of aerobic capacity leads to it.

HOW CARDIOVASCULAR RESPONSES AFFECT TISSUE OXYGENATION AT REST AND DURING EXERCISE IN WATER?

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INTRODUCTION
It is generally accepted that the central shift in blood volume with water immersion is due to the hydrostatic pressure, which causes a translocation of blood from the lower limbs into the thoracic region. As a result of that, cardiac output (CO) has been reported to increase. The increment has been attributed to an elevated stroke volume (SV), which is related to an enhanced diastolic filling. Such responses are well-known but it is not clear how these responses affect tissue oxygenation in water. The purpose of this study was to investigate cardiovascular responses and tissue oxygenation at rest and during exercise in water.

METHODS
9 healthy male served as the subjects. After the subjects rested on land, they immersed up to their xiphoid level in a thermoneutral water (32˚C) and rested on the underwater ergometer for 5min, then pedaled for 12 min. They underwent the trial at 40% and 60% $\dot{V}O_2$peak both on land (LE) and in water (WE). $\dot{V}O_2$, heart rate (HR), CO and mean blood pressure (MBP) were measured during all experiments. Total peripheral resistance (TPR) was the difference between MBP and an estimate of central venous pressure divided by CO. The tissue oxygenation including oxy-hemoglobin (HbO$_2$) and total-hemoglobin (T-Hb) was simultaneously measured by near infrared spectroscopy as well.

RESULTS
At rest and immersed, HR and TPR decreased (p<0.05) when compared to pre-immersion. CO and SV also significantly increased (p<0.05) with immersion. With regard to the tissue oxygenation, HbO$_2$ increased and T-Hb decreased with immersion when compared with the pre-immersion. On the other hand, at both intensities (40%, 60% $\dot{V}O_2$peak) during WE, any cardiovascular responses but MBP didn't differ from that during LE. MBP during WE was significantly higher (p<0.05) than that during LE. HbO$_2$ during WE was significantly lower (p<0.05) than that during LE.

DISCUSSION
The increased SV and CO at rest in water resulted from the increment of venous return. It seems that the amount of the oxygen supply relatively increased with immersion so that HbO$_{2}$ tended to increase. There are some controversial reports about the responses of BP during WE but MBP in water was significantly higher (p<0.05) than that on land at the present study.

METABOLIC AND MECHANICAL CHARACTERISTICS OF OLYMPIC FEMALE GOLD MEDALIST.

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INTRODUCTION
Swimming performance is determined by the function of metabolic capacity, drag and stroke technique, and thus many investigations have examined what is a critical determinant of swimming performance. However, since data by top swimmers are very limited, it would give meaningful information to clarify metabolic and mechanical characteristics of Olympic gold medalist. Therefore, we performed physiological and biomechanical analysis of Athens Olympic gold medalist, and compared them to those of Japanese college top swimmers.

METHODS
The subjects were 15 elite Japanese college swimmers (age: 21±1 yrs) who belonged to inter-college champion team, and an Olympic gold medalist in female 800m free style event. In this experiment, maximal oxygen uptake (VO$_2$max), maximal blood lactate concentration (MBLC), and swimming speed at onset of blood lactate accumulation (V$_{OBLA}$) were measured as indices of metabolic capacity. Also a drag coefficient, a drag exponent, drag-swimming speed relationship and maximal propulsive power (MPP) were determined as indices of mechanical characteristics. All mechanical analyses were completed with a MAD system which modified the original system established by Toussaint et al.[1].

RESULTS
In the comparison of VO$_2$max, MBLC, no marked differences were observed between the gold medalist and the other swimmers. MPP in gold medalist was almost equal to average value of the others. On the other hand, the drag-swimming speed relationship revealed markedly lower drag for the gold medalist, especially at higher swimming speed (near race pace), was comparably lower in gold medalist than those in the others. Furthermore, V$_{OBLA}$ in gold medalist was the highest of all swimmers.

DISCUSSION
In this study, a marked feature of metabolic capacity in gold medalist was not observed, however, it was found that the drag at higher swimming speed became lower compared to the others. Therefore, it is suggested that mechanical (technical) factors such as propelling efficiency, the stroke technique to reduce drag should be more significant determinants of superi-

or swimming performance although metabolic power has been considered as a significant determinant of swimming performance.

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PATTERN MATCHING APPLICATION FOR THE SWIMMING STROKE RECOGNITION.

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INTRODUCTION

In the field of sports biomechanics, we have been quantified the similarity between subjects using kinematics. Many studies applied the normalisation in this procedure. On the other hand, in the field of speech recognition, in order to distinguish a phoneme by different speaker's or voice, they have been applied the dynamic time waping (DTW) method. In this study, the author quantified the similarity of the swimmers' stroke motion, which depend on their skill level and swimming speed using dynamic time warping.

METHODS

Both the three dimensional wrist acceleration and the angular velocity on the crawl stroke were analysed using our data logger. Using DTW, we can quantify the similarity between two different time series. In addition, we can also detect where is the different phase in the compared two strokes from the matching path after the calculation.

RESULTS

DTW method is available for the pattern matching on the swimming stroke analysis. It revealed that the similarity between two different swimmers' strokes. In addition, as for the same swimmer, DTW also clarify the change of the underwater stroke phase depends on their swimming speed and fatigue.
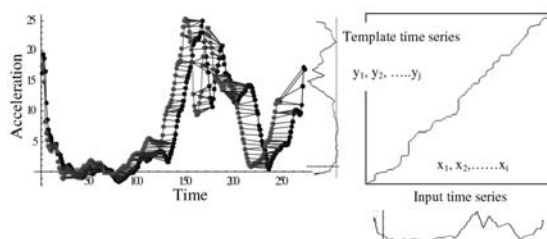
Fig. 1: Result of stroke pattern matching and its matching path using dynamic time warping.

DISCUSSION

Using DTW application for the wrist kinematical data, it was clarify the difference, which means the non linear distance between two different swimmers' stroke patterns or two different swimming speed strokes. The author proposes that DTW method based on the sensory data has a possibility that it will be available to instruct for swimmers to correct their stroke motion.

DURATION OF ONE UNIT (80KCAL) DURING TREADMILL WALKING IN WATER.

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INTRODUCTION

Recently the number of Japanese people diagnosed with diabetes has been increasing. Diabetic renal disease is the No. 1 cause of artificial dialysis in Japan. Many diabetes patients also suffer from obesity. Epidemiological and intervention studies of endurance exercise training strongly support its efficacy for the health of those with diabetes. A healthy amount of kidney blood flows is maintained during underwater exercise. The purpose of the present study was to make clear the difference of duration per expended one unit (80kcal) between younger and older people during treadmill walking in water.

METHODS

Ten healthy young men (age: 22.6 ± 1.1 yrs, height: 171.6 ± 5.4 cm, weight: 67.7 ± 8.4 kg and %fat: 19.2 ± 4.7 %) and eight healthy women (age: 61.8 ± 4.3 yrs, height: 152.4 ± 3.9 cm, weight: 60.0 ± 4.9 kg and %fat: 34.1 ± 2.8 %) participated in this study. Subjects walked at 3 velocities (1, 2 and 3km/h). Heart rate (HR) and oxygen uptake (VO_2) were measured. HR was recorded for each minute. Exhaled gas was gathered to calculate VO_2. The duration of exercise that expended one unit of energy was calculated from oxygen uptake. Water temperature, room temperature and humidity during the experiments were $30.3\pm0.3°C$, $26.9\pm0.7°C$ and $76.6\pm2.3\%$.

RESULTS

Younger and older people's VO_2 was 0.39 ± 0.04 l/min. and 0.42 ± 0.07 l/min. (1km/h), 0.49 ± 0.07 l/min. and 0.51 ± 0.07 l/min. (2km/h) and 0.67 ± 0.12 l/min. and 0.66 ± 0.11 l/min. (3km/h). There was no significant difference in VO_2 between younger and older people. Relative VO_2 was lower in older than younger people. Calculated results for younger and older people were 41.66 ± 4.56 minutes and 39.73 ± 6.54 minutes (1km/h), 33.37 ± 4.59 minutes and 31.94 ± 4.49 minutes (2km/h) and 24.86 ± 5.23 minutes and 24.93 ± 4.18 minutes (3km/h).

DISCUSSION

There was no difference due to the difference of the age in duration expending one unit. The unit conversion which designates 80kcal as one unit in the diet of people with diabetes has been used in Japan. It was suggested that it becomes possible

to prescribe underwater exercise for older diabetes patients by using the young's one unit index.

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THE INFLUENCE OF REPEATED SPRINTING ON THE KINEMATICS OF BUTTERFLY SWIMMING.

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[2]English Institute of Sport, E.I.S. Pool, Loughborough University, Leicestershire, UK.

INTRODUCTION
Only a few studies have investigated intra-cyclic stroke kinematic variations that occur under exhaustive conditions in swimming, with even less specifically examining the butterfly stroke. The purpose of this study was to determine the effect of repeated sprint performance and fatigue on the kinematics of butterfly swimming.

METHODS
Six experienced national youth (16.8 ±1.5 years) male butterfly swimmers undertook a maximal effort repeated sprint test: 8 x 50 metres (long course) at intervals of 1 min 30s from a dive start. Swimming repeat times were recorded and blood lactate concentrations were measured pre- and post- test. On the first and seventh repeats, swimmers were filmed with two underwater and two above water cameras (oblique plane) at 50 Hz. The whole body was digitised during a full stroke cycle for each view, with the three-dimensional coordinates being obtained using a DLT algorithm.

RESULTS
Mean swimming performance decreased by 9 ±5% (p<0.01) over the 8 x 50 metres, while mean blood lactate concentration rose to 12.6 ±1.7mmol.l^{-1} (p<0.01) post- test. Mean stroke speed decreased by 8 ±6% (p<0.05) between repetitions one and seven, with swimmers exhibiting slower stroke rates (p<0.01) but similar stroke lengths. Total stroke time increased by 10 ±6% (p<0.01), as a result of a longer duration in all stroke phases (Recovery and Catch p<0.05). Swimmers exhibited slightly deeper (4 ±7%), narrower (7 ±12%) and shorter (3 ±8%) hand path trajectories during the propulsive phase, with 4 ±10% less elbow flexion during the Insweep and 7 ±18% less elbow extension during the Upsweep. Peak hand velocities during all arm phases decreased – Outsweep: lateral by 17 ±18%; Insweep: medial by 11 ±19%; Upsweep: backward, upward and lateral by 12 ±17%, 17 ±18% and 23 ±26% respectively; Recovery: upward by 12 ±16%. Hand Recovery was 5 ±4% wider (p<0.05) with swimmers exhibiting 2 ±1% less elbow extension. Maximum trunk inclination increased by 13 ±15% during the Recovery phase. No differences in arm and leg phase coordination were observed. Peak vertical foot velocities during all leg phases decreased, although these differences were not significant.

DISCUSSION
As butterfly swimming speed decreased, stroke rate decreased, while stroke length remained relatively constant. Swimmers exhibited similar hand movement patterns during the propulsive phase, while changes in elbow angle were observed. This may indicate that the effectiveness of the elbow flexors and extensors was reduced by the seventh 50m repetition. The Upsweep, the Recovery and the Catch appear to be the critical stroke phases as butterfly swimmers become fatigued (these are the phases in which the greatest changes were observed). Encouraging swimmers to accelerate the hands outwards during the Upsweep while maintaining a more horizontal trunk and a lower and faster hand recovery, may help to resist changes in stroke mechanics brought about by the onset of fatigue.

INTRA-CYCLIC SPEED FLUCTUATIONS OF UNI-LATERAL ARM AMPUTEE FRONT CRAWL SWIMMERS.

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INTRODUCTION
In front crawl swimming the majority of propulsion is generated by the arm action and the main propelling surfaces are the hand and forearm. It is doubtful that the upper arm contributes much to propulsion as this segment moves forwards relative to the water and encounters drag forces that resist forward motion of the body. Swimmers with an amputation at elbow level are therefore deprived of an important propelling surface. Although these swimmers pull with their affected limb when swimming front crawl, the effectiveness of this pull, compared to that of the sound limb, has not been established. The purpose of this study was to determine the extent to which competitive uni-lateral arm amputee front crawl swimmers are able to generate swimming speed with their sound and with their affected limbs.

METHODS
Two male and six female, trained swimmers (age 17.6 ± 3 years) consented to this study. All participants had a uni-lateral amputation at the level of the elbow. Best times for the 100 m front crawl ranged from 64.0-99.3 s. Participants swam 25 m front crawl trials at middle distance pace with a small buoy placed between the legs in order to isolate the arm action. Trials were filmed below water, from the side, using a tracking camera system. Instantaneous swimming speed was measured simultaneously using a velocity meter sampling at 100 Hz. Three consecutive, non-breathing stroke cycles, were selected for analysis. The gleno-humeral joint centre and the most distal point of the affected limb were digitised at 50 Hz to obtain the angular position of the limb, as a function of time. The times at which key moments occurred in the stroke cycle were also obtained from the video recordings.

RESULTS

Mean swimming speed during the trials was 1.09 ± 0.13 m.s^{-1}. Mean Speed fluctuation within a stroke cycle, expressed as a percentage of mean speed, was $35 \pm 5\%$. Peak swimming speed achieved during the push phase of the sound limb (1.30 ± 0.17 m.s^{-1}) was significantly higher ($p<0.05$) than that found during the push phase of the affected limb (1.14 ± 0.11 m.s^{-1}). Mean extension velocity of the affected limb was 10.3 ± 1.5 rad.s^{-1}. There was no relationship between the extension velocity of the affected limb and the peak swimming speed that was produced during the push phase of this limb.

DISCUSSION

The intra-cyclic speed fluctuations of the uni-lateral arm amputee swimmers were similar to those previously reported for able-bodied swimmers, which was unexpected. It had been anticipated that intra-cyclic speed fluctuation would be higher in the amputee swimmers due to a less consistent application of force through the stroke cycle. The amputee swimmers were able to use their affected limb to increase their swimming speed, but not as effectively as with their sound limb. Surprisingly, the speed with which the affected limb was pulled through the water did not influence the peak swimming speed produced by this movement. The timing of the pull with the affected limb, relative to that with the sound limb, varied considerably between the participants. Further work is necessary to establish what influence this has on performance.

RACE PACE CONTROL BY MEANS OF A NEW CHRONOMETER SYSTEM.

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INTRODUCTION

Compared with other terrestrial sports, coach-swimmer communication during training is a very difficult task. However, numerous studies indicate the importance to provide real time feedback for technique improvement (Weinberg, & Gould, 1995). The aim of the present communications is double: first, to present a new chronometer system that provide real time feedback without interfering with swimmer's execution and, second, to evaluate tree different ways to provide feedback to swimmer in order to control the race pace.

METHODS

A) Chronometer system (figure 1): The system consists on a leds screen (water resistant) installed on the bottom of the pool, so that swimmers can see it every time they perform a turn. This system can be connected to a PC or PDA, which permits register lap times and provide feedback to swimmers.
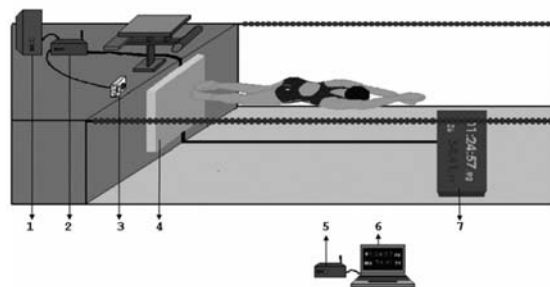
Figure 1: Chronometer system Scheme: 1) battery, 2) and 5) telemetric system, 3) start-stop control, 4) contact platform, 6) PC or PDA, 7) leds screen and subaquatic box.

B) Feedback tests: Six swimmers of national level perform the tests. Feedback provided by the chronometer to control race pace was compared with the condition "traditional feedback" provided by the coach and with the condition "no feedback", at two race pace speeds, aerobic and anaerobic threshold speeds.

RESULTS

Results show little dispersion on lap time with this new kind of feedback at aerobic race pace. At an anaerobic threshold race pace, dispersion was similar between "traditional feedback" and chronometer feedback, and a little more dispersion in "no feedback" condition.

DISCUSSION

Results shows the utility of the new system, since dispersion on lap times with it are little than with traditional feedback or without feedback.

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EVALUATION OF SELECTED KINEMATIC VARIABLES IN SWIMMERS WITH PERMANENT PHYSICAL DISABILITIES, USING MOTION ANALYSIS TECHNOLOGY.

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INTRODUCTION

The underwater movement patterns of persons with permanent physical disabilities are unique insofar that the variations in stroke mechanics have evolved while compensating for anatomic and neuromuscular deficits. The study of the kinematic parameters associated with disabled swimming has been made easier with the development of motion analysis equipment. The purpose of this paper is to demonstrate the use of this technology as applied to the analysis of selected stroke patterns employed by disabled swimmers.

METHODS

The following disability categories were examined: Amputation; Cerebral Palsy; Guillain-Barre Syndrome; Thrombocytopenia - Absent Radius (TAR) Syndrome. Subjects were video taped underwater from two views, frontal and lateral. Two-dimensional kinematic analysis of selected parameters was conducted using the Peak Motion Analysis system with Motus software (Vicon Peak, Denver, Colorado). The factors that were examined are as follows: (1) Oscillations in hip and knee angles as a function of pull patterns. (2) Relative changes in hand speed between amputee swimmers with complete and reduced limb segments. (3) Variations in body position between swimmers with and without lower extremity control. (4) Tracking of the paths of motion of the hands and feet during swimming as a means of comparing stroke patterns between disabled and able-bodied swimmers.

RESULTS & DISCUSSION

Kinematic and visual analysis of the video taped footage provided insight into the varying movement patterns of the subjects. When performing strokes that required unilateral, alternating arm movements, swimmers lacking neuromuscular control of the lower extremities demonstrate oscillations of the hip and knee joints in both saggital and frontal planes. These oscillations were seen to contribute to altered frontal resistance. Differences in hand speeds between amputees with varying degrees of limb loss demonstrate compensatory adjustments in stroke rates. In observing body positions in the water, large variations were seen between the different types of disabilities. As expected, loss of lower extremity control was the major contributory factor in these differences. The study also demonstrated that improved propulsive skills contributed positively to altering body position. With respect to pull patterns, unusually pronounced sculling movements were observed in select subject populations, when compensating for anatomical and neuromotor limitations.

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TRAINING INDUCED CHANGES IN CRITICAL VELOCITY AND V4 IN AGE GROUP SWIMMERS.

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INTRODUCTION

The validity of critical velocity (Vcri) as a marker for aerobic capacity and its utility for intensity exercise prescription were confirmed by numerous studies. However, conclusions from studies with young swimmers are not consensual, revealing Vcri to be lower than or similar to the velocity corresponding to lactate concentrations of 4 mmol.l^{-1} (V4). Furthermore, the sensitivity of critical velocity to training adaptations in the course of the competitive season have not yet been verified for age group swimmers

The aim of this study was (1) to verify the relationships of the Vcri index to V4 and to the mean velocity of the T2000 test (V2000) in front crawl swimming and (2) determine the changes induced by training in these parameters in age group swimmers.

METHODS

Twenty nine national level swimmers, 18 males and 11 female (age = 12.9±1.15 years) participated in this study. Each subject was tested in the beginning and in the end of the general preparation period (1st stage and 2nd stage). Vcri was calculated from the slope of a regression analysis between the distances of 50, 200, 400 meters front crawl and the correspondent time determined in practice. The subjects performed two repetitions of 200 meters freestyle, one at 85% and another at maximum speed for determination of V4. Blood was sampled from the fingertip after one and three minutes of recovery and blood lactate concentration was determined. Each subject performed a 2000 meters trial at maximum but constant speed for determination of V2000. Blood was sampled after one minute and lactate concentration was determined (La2000).

RESULTS

Table 1: Vcri, V4, V2000, T2000 and La 2000 values in the two testing stages.

	Vcri (m.s^{-1})	V4 (m.s^{-1})	V2000 (m.s^{-1})	T2000 (s)	La 2000 (mmol.l^{-1})
1st stage	1.12±0.10	1.11±0.086	1.067±0,096	1850±165	5.75±2.3
2nd stage	1.20±0.11	1.19±0.09	1.13±0,09	1772±128	4.5±1.7

All the inter-stages differences were statistically significant. In each stage, Vcri were not significantly different from V4, but were significantly higher than the V2000. These variables presented high and significant correlations (p<0.01) among them. The Vcri corresponded to 96.4% (1st stage) and 96.8% (2nd stage) of the mean velocity of the 400m front crawl maximal trial.

DISCUSSION

The results presented in this study are similar to those obtained with adults concerning the observed correspondence between Vcri and V4. Furthermore, it can be concluded that Vcri it's sensitive to training, namely to a strong aerobic loads period. This fact, associated with the correspondence between Vcri and V4, indicates Vcri as a reliable index to evaluate changes in the aerobic capacity of young swimmers.

ASSESSMENT OF SUBMAXIMAL AND SUPRAMAXIMAL SWIMMING ENERGY COST IN CRAWL AND BREASTSTROKE SWIMMERS.

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INTRODUCTION
The assessment of energy cost during swimming if often done by measurement of mechanical indicators (2) or physiological measures (1). The aim of the present study was to assess and compare the energy cost during crawl and breaststroke swimming at five submaximal and one supramaximal (200m all-out bout) intensities.

METHODS
Twelve crawl and twelve breaststroke experienced swimmers (more than 10 years of training) volunteered for the study. The mean ($\pm$SD) age, weight, height, arm span and fat percentage of the subjects were, respectively: $17,3\pm2,5$ years, $69,42\pm6,63$ kg, $1,78\pm5,70$ m, $1,84\pm5,44$ m and $9,03\pm2,01$ %. The subjects' mean ($\pm$SD) VO_2max of the subjects was $66,0\pm11,35$ ml.Kg.$^{-1}$m^{-1}. The subjects performed two tests: an incremental discontinuous test to exhaustion and an all-out supramaximal 200m test. The exercise intensity during the submaximal test was comprised between 50% and 90% of each subject's best performance over the 200m event. Each group performed the two tests on their preferential style. During both tests VO_2 measured with a portable gas analyser (K4b2, Cosmed, Italy) connected to a specific valve for swimming (Aquatrainer, Cosmed, Italy). Submaximal energy cost was calculated by the slope of the regression line traced by steady-state VO_2 vs swimming velocities during the incremental test. Supramaximal energy cost was calculated by linear extrapolation of the submaximal energy cost.

RESULTS
Submaximal and supramaximal energy cost during breaststroke swimming were 0.891 ± 0.21 ml.kg^{-1}.min.$^{-1}$ and 0.959 ± 0.19 ml.kg^{-1}.m.$^{-1}$, respectively. Submaximal and supramaximal energy cost during crawl swimming were 0.691 ± 0.06 ml.kg^{-1}.min.$^{-1}$ and 0.714 ± 0.09 ml.kg^{-1}.m.$^{-1}$, respectively. The energy cost during breaststroke swimming was significantly higher compared to crawl swimming (both for sub and for supramaximal intensities). No significant differences were found between sub and supramaximal energy cost at each of the two swimming styles.

DISCUSSION
The higher energy cost during breaststroke compared to crawl swimming is consistent with previous reports (Capelli et al., 1998). Since there were no significant differences in the VO_2max of the two groups, we may suggest that those differences are attributable to the swimming style rather than to physiological characteristics of the subjects.

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ISOMETRIC FORCE, TETHERED FORCE AND POWER RATIOS AS TOOLS FOR THE EVALUATION OF TECHNICAL ABILITY IN FREESTYLE SWIMMING.

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INTRODUCTION
Performance in swimming is strongly related to the arm power (1) and to the isometric strength. The aim of this study is to determine the relationships between isometric force, tethered force and force produced in power to be used as indicators of the technical ability.

METHODS
Eight international swimmers (age 22.5 ± 2.3 yr, height 1.87 ± 0.07 m and weight 79.0 ± 6.5 kg) realised maximal isometric forces for 3 arm–trunk angles (Fiso30°, Fiso90°, Fiso120°). Then, a 5s full tethered swim allowed the measure of the maximal propulsive force in water (Fpmax). Finally, a 25m maximal power test was realised in a 1/2 tethered condition with a resistive force of 5% of Fpmax. Force (Fp and Fpmax), velocity (Vp) and power (P) were measured using a specific ergometer (2).

RESULTS
Isometric forces were not significantly different for the 3 angles (figure 1). Large individual variations were observed for the ratio Fpmax/Fiso30° as for the ratio Fp/Fpmax, the stronger swimmers presenting the lower ratios (figure 2). Fiso30° was significantly correlated to Fpmax (0.83) and to Fp (0.74).
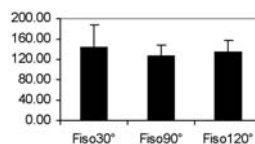
Figure 1: maximal isometric forces for 3 arm-trunk angles.
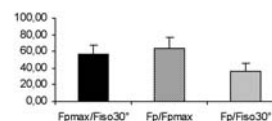
Figure 2: ratios Fpmax/Fiso30º, Fp/Fpmax, Fp/Fiso30°.

DISCUSSION
The large variations observed in Fpmax/Fiso30° reflected the technical ability to use the force capacity in the production of the swimming propulsive force while the variations found in Fp/Fpmax indicated the ability to negotiate the compromise force-velocity in power production. These results could be useful to determine the swimmer's insufficiencies, i.e., low isometric force and/or bad technical ability.

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START TECHNIQUE QUALITATIVE EVALUATION OF INTERNATIONAL SPANISH JUNIOR AND PRE-JUNIOR SWIMMERS: AN ANALYSIS OF ERROR FREQUENCY.

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INTRODUCTION
This is a four year study compilation of the analyses developed with the Spanish Junior National Team during their summer training camps (three-week taper) before their participation in the European Junior Championships. The purpose of this study is to determine the frequency of mistakes observed in the aerial preparatory position, the pull, the drive from the block, the flight and the entry pike start phases.

METHODS
177 junior and pre-junior male and female elite swimmers performed the pike start. All swimmers were video-recorded since they enter in the water (sagital view) until the end of a 50m at competitive speed main style trial.

	Male		Female	
Group	Junior	Pre-junior	Junior	Pre-junior
Age	14-15	12-13	16-17	15
N	48	39	47	43

RESULTS
The most frequent problem found in the pike start (3 of 4 swimmers) is the incorrect head position at the moment of the entry in the water. 66% of the swimmers keep their heads up and 55% flexed knees more than is advisable, causing the displacing of the center of mass backward (Maglischo, 2003). The push is not supported by the lack of force application of the hands on the pool block (45%) considering this a more evident problem in women.

STARTING	Male		Female	
errors (%)	Junior	Prejunior	Junior	Prejunior
Head not between arms (neck flexed/ shoulders extended)				
	79	72	69	74
Head not down in preparatory position				
	48	70	82	67
Excessive knee flexion (knee angle <140º)				
	44	74	28	70
Misaligned trunk-legs at the take-off				
	27	30	67	77
Hands not apply force in the block, push phase				
	31	30	64	60
Arms/hands are separated in the entry moment				
	40	36	49	51

DISCUSSION
Junior women seem to have more facility, than the rest of the groups, in keeping in the preparatory position a correct leg angulation; whereas in the pre-junior group seems to exist an adequate position ignorance. Almost a half of the swimmers maintain their upper limbs in a non hydrodinamic position; this should provide a warning to work on start technique basic questions. Probably, although static situations can be easier to correct, the importance of technique work in starts must fall on those factors that can increase the advance resistance or reduce the horizontal push off force component.

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THE BREASTSTROKE START IN EXPERT SWIMMERS: A KINEMATICAL AND COORDINATIVE STUDY.

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INTRODUCTION
Few kinematical analyses have focused on the underwater phase of the start, although Cossor and Mason (2) noted a negative correlation ($r=-0.734$) between the underwater velocity and the 15-m start time in the 100-m breaststroke. On the other hand, the high arm to leg coordination required to minimise the propulsive discontinuities in the breaststroke has recently been pointed out (1, 3, 4). This study analysed the kinematics and coordination of a start at the 100-m breaststroke pace, comparing national and international swimmers.

METHODS
Eight national swimmers were compared to the bronze medallist of the Athens 2004 Olympic Games in the 100-m breaststroke. All simulated the 100-m pace for 25 m after a grab start. Two aerial lateral cameras (50 Hz) placed at 5 m and 15 m, and a trolley on which an aerial lateral video camera was superposed on an underwater lateral video camera (50 Hz), were video timed, synchronised and genlocked. The kinematical analysis assessed the durations of the following phases up to the 15-m mark: leave block, flight, entry and glide, pull-out, and swim. The coordination analysis assessed the durations of two time gaps of the pull-out phase: the time spent with the arm close to the thigh after the arm pull-push, and the time gap between the end of the arm recovery and the beginning of the leg propulsion.

RESULTS
The international swimmer had a faster 15-m start time than the national swimmers due to a shorter swim phase, a longer underwater phase (notably, longer glide and pull-out phases) and a longer time with the arm close to the thigh after the pull-push of the arms. The whole population showed a superposition of two contradictory phases: the leg propulsion began, whereas the arms were not extended forward (in a streamlined position) because their recovery was not finished.

DISCUSSION
One practical application of these findings would be to monitor the duration of the start phases and the arm to leg coordination during the pull-out phase so that the superposition of contradictory phases - which increases drag - can be corrected.

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EFFECT OF COMPUTER ASSISTED INSTRUCTION WEB SITE FOR SWIMMING TO CHILDREN'S LEARNING MOTIVES AND LEARNING STRATEGY.

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INTRODUCTION
We have developed a computer assisted instruction (CAI) web site aimed for elementary school children and reported the characteristics of the different contents involved in the CAI program[2]. Still the benefit using CAI program in the educational scene compared to the traditional teaching method has not been clarified. The purpose of this study is to identify the effect of CAI web site for swimming to children's learning motive and learning strategy.

METHODS
CAI web site was developed to provide information about how to swim (Front crawl, Breaststroke) and the step to practice each stroke. Sixty elementary school children (5th grade) participated in this study. The subjects were divided to two groups which learned with the CAI web site trough out the swimming class (WEB n=29) and the control group which only participated in the ordinary swimming class (CON, n=31). WEB group utilized the CAI web site day before the swimming class to collect information for their own study and contributed question in the BBS to get more precise information from a university researcher.
Both groups answered a questionnaire[1] before (Pre) and after (Post) the swimming class (8 classes in 4 weeks) to analyze the learning motives (practice, superiority, approval, fulfillment, group, performance orientated) and learning strategy (general, aim, effort arrangement).

RESULTS & DISCUSSION
Approval and fulfillment orientated motives significantly decreased ($p<.05$, $p<.01$ respectively) after the swimming class in CON. Fulfillment orientated motives decreased ($p<.05$) in WEB. Aim learning strategy in CON significantly decreased ($p<.05$) and effort arrangement learning strategy decreased ($p<.05$) in WEB.
It was indicated that by using CAI web site the motivation to achieve higher swimming performance was kept high through the swimming class. This result is related with the aim learning strategy. WEB were able to gather information from the CAI web site for each children's swimming ability and were able to obtain a clear aim for their swimming class which led to a higher approval orientated motive.

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EXAMINATION OF FEEDBACK TOOL USING INTERACTIVE MOVIE DATABASE FOR SYNCHRONISED SWIMMING.

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INTRODUCTION
We provided instant visual feedback service at the venue of a synchronised swimming competition (Shimizu et al, 2005). To realize this service we used the following flow of action: taking the movie, capture, encode and registration of the data (movie) in the distribution server. This system was able to provide individual visual feedback to several users at once. The instant visual feedback service could only be accessed at the competition venue; therefore we developed a new system, which enables its users to access an interactive movie database for sports via the Internet (Miyaji, 2005). The purpose of this presentation, as a case study, we constructed an operation model of the system for synchronised swimming.

METHODS
We examined various movie formats and its adjustable parameters, and compared the movie quality. To add information tags and annotation information to the movies files, we clarified the important characteristics of synchronised swimming. Then we simplified the search procedure for information tags in the movie database.

RESULTS
The windows media movie format was chosen because of its widespread among users and its good compression. For browsing the movie files we used a bit rate of about 1 Mbps, therefore an ADSL Internet connection is sufficient to browse the files. Due to the relative slow bit rate the movie files have block noise at the water surface.

DISCUSSION
Even though block noise at the water surface is visible, due to the movie parameters chosen foe Internet access, it does not affect the observation of the movement itself and the function as a learning tool. With the development of the Internet environment the movie bit rate can be raised and movie files of

higher quality can be accessed. Athletes can use instant visual feedback system in competition venue while the image is still present in the athlete's head, after the competition, athletes can check skills using new Internet based feedback system anywhere. Both systems can be provided chance to get movement skills for many athletes.

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DOES THE LONG-TERM ORAL CREATINE SUPPLEMENTATION IMPROVE REPEATED SPRINT PERFORMANCE IN ELITE SWIMMERS?

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INTRODUCTION
There were few studies that investigated the effect of creatine supplementation on elite swimmers with long-term supplementation. Although several studies showed the ergogenic effect of creatine supplementation, it is controversial to improve the sprint performance in swimming. The purpose of this study was to investigate the effects of long-term oral creatine supplementation on intermittent repeated sprint performance in elite male swimmers.

METHODS
Twelve subjects were randomly separated into creatine group (n = 6) and placebo group (n = 6). Creatine group were supplemented 12 grams creatine per day during 8-weeks in training session. Supplementation was performed by double-blind method. ^{31}P-NMR spectroscopy of triceps muscle of the arm, analysis of blood and intermittent repeated sprint swimming test were executed before and at the end of supplementation. Repeated sprint swimming test was carried out using the swimming flume. The test was consisted of 30sec sprint swimming (flow velocity = 85 % of 100 m best: 85%@V100) and rest, and continued up to exhaustion. Body compositions (weight, % body fat) were measured through the supplementation period.

RESULTS
Eight-weeks creatine supplementation tended to increase muscle PCr content ($P = 0.055$). Plasma creatine concentration of creatine group was significantly higher than those of placebo group at the end of supplementation ($P < 0.05$). The values of plasma GPT and LDH activity in creatine group were increased significantly ($P < 0.05$), but those were in normal range. There was no significant improvement on intermittent repeated sprint swimming performance. Further, there were no differences in race performance between each group at subsequent event.

DISCUSSION
Present results suggested that long-term creatine supplementation increased muscle PCr content and plasma creatine concentration with no disadvantage on physiological functions in elite male swimmers. However, it was difficult to prove an ergogenic effect on repeated sprint performance and race performance in elite male swimmers.

ASSOCIATIONS BETWEEN ENERGY RELEASE AND PERFORMANCE IN A SUPRAMAXIMAL EFFORT OF 200M IN CRAWL.

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INTRODUCTION
The data available on the literature on the estimations of the aerobic and anaerobic fractions of energy release during a supra maximal swimming effort in 200m is scanty (1, 3). Additionally, those measurements are rarely based on direct calorimetry estimates. Therefore, the aims of the present study were to describe the aerobic and anaerobic energy production during a supra maximal swimming effort in 200m crawl by respiratory measurements and to investigate the association between those measures and the performance over the same distance.

METHODS
Twelve crawl experienced swimmers volunteered for the study. The mean ($\pm$SD) age, weight, height, arm span and fat percentage of the subjects were, respectively: 17,7$\pm$2,4 years, 71,90$\pm$6,95 kg, 1,79$\pm$6,28 m, 1,87$\pm$4,57 m and 10,05$\pm$0,76 %. The subjects´ mean ($\pm$SD) VO$_2$max was 65,1$\pm$6,31 ml.Kg.$^{-1}$m^{-1}. The subjects performed two tests: an incremental discontinuous test to exhaustion and a supra maximal 200m test. A 24h interval was comprised between the two tests. During both tests VO$_2$ measured with a portable gas analyser (K4b2, Cosmed, Italy) connected to a specific valve for swimming (Aqua trainer, Cosmed, Italy). Aerobic fraction of energy release was calculated by dividing the accumulated VO$_2$ by the total energy cost. Anaerobic fraction of energy release was calculated by dividing the accumulated oxygen deficit by the total energy cost. Accumulated VO$_2$ was calculated by integrating the VO$_2$ in order to the time of the 200m test. Accumulated oxygen deficit was estimated as explained elsewhere (2). The associations between fractions of energy release and the performance was investigated with the Pearson product-moment correlation coefficient after the normality assumption was confirmed (p$\leq$ 0.05).

RESULTS
The anaerobic and aerobic fractions of total energy released during the 200m crawl event were $\approx$15% and $\approx$85%, respective-

ly. No association was found between these variables and the performance.

DISCUSSION

Maglischo (1) and Troup (3) both suggest an aerobic contribution to the total energy release during a 200m crawl event to be ≈40%, a value much lower than the ≈85% that we have observed. The differences are probably due to methodological issues. We conclude that the estimations presented on the literature may not reflect estimations by direct VO_2 measurements.

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MENTAL TRAINING IN SWIMMING: APPLYING A NEW GOAL DEFINITION MODEL.

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INTRODUCTION

Many researchers studied mental training and sport performance in limited training conditions. The transfer from training to competition situations is not guaranteed. A worthy goal is to better understand intrinsic mechanisms of mental training and application (Rushall, 1991), which can be accomplished by a guided/planned of *Goal Definition Model* (Vasconcelos-Raposo, 2001) in two conditions: during the intervention period and the retention (follow–up) period in two consecutive swimming sport seasons.

METHODS

Interpretive case studies of nine elite swimmers, 4 males and 5 females, aged from 14 to 20 years old, were undertaken under the same intervention model. Seven moments of individual strategies evaluations were made during 2 years by analyzing several training domains (procedures adapted from Thomas & Nelson, 1996): i) psychological domain, measured by the Psychological Profile (Loher, 1986), the Imagery Questionnaire (Bump, 1989), the test of attention and Interpersonal Style (Nideffer,1976), the competitive state anxiety inventory-2 (Martens et al, 1990), the task and ego orientation in sport questionnaire (Duda & Nicholls, 1989); ii) the performance domain, measured by swimming time; iii) and the semi-quantitative biomechanical parameters measured by the chronometric (start time, swimming time, turning time) and biomechanical (stroke rate, and stroke index). To compare the intervention with the follow-up season we applied the Wilcoxon, non parametric test, for testing the different evaluation moments (Bonferroni correction, $p<0.05$).

RESULTS

The results pointed out: i) a somatic anxiety decreased during the intervention period; ii) positive thoughts decreased from intervention to follow-up; iii) imagery dimension, image control, emotion control and seeing was significantly higher in intervention when compared with follow-up; and finally; iii) broad internal attention was significantly higher in intervention when compared with follow-up.

DISCUSSION

Preliminary data analyses suggest that mental variables have an evolutionary profile similar to the same demonstrated for swimming performance. Mental and performance data appear to converge over time as mental skills and procedures are mastered. The integrated psychological program employed also seems to influence swimmers general psychological profile and indirectly their motor development. In the follow-up there is a regression as to psychological and performance profile. Structural methodologies and principles underlying physical and psychological training appear to be similar.

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VELOCIMETRIC CHARACTERIZATION OF A 30 SEC MAXIMAL TEST IN SWIMMING: CONSEQUENCES FOR BIOENERGETICAL EVALUATION

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INTRODUCTION

The existence of a valid direct method to evaluate anaerobic proficiency of swimmers is still a matter of controversy. The use of an alactic-lactic threshold has never been feasible, namely due to the difficulty of exactly quantify the alactic energetic contribution to an effort (1). Moreover, the possible existence of that threshold remains strictly theoretical. In the present study, the use of a velocity decay analysis during a maximal swimming test is related to a possible transition from a mainly alactic to a lactic metabolic pathways. Different maturational statuses of swimmers are considered.

METHODS

A total number of 72 swimmers performed a 30 sec maximal front crawl test connected to a mechanical speedometer developed by our investigation group (2). This velocimetric system produced individual curves of the instantaneous velocity corresponding to each swimmer total effort time. Data treatment was performed using a routine, written by our research group,

in the *MatLab* program. We started by removing the start, glide and final phases of the velocity curve, and then a continuous wavelet analysis of this curve was performed. From the wavelet results it was possible to discriminate one, or more, points separating zones of different spectral characteristics, that we loosely call fatigue thresholds.

RESULTS AND DISCUSSION
Results revealed a tendency to an inverse relationship between the number of different fatigue thresholds and maturational status. This should be related to a less mechanically stable swimming technique of younger swimmers. The velocity curves for all studied groups are mainly characterized by two fatigue thresholds. The first fatigue threshold was found to be around 8 to 12 sec (table 1). It seams to be legitimate to speculate about the possibility of using the velocity curves to determine the individual alactic-lactic threshold in order to better plan and control anaerobic swimming training.

Table 1. Mean effort time (sec) and respective standard deviation correspondent to velocity curves with one or two fatigue thresholds.

| | One threshold | Two thresholds | |
	1st threshold	1st threshold	2nd threshold
Post-pubertal	12.5±1.58	8.94±1.55	16.22 ±2.65
Pubertal	13.6±1.34	9.42±1.88	17.50±2.24
Pre-pubertal		8.44±2.80	17.06±2.95

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ANALYSIS OF USA SWIMMING'S ALL-TIME TOP 100 TIMES.

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INTRODUCTION
There is a paucity of studies on effects of early high-level performances on athletes' progression later in their career (1, 2). The purpose of this study was to investigate the performances of elite level swimmers based on the All-Time Top 100 times.

METHODS
We analyzed USA Swimming's All-Time Top 100 age group times by girls and boys. The following swimming events were analyzed: 100, 200, and 500 freestyle; 100 and 200 backstroke; 100 and 200 breaststroke; 100 and 200 butterfly; and the 200 individual medley.

RESULTS
Data presented for age groups includes elite swimmers from Top 100 at age 17-18 in all events (Figure 1). The data shows that the number of participants in all events increases exponentially from age 10-under until the age of 15-16 years. As it was expected, the older the elite swimmer, the more likely he/she will be ranked in the Top 100. About half of the elite swimmers in the Top 100 at age 17-18 were new swimmers who were never ranked in the Top 100 at any age.
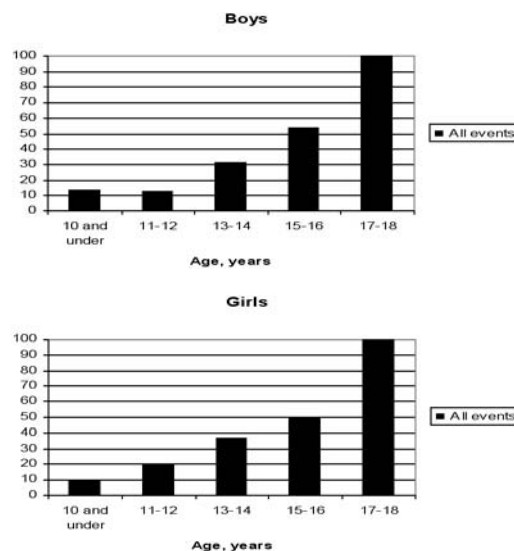
Figure 1. Participation for USA Swimming All-Time Top 100.

DISCUSSION
The analysis shows that most of elite level swimmers were unknown at young ages. Most of the future elite swimmers swim slower than age group champions, especially at ages until 15-16 years. Many participant ranked in the Top 100 as age groupers are not present in the Top 100 in the 17-18 age group. We speculate that the two reasons for losing these young Top 100 ranked champions may be related to their early biological maturation and/or an inappropriate training volume at a young age.

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EVIDENCE OF INSUFFICIENT PULMONARY VENTILATION DURING CRAWL SWIMMING WITH MAXIMAL AND SUPRAMAXIMAL INTENSITIES.

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INTRODUCTION
Respiration during front crawl swimming is limited with swimming technique. In the previous studies found no indication of hypoventilation (1), however only saturation of blood with

oxygen was measured. In another study (2) found increased $PaCO_2$ in swimming with controlled frequency breathing from 2 to 8 strokes.

The aim of the research was to establish whether limited pulmonary ventilation due to biomechanical characteristics of front crawl swimming causes insufficient elimination of CO_2 from the lungs during breathing, which induce hypercapnia.

METHODS

Twelve male swimmers (23.6 ± 3 y) performed 4 swims on 200 m crawl at intensities from 80%, 90%, 100% to 110% on separate days with a swimming snorkel. All swimmers first performed maximal 200 m crawl swim. At 110% swimmers performed swimming to exhaustion. Respiratory parameters (V_E, Vco_2, Vo_2) and some parameters in the blood (pH, [LA^-], Pco_2, Po_2) were measured. Blood samples were taken at rest and in the 1st, 3rd and 5th minute after swimming. Individual one-way ANOVAs were employed to test for any significant differences.

RESULTS

Maximal V_E increased at intensities ranging from 80 % (78.2±13.5 l x min^{-1}) to 100 % (117.4±18 l x min^{-1}), but at 110 % intensity it was similar to the values at 100 % intensity. Something similar happened with Vo_2 (80 % = 2.65±0.5 l x min^{-1}, 100 % = 2.76±0.6 l x min^{-1}) and Vco_2 (80 % = 3.17±0,4 l x min^{-1}, 100 % = 4.44±0.6 l x min^{-1}). Excess Vco_2 after exercise increased most notably from 90 % (1.69±0.7 l) to 100 % (2.72±0.7 l) intensity; at 110 % intensity it was similar to 100 % intensity. The most notable change of pH was from 90 % (7.30±0.03) to 100 % intensity (7.16±0.06). Between 100 % and 110 % intensity there were no changes. There were no differences between the values of Pco_2 and Po_2 measured when resting and those measured during the 1st minute after exercise.

DISCUSSION

In our research we were not able to demonstrate that limited V_E during exercise in swimming is a limiting factor; however, we were able to demonstrate that it does occur and that limited V_E is a possible influence on increased acidosis during maximal and supramaximal swimming. We found notable excess Vco_2 after exercise at these intensities. We can also not conclude that hypercapnia was caused because values of Pco_2 were similar to those during rest; however, it has to be considered that these values were obtained with significantly increased V_E.

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ESTIMATION OF THRUSTS GENERATED BY EACH BODY PART DURING UNDERWATER DOLPHIN KICK USING "SWUM".

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INTRODUCTION

It is important to understand the dynamics of the whole human body during swimming for the evaluation of the swimming motion. However, the measurements of the fluid forces of a self propelled human body are extremely difficult. The purpose of this study is calculation of the thrusts generated by each body part during swimming using SWimming hUman Model "SWUM" (Nakashima, 2003). In the SWUM, the dynamics of the whole human body can be taken into account. In this study, underwater dolphin kick was taken because of simple swimming motion.

METHODS

In the SWUM, the whole body is represented as the series of elliptic cylinders whose radius can vary along the axial direction. Four kinds of fluid forces acting on the elliptic cylinders were computed from the shape and the density of the elliptic cylinders and the relative body motion for one cycle.
The input data for the SWUM were measured in one well-trained male swimmer. The shape and the density of the elliptic cylinders were measured in the subject's body shape. The relative body motion (joint motion) for one cycle was measured in the underwater dolphin kick by the three-dimensional DLT method.
Using the measured input data, the change patterns in the swimming velocity for one cycle were simulated by the SWUM, and compared with the measured values by the motion analysis. Three fluid coefficients in the SWUM to calculate the fluid forces were optimized to fill those differences between the simulated and the measured values. After optimization, the computed fluid forces acting on the human body were analysed.

RESULTS & DISCUSSION

The dynamics of the underwater dolphin kick were almost recreated on the SWUM after optimization of the coefficients (Fig.1). Not only kick motion of lower limbs but also undulation of trunk and head contributed to the thrust (Fig.2).
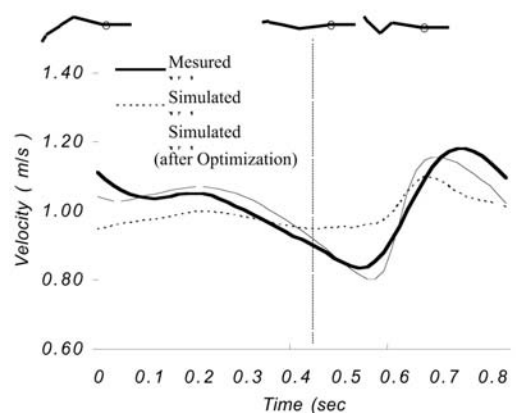
Fig. 1. Change patterns in swimming velocity for one cycle.
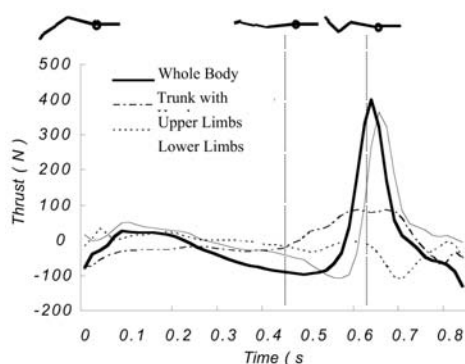
Fig. 2. Contribution of each body part to thrust for one cycle.

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WHAT ARE THE DIFFERENCES BETWEEN GRAB AND TRACK START?

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INTRODUCTION
Numerous studies compared between grab and track start. Take-off velocity of grab start was faster than that of track start, whereas block time of track start was shorter than that of grab start. The differences for kinematical characteristics between both techniques have not been clarified. The aim of present study was to explain the difference between grab and track start using a pendulum model.

METHODS
12 elite competitive swimmers were divided into 2 groups according their type of starting technique (grab or track start). Starting trials were recorded from a sagittal view by high speed camera at 125 fps. The 2D-DLT method was used for calculating kinematic variables (V_t: take-off velocity, ϕ: take-off angle, flight distance, block time). The starting movement was modeled with the pendulum model, and the take-off velocity was resolved to the rotational component (Vr_t) and extensional component (Ve_t). This model was shown in Fig.1.
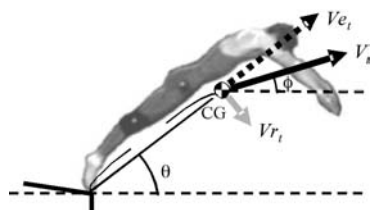
Fig.1 The pendulum model. The start movement was modeled as a movement composed of the rotation of segment l around the front edge on the starting block (Vrt : rotational component) and expansion-contraction of segment l (Vet: extensional component). θ represents the body angle.

RESULTS
Kinematic variables were shown in Table 1. Block time was significantly shorter in track start. Vr_t was significantly faster in track start and Ve_t was significantly faster in grab start.

Table 1 Comparisons of kinematic variables between grab and track start.

		Grab start (n=6) Mean	±SD	Track start (n=6) Mean	±SD	
Block time	sec	0.78	0.03	0.71	0.05	*
V_t (Take-off velocity Aj)	m/s	4.38	0.13	4.26	0.11	
Vr_t (Rotational component at the take-off)	m/s	1.99	0.11	2.56	0.05	**
Ve_t (Extensional component at the take-off)	m/s	3.91	0.12	3.42	0.12	**
Flight distance	m	3.25	0.20	3.15	0.10	
ϕ (Take-off angle)	deg	-1.6	4.1	-3.4	1.6	

*: Significant difference between grab start and track start. (P <0.05)
**: Significant difference between grab start and track start. (P <0.01)

DISCUSSION
With the track start, swimmer's feet placements were opened back and forth. Increment of Vr_t was caused by its feet placements in track start. As for velocity change of center of gravity to the take-off, Ve_t was added to Vr_t. It was suggested that the block time shortened because track start was faster than grab start for Vr_t.

KINETIC RESPONSE OF SALIVARY IGA TO SEVERAL EXERCISE PROTOCOLS PERFORMED BY WELL TRAINED SWIMMERS.

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INTRODUCTION
The relationship between training load and the mucosal immune responses has been the focus of some research (1). Intense training and the psychological stress associated with competition seems to lower the levels of salivary IgA (sIgA) in athletes. sIgA antibodies protect against infections and play a significant anti viral role at the mucosal surface. IgA deficient persons are prone to recurrent infections, namely of the upper respiratory and gastrointestinal tract. The purpose of this study was to monitor the salivary IgA response to aerobic and anaerobic land tests and to two aerobic swimming tasks, using several time points in order to study the time effects of the exercise loads in the mucosal immunity of the athletes.

METHODS
Twelve male swimmers of Portuguese national level (17.03±0.89 years old, height 177.10±7.16cm, weight 66.45±7.16Kg, 7.33±0.88 years of training), participated in the study. During 10 days they accomplished four different protocols: two swim aerobic tasks – a 20 min continuous swim and an intermittent 5 x 400 meters with 45" rest; and two land protocols- the Luc Léger running test aiming to estimate the VO_2 max, and the Wingate Anaerobic Test used to determine the maximal anaerobic power. The schedule used alternated land and water protocols, with at least 48h between testing

sessions. All sessions took place at the same hour of the day (7.00pm). Time points for collection of saliva samples for the determination of IgA concentration and secretion rate were: immediately before de exercise; 15', 1,5hours and 2,5hours after; in the next morning at wakeup; and 24 hours after the test. The same schedule of collection was used on the nearest weekend free from either training workouts or competitions, in order to assess the sIgA response on a resting day.

RESULTS
Considering that no significant differences at pre-test salivary IgA values were found, this parameter shows an apparent circadian pattern, reaching the highest values the following morning and at recovery to pre-test values in the afternoon (24h later). On the resting day, the variation of sIgA was quite smooth compared to exercising days. The acute response of sIgA to swimming protocols shows a particular decrease at 1,5h after exercise and a slight recovery 2,5h after. The same occurs at the same time points following the Wingate test. However, the sIgA values after the maximal Luc Léger running test, were different with a significant decrease 2,5h after exercise, probably related with the extreme fatigue associated with this test. The sIgA concentrations and secretion rates showed identical patterns.

DISCUSSION
The relevance of this study resides on being able to identify the time point at which immune depression may occur in response to exercise tests or training sessions. Our results show that a 24h rest is sufficient to normalize de sIgA values.

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INTRACYCLE SPEED AND COORDINATION VS FATIGUE IN SWIMMING.

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INTRODUCTION
The intracycle speed and coordination analysis contributes to obtain better information about the relevance of these in swimming (1). (2) define 4 phases for the study of the intracycle speed in crawl swimmers. As far as the assessment of the coordination is concerned, (3) state a crawl intracyle coordination index (IC in the style). The aim of this study is connecting the intracycle speed with the swim coordination in crawl style at maximum effort with and without muscular fatigue.

METHOD
Sample: 17 national level swimmers aged 14 to 16.10 were male swimmers and 7 female. Material: 1 speedmetre JLML from MV- 30m to 1000Hz. A subaquatic camera registering at a frequence of 50 Hz was used. Two series (A and B) swimming at maximum speed. Series A, 25 metres at maximum speed resulted in *without fatigue*. Series B, 25 metres after 75 metres at maximum speed resulted in *with fatigue*. Dependent vari-

ables: average intracycle speed (S), average speed phase 1 (Sph1), average speed phase 2 (Sph2), average speed phase 3 (Sph3), average speed phase 4 (Sph4) in m/s and the IC. Method: descriptive study (t event for related samples) and correlational study (Pearson): SPSS 11.5 for windows.

RESULTS
Sph1, Sph2, Sph3 and Sph4 show significant differences (p<0,01) when comparing A with B in male swimmers (in A 1,68; 1,71; 1,65; 1,74 m/s and in B 1,40; 1,49; 1,43; 1,38 m/s) and female swimmers (in A 1,42; 1,55; 1,41; 1,52 m/s and in B 1,17; 1,26; 1,18; 1,24 m/s). However, IC does not show any difference either with male swimmers (4,84% in A and 5,47% in B) or female swimmers (6,34% in A and 8,44% in B). In A and B, S has a high and positive correlation (r>0,8; p<0,01) with Sph1 and Sph3 in both sexes. In B, Sph2 for the male swimmers (r=0,8; p<0,01) and Sph4 for the female swimmers (r=0,9; p<0,01) obtain a positive correlation. In B, IC shows a high and positive correlation (r=0,9; p<0,01)) in female swimmers with Sph4.

DISCUSSION
In A, Sph1 and Sph3 seem to be good performance indicators. In B, Sph1, Sph2 and Sph3 for the male swimmers and Sph1, Sph3 and Sph4 for the female swimmers are the best performance indicators. Concerning female swimmers, a high IC in B is related to a better performance in Sph4. In conclusion, the overall analysis of the IC and the Sph1, Sph2, Sph3 and Sph4, can conclude significant information on the type of coordination according to the muscular fatigue.

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CONSEQUENCES OF UNSTEADY FLOW EFFECTS FOR FUNCTIONAL ATTRIBUTION OF SWIMMING STROKES.

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INTRODUCTION
Swimming strokes are means to propel the body to the desired direction. Different modes of parts of action, e.g. closed or spread fingers at the start of underwater action, require an answer to what the function of a mode is? In swimming, the functional attribution of modes of actions is closely related to the reasoning concerning flow conditions. Here flow is characterised by a mixture of steady and unsteady effects (1). By reciprocal interaction of body motion and motion of water momentum is simultaneously created and transferred while

time solving the problem to produce more thrusting effects than braking ones. The purpose is to direct attention to the relation of unsteady approach and functional attribution of strokes.

METHODS

By using flow-visualisation techniques (in a fixed reference system) it was demonstrated that in unsteady flow situation propulsion is produced more effectively by vortex-induced momentum transfer using PIV-Method (2). Forms of vortex, which differ in front– or back driven locomotion are known as a very good means "for carrying as much momentum as possible in relation to their energy" (3). In front-driven locomotion the momentum-transfer is related to effects from bound vortex (rotating water), shed vortex and the interaction between bound and shed vortex, called jet-flow; which is changing pressure in time and which does not exist in stationary flow. Based on this, the functional attribution of actions are re-checked placing emphasis on the goal "Which action supports the organisation of vortex-forms?

CONSEQUENCES

In any of the four swimming strokes appropriate flow-forms are created and organised by similar actions of the hand/arm, these mutual goals and same actions are:
— Goal: creating flow at the hand(s) at the beginning of the arm cycle by: fully stretched arm (elevated elbow position), slightly spread fingers, abducted thumb, shrugging shoulder(s).
— Goal: creating long path of action by: sweeping outwards with stretched arm (combined with upward sweep), slightly spread fingers.
— Goal: creating jet-flow by: transition action of the hand: supination in butterfly and breaststroke, followed by inward sweep of hands and/or pronation in butterfly, back- and crawl stroke, followed by slicing hands with extending arms.
The rotation around body axes are modulating hand relative velocity and thus influencing momentum generation. While interacting with water mass hand/arms transfer momentum to the centre of body mass (propelling the body) as follows: a low pressure in the back of the hand refrains the hand from being moved *back*wards - the body is moved forward instead (the trunk/arm muscles mediates between the effects and the body centre of mass).

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ARE CHAMPIONS THAT SPECIAL? – PSYCHO-SOCIAL COMPARISONS WITH OTHER FINALISTS.

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INTRODUCTION

Anthropometric, physiological, and biomechanical distinctions between champions and those who do not quite reach the top of the podium are well researched in swimming science. However, divergences in psycho-social characteristics are less well mapped out in spite of the possibility that performance-enhancing interventions in this arena may be more productive in terms of time/energy, cost/benefit analyses.

METHODS

The present study applied the Rushall[1] Psychological Inventories for Competitive Swimmers (PICS) to 18 Norwegian winners of National Senior Swimming Championships who had represented Norway in international competition (9 women and 9 men), and to 19 swimmers (8 women and 11 men) who in their careers qualified for finals but did not achieve victory. The Rushall[2] methodology from the construction of the Champion Characteristics Checklist (based on responses of champion athletes to a series of specific sport inventories) was employed whereby items answered in a like manner by 75% or more of the swimmer samples were judged as indicating commonality. The items resulting from this procedure were then assessed for clustering tendencies.

RESULTS

Seven clusters emerged from the examination of the responses to the 242 PICS items: General Features, Relationship with Coach, Relationship with Swimmers, Training, Pre-Competition, Competition, and Motivational Features. Items are listed as: specific to champions, specific to other finalists, and common to both.

DISCUSSION

Developmental implications are discussed for both swimmer and coach, particularly in terms of the differences between champions and finalists. The primary utility of this chart of characteristics is to augment the recognition of the psycho-social elements in the aquatic performance equation, based on the modelling impact of champions. As an investigative tool for swimmer and coach development, it lends itself well to longitudinal application.

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THE ASSESSMENT OF SPECIFIC STRENGTH IN WELL-TRAINED MALE ATHLETES DURING TETHERED SWIMMING IN THE SWIMMING FLUME.

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INTRODUCTION

Eighteen well-trained male swimmers were tested during teth-

ered swimming in swimming flume at flow velocities 0, 0.6 m·s⁻¹, 0.8 m·s⁻¹, 1.0 m·s⁻¹, 1.2 m·s⁻¹, 1.4 m·s⁻¹, 1.5 m·s⁻¹, 1.6 m·s⁻¹ and 1.7 m·s⁻¹ and in some strength tests on land. The questions to answer were: how does the value of pulling force (PF) change with a change of the flow velocity during tethered swimming in the flume and how closely relates that pulling force to competitive results in swimming in comparison to other specific and non-specific strength tests?

METHODS
The study was performed in the swimming flume of the Moscow Olympic Centre of Aquatic Sports. The subject was connected to the measuring force unit by a rubber cord used in order to smooth fluctuations of the PF caused by fluctuations of intra-cyclic swimming speed [1]. The swimmer was instructed to exert maximal effort for 5-6 seconds after the cord will be stretched. The highly sensitive mechanical gauge registered the peak force. Measurement started with zero velocity. The same procedure was followed for every chosen flow velocity with rest interval 1.5 min. All subjects performed flume test after standard 800 m warm up in a pool. The front crawl was used for all testing procedures in the water. We also measured maximal pulling force in bench test and working capability in 30-sec double arm pulling test with standard resistance 332.5 N.

RESULTS AND DISCUSSION
In all subjects the value of PF demonstrated a decrease with an increase of water flow velocity in the flume. The relationship between PF and flow velocity (V) may be described by the linear regression equation:

$$PF_V = -8.502V + 20.052 \ (R=0.924; R^2=0.852; p<0.01)$$

The PF measured during swimming in the flume at V=0.6-1.7 m·s⁻¹ correlates to CSS in 100 m freestyle closer than PF at V=0 or strength abilities tested in land exercises. This enables to utilize the PF in the flume for prediction of the performance and assessment of swimming abilities of individuals. Since the correlation between PF and CSS increases with an increase of V, it follows that the values of PF at flow velocities 1.4-1.7 m·s⁻¹ may be used as reliable criteria of the specific swimming strength - the ability to create an effective propulsive force during swimming. It was also found that the values of the PF change in accordance with predominant character of training at different stages of a macro-cycle. They fall during periods of extensive aerobic training and grow up again during race-specific training.

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INSULATION AND BODY TEMPERATURE CHANGES BY WEARING A THERMAL SWIMSUIT DURING LOW TO MODERATE INTENSITY WATER EXERCISE.

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INTRODUCTION
Water exercise in cool water environment lowers body temperature in cool water environment because of the higher thermal conductance of water. It is important to prevent the body heat loss during exercise in cool water. The purpose of this study was to evaluate the effects of a thermal swimsuit (TSS), which is a partially-coverage wetsuit, on body temperatures and thermal insulation during low and moderate intensity water exercise.

METHODS
Nine healthy male subjects participated in this study. They immersed in water (23°C) up to the chest level, and pedaled on an underwater ergometer for 30 min. Each subject underwent the protocol with TSS and normal swimsuit (NSS) at two submaximal (low and moderate) exercise intensities. Esophagus temperature (T_{es}), skin temperatures (T_{sk}) and oxygen uptake (V_{O2}) were measured. Total insulation (I_{total}) and tissue insulation (I_{tissue}) were estimated by dividing the difference between T_{es} and T_w or T_{es} and T_{sk} with heat loss from the skin (H_s). Suit insulation (I_{suit}) was calculated by subtracting I_{tissue} from I_{total}. Cardiac output (Q_c) and blood pressure were measured to calculate total peripheral resistance.

RESULTS
During low intensity exercise (V_{O2}=11-12 ml/min/kg) T_{es} were maintained in TSS. On the other hand, T_{es} decreased in NSS. Moderate exercise (V_{O2}=20-22 ml/min/kg) increased T_{es} with both swimsuits. I_{tissue} during moderate exercise was lower than that of low intensity exercise with both swimsuits. TSS decreased I_{tissue} compared to NSS during moderate exercise. I_{suit}/I_{total} and skin fold thickness (SFT) showed a negative correlation.

DISCUSSION
The lower I_{tissue} during moderate exercise were caused by the higher Q_c due to increased exercise intensity. However, the increased metabolic heat production during moderate exercise and added I_{suit} could offset the decreased I_{tissue} and decrement of T_{es}. Peripheral blood flow could be increased due to reduced vasoconstriction so that the I_{tissue} was decreased during moderate exercise with TSS. The negative correlation between I_{suit}/I_{total} and SFT indicated that the lower fat subjects could have more benefit of TSS to I_{total}. It was suggested that TSS in cool water (23°C) was especially useful for low fat subjects.

GENESIS OF LATERAL DIFFERENCES OF SWIMMERS.

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INTRODUCTION
In swimming evenly distributed movements are performed by the limbs. Nevertheless differences in the motion of the left and right

body side are to be observed frequently. These effects are strongly related with breathing and lead to necessary correction movements, without a propulsion effect (1). A goal of the investigation was to quantify the energetic causes of these side differences.

METHODS

For the evaluation of the side differences we analyzed specific power tests for upper limbs of 1 or 2 min duration (freestyle/butterfly stroke) on a rope pulling ergometer. 82 tests (43 male and 39 female subjects) were included into our investigation. In addition 22 of the freestyle swimmers also participated in a three-dimensional trunk force test (Pegasus, BfMC Leipzig).

RESULTS

We found significant side differences in the dynamic parameters power, strength and maximum speed of both strokes. While the side differences in the butterfly stroke were generated by differing stroke length, different stroke duration was the reason for the differences in freestyle stroke. The results of a trunk force test with the freestyle swimmers proved a significant correlation between the results on the rope pulling ergometer and the trunk strength in the frontal direction.
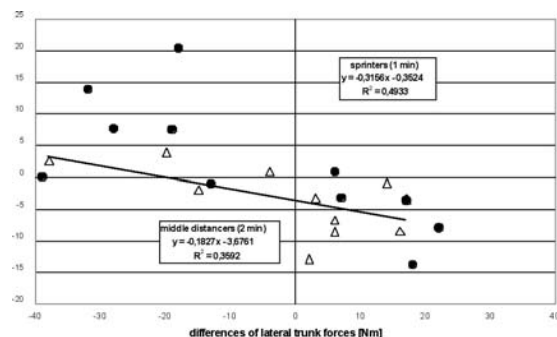
Fig.: Relation between power of upper extremities and trunk.

DISCUSSION

The results show the relation of the higher dynamic parameters in the cyclic movement with a better stabilization of the trunk on the contra lateral side. This result stresses the importance of trunk muscles for the transmission of the generated momentums from the limbs to the overall system especially for freestyle sprinters. The conclusions for training practice of these results are a high-quality trunk muscle training as well as the control of an effective breathing technology in swimming.

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MOTION ANALYSIS OF FRONT CRAWL SWIMMER'S HANDS AND THE VISUALIZATION OF FLOW FIELDS USING PIV.

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INTRODUCTION

Schleihauf[1] evaluated a force exerted on a hand in swimming using a quasi-steady analysis. However, swimmer's motion cannot be evaluated quantitatively by the quasi-steady analysis, because of the extremely unsteady motion. In general, unsteady lift force is greater than the steady one. Therefore top swimmers are expected to swim by using effectively unsteady flow force. A motion analysis can evaluate the unsteady movement of swimmers qualitatively and quantitatively on digitizing the movement of the swimmer. In addition, PIV (Particle Image Velocimetry)[2] can visualize the unsteady flow field around a swimmer. With this method, the vortex motion around a hand can be evaluated quantitatively. Our study is to clarify the relationship between the vortex behavior and the motion of a hand in crawl swimming by using the motion analysis combined with PIV.

METHODS

We used the flume installed in the Univ. of Tsukuba whose dimensions of the test section are 4.6m in length, 2.0m in width, and 1.5m in depth. The flume has the ability of 2.5m/s at the maximum velocity. We paid our attention to the phase turned from In-Sweep to Out-Sweep. Subjects are a male with no competitive career (subject 1) and a female Olympic swimmer (subject 2). Flow velocities are set 0.8m/s for subject 1 and 1.5m/s for subject 2. The motion analysis determines the geometry of a hand in space by the movement viewed from the bottom and the side of the flume with two synchronous high-speed cameras. Several points on the hand are digitized using video motion analysis system Frame-DIAS. Trajectory and palm inclination angle (θ) are derived from the coordinates. The palm inclination angle is defined as the angle between the palm and the flow direction when the hand is seen from underside of the flume. This system can get 250 planes per second. On the other hand, PIV system measures flow velocity from the movement of tracer particles irradiated by YAG laser sheet. The interval of the laser pulse is controlled using a pulse generator. Our PIV system can get 15 planes per second. The distribution of the velocity and vorticity is derived from the particle image data.

RESULTS & DISCUSSION

We compared both subjects from the unsteady point of view. The trajectory of the hand of the subject 2 was in somewhat s-shaped motion while that of the subject 1 was in the straight line. From the palm inclination angles of subjects we confirmed that the hand of the subject 2 reverses the orientation of circulation in the phase turned from In-Sweep to Out-Sweep. From these observations it is supposed that the subject 1 does not generate a pair of vortices. PIV measurement confirmed that the vortex pair does not exist for the subject 1 but exists for the subject 2. We concluded that the subject 2 swam by using effectively unsteady flow force by changing the palm inclination angles.
From the combined way using the motion analysis and PIV method, it was found that the hand motion in swimming was closely related to the vortex behavior.

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MUSCLE ACTIVATION IN WATER EXERCISE: AGONIST AND ANTAGONIST ACTION WITH OR WITHOUT RESISTIVE EQUIPMENT.

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INTRODUCTION
For a better exercise prescription in water it is necessary to know about the muscle action. Some authors believe that, in water, there's only concentric action. The purpose of this study is to analyse the electromyography of rectus (RF) and biceps femoris (BF) like agonist and antagonist in water with or without resistive equipment (RE).

METHODS
Eleven women with mean values of age $21,38 \pm 1,3$ years old, weight of $55,91 \pm 6,71$kg and height of $161,69 \pm 6,21$cm. In order to collect data properly it was used portable elecromiography and oclusive tapes in surface electrodes. It was done a maximal voluntary contraction (MVC) of RF and BF for normalization. After that, they did the exercise (flexion and extension of the hip) in 40bpm and maximal velocity, with and without RE (Aquafins) on the ankle. The RMS values of EMG was analysed and normalized by MVC (%MVC).

RESULTS
The mean values and standard deviation of every situation are present in Table 1. Observing the values, note the pattern of high %MVC with high velocity. The %MVC of RF as agonist and BF as antagonist in both cadence with and without equipment, it was observed that BF as antagonist didn't show a high activation, probably not representing the activity of extension muscles. When the BF was observed as agonist alongside the RF as antagonist, it was verificated that there were not many differences denoting a high activity of the RF as antagonist.

Cadence	muscles	Without equipment		With equipment	
		Agonist	Antagonist	Agonist	Antagonist
40bpm	RF	$15,46 \pm 4,11$	$14,35 \pm 8,7$	$20,97 \pm 5,16$	$18,35 \pm 7,5$
	BF	$11,90 \pm 7,94$	$3,7 \pm 2,43$	$16,0 \pm 7,6$	$8,46 \pm 5,39$
Maxim	RF	$65,99 \pm 20,47$	$36,31 \pm 17,6$	$72,7 \pm 28,48$	$35,31 \pm 17,09$
	BF	$58,58 \pm 22,42$	$25,6 \pm 16,6$	$69,62 \pm 20,4$	$25,45 \pm 10,64$

Table 1. Mean value (%MVC) and standard deviation of electromyography of RF and BF in agonist phase and antagonist with and without equipment.

DISCUSSION
To realize the flexion extension movement of the hip in water in slow and high velocity it was observed that there is an antagonist activity (1). These results show that the continuous movement in water creates excentric activities, different of other concepts. This pattern was used because of turbulence water flow due to continuous movement and the necessity directions change of the movement.

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THE RELIABILITY OF VO$_2$-MEASUREMENTS IN SWIMMING: A PILOT STUDY.

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INTRODUCTION
The reliability of a portable mixing chamber respiratory analyzer used for swimming has to our knowledge never before been investigated. This study was carried out to test the feasibility of valve and mixing chamber analyzer and to investigate the reliability of the equipment for future research.

METHODS
A test-retest design was conducted, including 4 subjects acting as their own controls. Oxygen uptake (VO_2) was measured with the use of a respiratory valve and a mixing chamber analyzer (Cortex MetaMax II). Workload was controlled by moving pacerlights below the swimmer. Swimming economy (C_S) protocol was similar to the one used by Kjendlie et al. (2004)[1] – using four workloads of increasing intensity. Subsequently VO_{2peak} was measured by a 5-7 min workload with increasing velocity to exhaustion. Wilcoxon matched-pairs signed-ranks test was used to compare test and retest.

RESULTS
No test – retest differences were found at the $p \leq 0.05$ level. A summary of results is displayed in table 1.

	v (m·s^{-1})	Test	Retest	CV (%)
VO$_2$ (l·min^{-1})	0.6	1.07 ± 0.37	1.12 ± 0.23	13,5
	0.8	1.68 ± 0.52	1.75 ± 0.40	10,9
	1.0	2.28 ± 0.66	2.55 ± 0.68	13,7
	Peak	3.28 ± 0.72	3.11 ± 0.46	9,7
vVO$_{2peak}$ (m · s^{-1})	Peak	1.23 ± 0.20	1.20 ± 0.16	4,7

Table 1: Mean $\pm$ SD oxygen cost of submaximal swimming, VO_{2peak} and velocity of VO_{2peak} (vVO_{2peak}) (v is velocity, CV is coefficient of variance).

DISCUSSION
No statistical differences were found, which indicate that the system is applicable for reliably measuring respiratory parameters in swimming. Established protocols for testing both C_S and VO_{2peak} were used. Valve with hose and analyzer have previously been validated, but never together. The findings are, however, weighed down by bias, relatively high coefficient of variances and few participants. As only one of the subjects had used the valve before, they were allowed a short habituation. It is rational to expect no statistical differences also for future investigations and larger samples, as this and former investigations indicate reliability.

CONCLUSION

In light of the bias and few participants, it has to be concluded that further investigations are needed to examine the reliability of the test system for swimming. Prior to testing, personnel and subjects should be properly acquainted with equipment and procedure.

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TIME LIMIT AT THE MINIMUM VELOCITY OF VO$_2$MAX AND INTRA-CYCLIC VARIATION OF THE VELOCITY OF THE CENTRE OF MASS.

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INTRODUCTION

The purpose of this study was to analyse the relationship between time limit at the minimum velocity that elicits maximal oxygen consumption (TLim-v$\dot{V}$O$_{2max}$) and intracyclic variations of the velocity of the centre of mass (dv) in the four competitive swimming techniques.

METHODS

Twelve Portuguese elite male swimmers (19.8 ± 3.5 y, 70.1 ± 8.0 kg and 178.3 ± 6.5 cm) swam their own best technique until exhaustion at their previously determined v$\dot{V}$O$_{2max}$ to assess TLim-vO$_{2max}$. TLim was considered to be the total swimming duration at v$\dot{V}$O$_{2max}$ (Fernandes et al., 2003). The test was videotaped in a sagittal plan, with two cameras, that provided, after mixing and editing, a dual-media image of the swimmer. The APAS software (Ariel Dynamics Inc, USA) was used to evaluate the horizontal velocity of the centre of mass (vcm) and its intra-cyclic variation (dv) per swimming technique. A complete cycle of all techniques was analyzed, in the first and last laps of the TLim test, as well as in all the intermediate 100m laps.

RESULTS

No statistical significant correlations were obtained between TLim-v$\dot{V}$O$_{2max}$ and dv. Values of the r correlation coefficient for the different techniques were as follows: Butterfly (r = -0.30, p = 0.81); Backstroke (r = 0.91, p = 0.27); Breaststroke (r = -0.95, p = 0.21); Front Crawl (r = 0.20, p = 0.88). The simultaneous swimming techniques were characterized by inverse relationships between both variables, while the alternated ones showed a direct one.
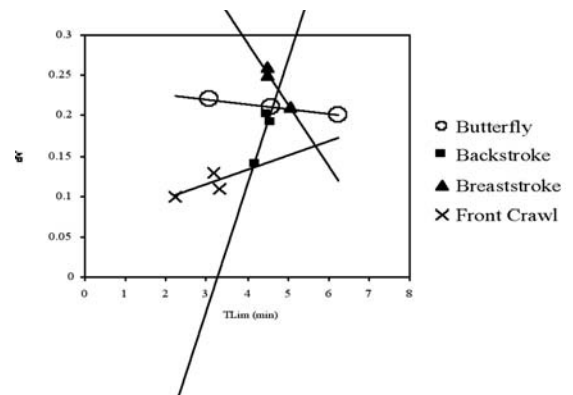
Figure 1. Relation between TLim and dV.

DISCUSSION

The strokes that present higher intra-cyclic variations also presented larger values of TLim. The front crawl stroke showed the lowest dv values and the breaststroke seems to be the one that imposes the largest dv. Intra-cyclic speed fluctuations (dv) decreased during the TLim test in the four strokes studied, probably due to fatigue.

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VALIDITY AND RELIABILITY OF A COMMONLY USED WATER POLO TEST: A PILOT STUDY.

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INTRODUCTION

A number of water polo tests, relating to swimming (2) and sport-specific demands of the game, exist. Crossbar jumps (for 30 or 60 seconds) have traditionally been used for assessment of anaerobic leg power. This study aimed to examine the validity and reliability of this commonly used water polo test.

METHODS

Thirteen elite, female water polo players (mean±s: age 22 ± 4.4 years, height 168.7 ± 7.9 cm, body mass 65.9 ± 6.1 kg) performed the 30 seconds crossbar jumps test (CJ) on two separate occasions, and the Wingate anaerobic test (WAnT) to determine fatigue index (FI), mean power (mP) and peak power (pP). All tests took place with a minimum of 24 hours intervening.
Pearson's correlation coefficient (r) was used to examine for relationships between both CJ and FI, mP and pP. Intraclass correlation coefficient (ICC) and the 95% limits of agreement (LoA) were used to examine for test-retest reliability and the degree of agreement between the two CJ tests, respectively.

Significance was set at $P < 0.05$.

RESULTS

Normality of data was examined using the Kolmogorov-Smirnov test and subsequently confirmed. No correlation was found between CJ (CJ1: 21.4 ± 2.6 jumps; CJ2: 23.3 ± 2.6 jumps) and the variables examined from the WAnT (FI: $48.3 \pm 7.1\%$; mP: 459.1 ± 45.3 W; pP: 667.8 ± 93.7 W). The two CJ were significantly correlated with each other ($P < 0.05$; ICC = 0.99). The LoA for the CJ scores was -1.5 ± 2.35 jumps, producing a range of $+0.85$ to -2.85 jumps.

DISCUSSION

The results indicated that the CJ is not a valid measure of anaerobic leg power. This can be attributed to a) the lack of a fixed resistance for the generated upward impulse, and b) the different movement mechanics required (3) compared to the WAnT. Additionally, although CJ is reliable, the LoA in which results from a re-test should lie in (1) are wide, making meaningful interpretation of results difficult. Therefore, coaches must be cautious when utilising the CJ for evaluation and monitoring purposes. Future studies should consider a) a larger sample, b) investigating other muscular performance parameters, and c) conducting the CJ for 60 seconds.

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RELATIONSHIPS BETWEEN ENERGY COST, SWIMMING VELOCITY AND SPEED FLUCTUATION IN ELITE BUTTERFLIERS.

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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 elite butterfliers.

METHODS

Four elite butterfly swimmers were submitted to an incremental set of nx200-m swims ($n \le 8$). 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 individual correlations between $\dot{E}_{tot}$ and v ranged from $r=0.95$ ($p=0.05$) to $r=0.90$ ($p<0.01$). For pooled data the relationship was $r=0.70$ ($p<0.01$). The individual correlations between EC and dv controlling the effect of v ranged from $r=0.99$ ($p=0.06$) to $r=-0.81$ ($p=0.09$). For pooled data, the relationship between EC and dv was $r=0.55$ ($p=0.01$). The individual correlations between EC and v controlling the effect of dv ranged from $r=0.92$ ($p=0.02$) to $r=-0.84$ ($p=0.36$). When the pooled data was plotted it was observed a relationship of $r=0.51$ ($p=0.02$). The individual correlations between dv and v ranged from $r=0.99$ ($p=0.04$) to $r=-0.83$ ($p=0.16$). For pooled data, the relationship between dv and v was $r=0.47$ ($p=0.05$). Therefore, when analysed on individual bases, it is possible to observe different profiles between EC and dv, as well as, between EC and v. However, for pooled sample, it seems that increases of EC were related to increases of dv and v.

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SPEED AND PHYSIOLOGIC REPLY IN SWIMMING, CYCLING AND RUNNING.

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INTRODUCTION
The anaerobic threshold varies in the three triathlon disciplines (1, 2). Connected with the heart rate (HR) as a variable determining intensity, (3) studied the different replies in each one of the disciplines. (4) suggests the "Borg scale adapted" to determine the "rating of perceived exertion" (RPE)in triathletes. The aim of this study is analising the different behaviour in swimming, cycling and running in triathletes at maximum and submaximum speeds.

METHOD
Sample: 11 triathletes of amateur national level aged 25,6 ± 4,7. Material: Lactate Pro for the lactate determination as well as the Polar pulsemeter S720i for the HR determination. Protocole: 3 events of similar time length: 300 metres in swimming, 3000 in cycling and 1500 in running, at 100% and 90%. Dependent variables have been the average speed in m/sg (S), the RPE, the maximum LA in mM/l (LA) and the HR minute at the end of each intensity. Method: t event for mixed samples with swimming, cycling and running through the statistic pack SPSS v.11,5 for windows.

RESULTS
Swimming at 100%: 12,8 LA; 173,1 HR; 18,1 RPE; cycling at 100%: 14,4 LA; 179,4 HR; 18,2 RPE and running at 100%: 14,2 LA; 186,3 HR; 18,3 RPE show statistically significant differences among the three disciplines (p<0,01) except for RPE in swimming, running and cycling. LA does not show any significant differences. In swimming at 90%: 5,1 LA; 152,6 HR; 13,4 RPE, in cycling at 90%: 5,9 LA; 158,3 HR; 13,5 RPE and in running at 90%: 7,2 LA; 176,5 HR; 14,7 RPE statistically significant differences are shown among the three disciplines (p<0,01) except in swimming and cycling. LA does not show any statistically significant difference in running and cycling, either. The percentage values of all variables in S at 90% in contrast to the obtained values in S at 100% only show significant differences (p<0,01) in swimming (39,9% LA; 87,5% HR; 74,1% RPE) and in running (51,3,% de LA; 95,4% HR; 80,8% REP).

DISCUSSION
The metabolic requirement facing mixed aerobic/anaerobic maximum intensities is less in swimming than in cycling or running. The 90% maximum speed approaches to the anaerobic threshold values in swimming and cycling, being higher than in running. In conclusion, the S percentage does not seem an equivalent indicator for the three disciplines discriminating the load intensity.

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SWIMMING PERFORMANCE IN ELITE MASTER SWIMMERS AND ITS RELATIONSHIP WITH STRENGTH.

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INTRODUCTION
In recent years several studies on Master athletes have been conducted in order to get a better insight into the effect of physical activity on ageing. However, to our knowledge not many studies focused on Master swimmers. Therefore the aim of the present research was to assess the relationship between age, strength and swimming speed in elite master swimmers.

METHODS
78 athletes (34 men, 44 women) aged 40-79 years, participating in the 10th Fina World Master Championships, held in Riccione (Italy) in June 2004, were recruited. Maximal voluntary isometric knee extensors strength (keMVC) and maximal isometric hand grip strength (hgMVC) of dominant side were measured. Performance, expressed as swimming average speed (SAS) in $m*s^{-1}$, was calculated by dividing the race distance by the official final time.

RESULTS
The results of correlation analysis (Pearson) for male (M) and female (F) are shown in Table 1.

Table 1. Simple correlation matrix for male and female master swimmers.

	1) Age		2) SAS ($m*s^{-1}$)		3) keMVC (N)		4) hgMVC (N)	
	M(N 34)	F(N 44)	M(N 34)	F(N 44)	M(N 34)	F(N 44)	M(N 34)	F(N 44)
1) Age	1	1						
2) SAS ($m*s^{-1}$)	-.657**	-.526**	1	1				
3) keMVC (N)	-.602**	-.390**	.584**	.213	1	1		
4) hgMVC (N)	-.682**	-.348**	.453**	.422**	.593**	.363*	1	1

** Correlation is significant at 0.01 level (2-tailed);
* Correlation is significant at 0.05 level (2-tailed).

DISCUSSION
As expected age had a negative and significant correlation (p<0.01) with SAS, keMVC and hgMVC both in males and females. SAS resulted positively related (p<0.01) to hgMVC both in males and females, whilst it was significantly related to keMVC only in males. It is well known that in swimming upper limbs give the most important contribution to forward

propulsion. Although hgMVC does not reflect the whole muscular involvement of the upper limb action, it was found a significant relationship between hand grip and performance in male young swimmers. Lower limbs give a minor contribution to the propulsion, although they are essential in starting and turning phases. However in master swimmers these phases are much less important than in younger elite swimmers. This could be true especially in women because they have less muscle mass and strength compared to men.

ELECTROMYOGRAPHY IN AQUATIC EXERCISE WITH DIFFERENT RESISTENCES AND VELOCITIES.

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INTRODUCTION
Some studies verify the influence of speed and resistive equipment (RE) in producing force in water. The purpose of this study is to compare the electromyography (EMG) activity of rectus (RF) and biceps femoris (BF) during leg's exercise in water with variable velocity and resistance (using or not an usual hydrogimnastic equipment applying in ankle)

METHODS
12 female (23.8±1.30yrs; 161.6±6.7cm; 55.9±6.21kg) participated. They did a maximal voluntary contraction (MVC) of the analyzed muscles and performed 8 repetitions of flexion and extension of leg in 4 cadences determined by metronome (40, 60, 80 bpm) and one in maximal velocity apply and not RE. The exercise was filmed. It was analyzed the RMS value. A Repeated Measure statistics analyses for EMG was performed as well as a T test ($p<0,05$).

RESULTS
For speed analysis the results revealed differences between some cadence in RF and BF (Table 1). The high velocity show the highest values. These are represented by different letters. The results of t-test, comparing the EMG between the situations with equipment versus without equipment, shows differences just for RF in cadences of 40bpm and 80bpm.

Table 1. Mean values, standard deviation (σ) and participants (n) of EMG (%MVC) and angular velocity. Repeated measure test, post hoc LSD and t-test (p) of EMG for RF and BF in 4 velocity with and without equipment ($p<0,05$).

	Without equipment (n=7)				With equipment (n=6)			
	RF		BF		RF		BF	
cadence	EMG mean±σ	AV Mean±σ	EMG mean±σ	AV mean±σ	EMG mean±σ	AV mean±σ	EMG mean±σ	AV mean±σ
40 bpm	15,36±4,42ᵃ	-33,4±6,3	13,47±7,8ᵃ	35,0±4,5	22,09±5,44ᵇ	35,0±4,5	16,48±7,75ᵃ	38,2±5,5
60 bpm	19,78±12,0ᵃᵇ	-49,0±6,7	15,40±8,1ᵃ	51,3±4,1	29,68±3,57ᵇ	51,3±4,1	17,40±5,63ᵃ	50,1±6,6
80 bpm	22,48±8,97ᵇ	-68,0±9,3	21,07±12,5ᵃ	66,3±10,2	42,35±13,87ᵇ	66,3±10,2	34,93±14,27ᵇ	67,0±9,3
Maxim	63,42±20,67ᶜ	-139,9±30,3	72,46±21,3ᵇ	138,0±30,9	75,14±30,39ᶜ	138,0±30,9	78,76±17,14ᶜ	95,6±27,5

DISCUSSION
The muscles using equipment showed higher activation than the ones that didn't use in all cadences for both muscles. These

values are in agreement with other research that observed higher %CVM (1 and 2). This research demonstrated that the equipment doesn't have much influence on the EMG in the lowest cadence. To elicit a high activation, exercises conducted at maximal speed and with resistive equipment are the best choice.

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ACTIVE DRAG AND PHYSICAL CHARACTERISTICS IN AGE GROUP SWIMMERS.

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INTRODUCTION
Active drag (D_a), the force that a swimmer has to surpass in order to maintain his movement through the water, while relying on his capacity to generate propulsion with his body segments, showed a large amplitude of values for swimmers with similar physical characteristics (Kolmogorov & Duplishcheva, 1992), which has been interpreted as a fundamental dependency on technique. The purpose of this study was to identify the influence of body characteristics on D_a in two groups of different performance level in age group male swimmers.

METHODS
Subjects were selected from a pool of 365 age group swimmers tested with the velocity perturbation method (VPM) (Kolmogorov & Duplishcheva, 1992) in front crawl, between 1997 and 2003. The inclusion criterion was to have achieved the same free swimming maximal velocity (V_{max}) in the test. Swimmers were assigned to 2 groups: G1 (N = 17; age: 15.42 ± 0.53 years, height: 178.52 ± 7.42 cm, body mass: 66.82 ± 7.45 kg, best time at 100m front crawl: 57,26 ± 1,67s), with V_{max} = 1.78 m.s⁻¹, and G2 (N = 12; age: 15.29 ± 0.68 years, height: 172.10 ± 3.51 cm, body mass: 64.15 ± 8.74 kg, best time at 100m front crawl: 61,14 ± 1,21s), with V_{max} = 1.66 m.s⁻¹. Active drag (D_a), drag coefficient (C_{Da}) and power output (P_o) determined by the VPM and anthropometric measurements were compared between the groups and relationships to competitive performance, assessed considering the swimmer's best time in the 100 m freestyle (BT_{100mF}) at the moment of the VPM evaluations, verified.

RESULTS
Only BT_{100mF} differed significantly between groups (Mann-Whitney Test). In spite of the rather homogeneous physical

characteristics observed within each group, hydrodynamic variables showed large variation. In G2, D_a was not related to physical caracteristics or performance. In G1, however, D_a showed significant correlations ($p \leq 0.001$) with body mass ($r = 0.859$), height ($r = 0.721$) and body surface ($r = 0.852$).

DISCUSSION
Performance differences between groups of age matched swimmers with identical physical characteristics were not accompanied by differences in hydrodynamic profile. In the more skilled swimmers (G1), contrarily to G2, D_a showed some dependency on physical dimensions, possibly due to a very identical technical level.

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DIFFERENCE BETWEEN GENERAL AND SPECIFIC SWIMMING ABILITIES OF JUNIOR TOP WATER POLO PLAYERS BASED ON THEIR POSITION WITHIN THE TEAM.

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INTRODUCTION
Organisation of the training process is determined by various factors. Tactical, technical and functional demands of each position during game is a very significant factor for planning the training. The basic aim of this paper was to define the differences in basic and specific swimming characteristics of junior water polo players based on their position within the team.

METHODS
The sample of 31 players was divided into three groups: 1. players in wing positions left and right (N = 19); 2. centers (N = 6); 3. backs (N = 6). Variables were the result of the following nine swimming tests: crawl 25m, 50m and 1500m ($25m_{crawl}$, $50m_{crawl}$, $1500m_{crawl}$), 25m crawl with ball ($25m_{crawlB}$), 25m back ($25m_{back}$), specific swimming using legs 25m, legs crawl, breast and mixing ($25m_{legcrawl}$, $25m_{legbre}$, $25m_{mixing}$) and swimming 10x50m crawl ($10x50m_{crawl}$), and three derived variables were: index of specific swimming efficiency (speceffic), index of coodination of crawl technique ($crawl_{armleg}$) and index of specific coordination of leg movement ($legs_{crawlmix}$). The results were subjected to cluster analysis and Student T-test.

RESULTS
Cluster analysis (1) has singled out five variables in which the observed groups differed: 25m back ($25m_{back}$), (F=3.826, p=0.034), specific swimming using legs crawl 25m ($25m_{legcrawl}$), (F = 6.068, p = 0.06), crawl swimming 1500m ($1500m_{crawl}$), (F = 3.737, p = 0.036), 10x50m crawl ($10x50m_{crawl}$), (F = 5.666, p = 0.009) and index of specific

coordination of leg movement ($legs_{crawlmix}$), (F = 3.963, p = 0.031). After Student T-test we found out that between groups 1. and 2. a significant difference has occurred in crawl swimming 1500m ($1500m_{crawl}$), (p = 0.041), between groups 1. and 3. in swimming using legs crawl ($25m_{legcrawl}$), (p = 0.002), crawl swimming 1500m ($1500m_{crawl}$), (p = 0.027), swimming 10x50m crawl ($10x50m_{crawl}$), (p = 0.003) and coordination of crawl technique ($crawl_{armleg}$), (p = 0.004) and difference between groups 2. and 3. in swimming 25m back ($25m_{back}$), (p = 0.025) and specific swimming using legs crawl 25m ($25m_{legcrawl}$), (p = 0.030).

DISCUSSION
Results indicate that there is a difference between the groups. Players in center position, had better aerobic capacity than players in wing positions which is not the characteristic of the teams on high training level. Specific speed was the chatacteristic which was better adopted in backs than in centers, as it was expected. Differences between groups 1. and 3. indicate that aerobic and anaerobic capacities as well as specific speed are dominant characteristics of players in back position, and coordination of crawl swimming is dominant in wing players. Gained results indicate that the level of training of players in various positions is different. Players in wing position are singled out as the least successful, except in one of the performed tests.

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BREASTSTROKE SWIMMING PATTERNS FROM VIDEO SEQUENCES ANALYZES, PRODUCED BY SPECIFIC FIELD FORMATS.

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INTRODUCTION
The objective of the research presented in this paper was to search for particular types of repeated behaviour patterns in breaststroke swimming using specific sequential analysis with SDIS-GSEQ (Backman & Quera, 1996). We developed one instrument to describe swimming movements from video sequences, focused on a qualitative approach. Across the model category system used by Colman et al. (1998) with other observation called field format (Anguera, 1999). Between other characteristics, the field formats produce the configuration and linking codes corresponding to simultaneous or concurrent behaviours, or movement characteristics, which will allow an exhaustive recording of the behaviour flow, and makes subsequent data analysis considerably easier.
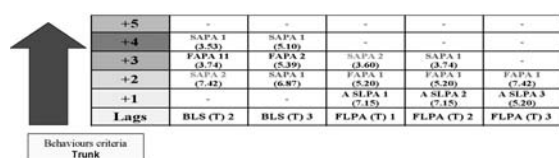
METHODS
Seven swimmers were recorded and analysed. The system analysis produced several stroke cycles to describe each swimmer's particular movements. The video images were captured from side-view by classical underwater criteria and converted

the stroke cycle to a digital format seen with the computer. To test the instrument's reliability we asked experts to describe the technical model of breaststroke. And to test the data's quality the reliability evaluation was made by retest, using Kappa coefficient calculation.

RESULTS

Different phases of application on this instrument and different criteria revealed discriminative power. It is possible to see the particular characteristics of the breaststroke cycle in one champion swimmer.

+5	-	-	-	-	-
+4	SAPA 1 (3.53)	SAPA 1 (5.10)	-	-	-
+3	FAPA 11 (3.74)	FAPA 2 (5.39)	SAPA 2 (3.60)	SAPA 1 (3.74)	-
+2	SAPA 2 (7.42)	SAPA 1 (6.87)	FAPA 1 (5.20)	FAPA 1 (5.20)	FAPA 1 (7.42)
+1	-	-	A SLPA 1 (7.15)	A SLPA 2 (7.15)	A SLPA 3 (5.20)
Lags	BLS (T) 2	BLS (T) 3	FLPA (T) 1	FLPA (T) 2	FLPA (T) 3

Behaviours criteria Trunk

Figure1: Based in lags-logs design, in this case, represents the patterns that were found across the selected behaviour criteria trunk, with different codes composed by the seven field format of the observational system.

DISCUSSION

The results are evaluated in accordance with swimming parameters, analyzing them in a way that ensures identification of the structures of behaviour – via their different relations – essential for the perception of gestures in advanced strokes swimming.

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Colman V, Persyn U. et al. (1998). A comparison of the intra-cyclic variation in breaststroke swimmers with flan undulating styles. Journal of Sports Sciences 16: 653-665.

INTRA-CYCLIC VARIATIONS OF VELOCITY IN THE BREASTSTROKE TECHNIQUE. ANALYSIS DONE THROUGH TWO MONITORING SYSTEMS.

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INTRODUCTION

There is an important controversy in literature about the adequacy of mechanical velocimetry for the assessment of kinematical variables of swimming movements, specially when simultaneous techniques are involved. The main question among the most commonly raised is related to the expected different pathways of the centre of gravity (CG) and an anatomical landmark, for example the hip. The purpose of this study was to compare the v(t) intra-cyclic variation of the CM and of a fixed anatomical point close to the hip, in the swimming technique expected to be the most distinguishable of all: the breaststroke.

METHODS

Ten (7 females and 3 males) trained swimmers were studied. Mean age was 18.3 ± 2.9 yy. After familiarisation, each subject performed a maximal 25 m breaststroke. The intra-cyclic swimming velocity was assessed both from mechanical velocimetry and computerized videogrametry (Ariel Performance Analysis System of the Ariel Dynamic Inc. - APAS). A mechanical speedometer, with a optic reader of revolutions, was used for real time velocimetery (Lima et al., 2006). For videogrametry, dual-media images (Vilas-Boas et al., 1996) were used. They were obtained after mixing and editing those (Panasonic Digital AV Mixer WJ-AVE5) captured from two videotape SVHS cameras (JVC GR-SX1) placed underwater and above surface. From videogrametry we obtained the kinematics of the hip (ViVhip1) and of the CG (ViVCG), and from the speedometer we obtained the kinematics of the attachment point, close to the hip (ViVhip2). Mean ($\pm$sd) and Pearson Correlation Coefficient were computed for statistical analysis.

RESULTS

All the r values obtained were positive and strongly significant: (i) ViVhip1 vs. ViVCG ($r=0.92$, $p<0.01$); (ii) ViVhip2 vs. ViVCG ($r=0.90$, $p<0.01$) and (iii) ViVhip1 vs. ViVhip2 ($r=0.96$, $p<0.01$).

DISCUSSION

It was concluded that speedometer can be used as a practical tool for the diagnose of technical problems within the breaststroke cycle, due to the similarity of v(t) curves of the hip and CG, despite the hip velocity peaks tended to reach higher/lower extreme values than those obtained for the CG.

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FRONT CRAWL KINEMATIC: BREATHING AND PACE ACUTE EFFECTS.

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INTRODUCTION

Swimming velocity (SV) is the product of stroke lenght (SL) by stroke rate (SR). SL and SR are defined according to individual strategies related to training level, to fatigue status and to individual characteristics (1, 2). Therefore, the aim of this study was to verify the effects of breathing and pace on front crawl SL, SR and SV in 50 m freestyle swimmers.

METHODS

Ten 50 m front crawl male specialists (age: 20.7 ± 2.4 yr.; upper limbs span: 193.5 ± 5.2 cm; 50 m freestyle mean best time: 23.5 ± 0.66 s) performed 6 trials front crawl of 25 m with a rest interval of 1min 30s, in a 25 meters pool. SL, SR and SV were measured under two breathing conditions: breathing to the preferred side every cicle (B) and no breathing (NB), and three paces representatives of: warm up pace, 1500 m freestyle race pace, and 50 m freestyle race pace. Each trial was filmed with a motion analysis system (60 Hz) from sagital view. A reflective marker was fixed to the swimmer's right wrist to quantify SL and SR, after digitalizing (only the first frame, when the wrist appeared in the surface of the water was used, in three consecutives cycles). A 2 m frame to calibrate was used. SV was obtained by the SL and SR product. Statistical analysis was made with repeated measures ANOVA in a mixed 2x3 model and, when necessary, a Bonferroni post-hoc test (significant level of 0.05).

RESULTS

Table 1 SL, SR and SV results.

Table 1. Mean ± standard deviation of SL, SR and SV; n = 10. B = breathing; NB = no breathing; 1 = warm up pace; 2 =1500 m freestyle race pace; 3 = 50 m freestyle race pace.

KP	B1	B2	B3	NB1	NB2	NB3
SL (m)	2.90±0.22	2.68±0.22	2.30±0.12	3.08±0.19	2.76±0.19	2.18±0.11
SR (Hz)	0.42±0.04	0.54±0,06	0.81±0.04	0.43±0.02	0.58±0.06	0.88±0.04
SV (m·s^{-1})	1.21±0.07	1.45±0.06	1.86±0.08	1.32±0.10	1.60±0,08	1.91±0.07

The increase of pace was related to a decrease of SL [$F_{(2, 18)}$ = 178.8; $p < 0.001$], and an increase of SR [$F_{(2, 18)}$ = 366.9; $p < 0.001$] and of SV [$F_{(2, 18)}$ = 250.4; $p < 0.001$].Under NB conditions, SR and SV increased (respectively $p = 0.006$ and $p < 0.001$).

DISCUSSION

Data were similar to previews reported (1). Evaluated swimmers showed dependence by the breathing movement: when they did not breathe, they could reach higher SV values, basically by the increase in SR. This acute combination of increasing SR and decreasing SL is in accordance with literature (3).

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TIME-FREQUENCY PARAMETERS OF WRIST MUSCLES EMG AFTER AN EXHAUSTIVE FREESTYLE TEST.

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INTRODUCTION

The swimmers propulsion is mainly generated by the hand-wrist complex (1). The wrist stabilisation was related to the coactivations of forearms muscles. New processings allowed to assess muscle fatigue from spectral parameters of EMG during cyclic dynamic conditions (2). The aim of this study was to evaluate the effects of an exhaustive exercise on time-frequency parameters of 2 forearm muscles.

METHODS

Seven male international swimmers (22.6 ± 2.7 years, height 191 ± 4 cm, weight 82,7 ± 5,3 kg) realised an exhaustive test of 4*50m freestyle. An EMG system (ME 3000 P8) was used to record the electrical activity of 2 right muscles: the M. *flexor carpi ulnaris* (FCU) and the M. *extensor carpi ulnaris* (ECU). The time-frequency treatment has been realised according to the Knaflitz' method (2). The instantaneous mean frequency (IMNF) was obtained for each stroke of each 50m. The mean IMNF was calculated for each 25m of each 50m (figure 1).

RESULTS

Results indicated a significant decrease of the IMNF between the 1st 25m of the 1st 50m and the last 25m of the 4th 50m both for the ECU and the FCU (figure 2). The regular decrease of the ECU was statistically similar to the decrease of the FCU. Individual différences were observed from one 25m to another.
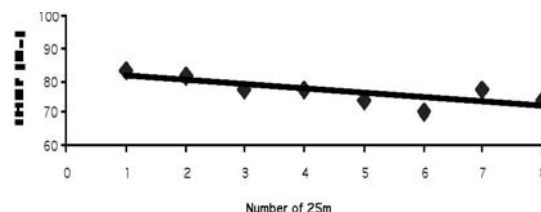
Figure 1: Mean of IMNF of the ECU for each 25m for one subject
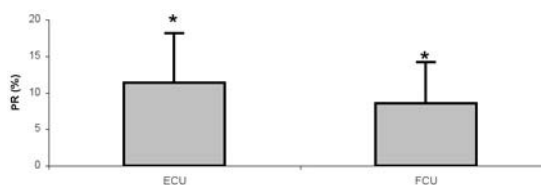
Figure 2: decrease of IMNF between the 1st and the 8th 25m

DISCUSSION

The decrease of IMNF at the end of the intensive test reflected the attempt of muscular fatigue as observed in elementary movements. ECU and FCU appeared as fatigable muscles in regard to the previous results (3). Individual differences could be usefull to adapt the training exercises.

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RESPONSE TO RESISTANCE EXERCISE PERFORMED IN WATER VS ON LAND.

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INTRODUCTION
The use of the water environment is usually undermined as a material in itself for resistance exercise since there is a generalised belief that this water-based exercise cannot create an intensity of training similar to the one that is obtained by the exercises of strength in dry-land (2). For strength training the role played by lactates and heart rate is a possible physiological indicator which could be linked to the exertion intensity. However no studies were found to have analysed this aspect using water exercises for resistance training (1), unlike the land-based setting where different studies are available. So, this study aims to verify if the cardiovascular and metabolic demands of well-designed water strength training are at least comparable to their land-based equivalents.

METHODS
Five trained men were evaluated with a horizontal shoulder adduction movement. This exercise was conducted similarly in water with a device known as Hydro-tone Bells and on land with an elastic band. Previously, a rhythm rate in water and on land was established in order to equate resistance, along with holding distance of the elastic band until reaching muscular fatigue after a twenty-five repetition set. A lactate measurer model Lactate Pro LT-1710 and a POLAR model S810i to monitor heart rate pulse were employed.

RESULTS
The results (table 1) showed that there were no statistically significant differences between both material resources concerning heart rate at exertion and the response of lactates.

Table 1. Mean and standard deviation for Heart rate values with regards to percentage of heart rate reserve and Percentage concentration of lactates with regard to basal values.

Minute post-exercise	Water		Land		p (Heart rate)	p (Lactic acid)
	Heart rate	*Lactic acid*	*Heart rate*	*Lactic acid*		
0	82,25±9,71		68,75±19,80		0,098	
3	47,75±18,77	2,34±1,66	33,25±16,5	1,14±1,43	0,079	0,125
5	37,00±14,85	4,3±3,24	25,75±14,45	1,55±0,78	0,002**	0,82

** p< 0,01 Statistically significant difference.

DISCUSSION
If the resistance training in water is performed according to the methodological indications followed in this study produces a similar physiological response to that produced by land-based exercise. Although there is a certain tendency suggesting that a certain increase is manifested with water strength training that would possibly be caused by greater muscular demand for stabilising groups found in the water setting, the influence of hydrostatic pressure, and even, the peripheral resistance that the above muscles create on return circulation (1). These data demonstrate the efficiency of water resistance training as an alternative and/or complementary resource to those usually applied on land.

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APPLICATION OF A PROTOCOL FOR EXERCISE INTENSITY PERCEPTION IN SUBJECTS WITH MULTIPLE SCLEROSIS EXERCISING IN THE WATER.

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INTRODUCTION
Multiple Sclerosis (MS) is characterized by variable symptoms (3), being acute physical fatigue (APF) one of the most common problems related to this pathology (1, 2); APF becomes one of the greatest problems to be treated. The aim of this study was to examine if CR10 scale for rating of perceived exertion (RPE) could be useful to manage with exercise intensity and effort perception in subjects suffering different grades of MS.

METHOD
Four subjects suffering MS participated in the study (Age 29±4; Weight 57,03±12,51; Height 1,60±0,12 and BMI 22,11±3,38). An intrasubject pretest-postest quasiexperimental design was developed to determine if a three week treatment (3 sessions of 30' each) could improve exercise intensity perception (production of intensities of 3, 6, and 9 grades in CR10 scale). Subjects were asked to produce these 3 exercise intensities -in a randomized order in each pretest session, and replicated exactly in postest sessions- while practicing 9 different regular activities (3 min each). Treatment sessions consisted in performing different activities regulating exercise intensity and focusing attention in different indexes as heart rate – HR - (Polar Electro, Oy, Finland), distance, repetitions, and time (significant, useful, and easy to measure indexes (4)). An intrasubject statistical analysis was developed, showing the descriptive values and utilizing a repeated measures analysis of variance (ANOVA).

RESULTS
Subject I and II (the less affected) showed that they could pro-

duce the pretended intensities from the beginning, although after the treatment the variability was smaller and the difference between each activity was more clear and proportional to 33, 66 and 99% of intensity (they learned significantly - p≤ .02 in 6 activities). Subjects III and IV (more affected), could not produce clearly the selected exercise intensities at the beginning (No significant differences in HR, or time and distance reached between activities previously defined as intensities of 3, 6, or 9 in CR10 scale), although after the treatment they improve the discrimination of the 3 intensities (according to the HR).

CONCLUSION
RPE is not a simple tool when the grade of MS affectation is high, although it can be a useful procedure to help the subjects when regulating exercise intensity (not to suffer APF). Physical affectation seems to determine clearly the grade in which a subject can produce desired exercise intensity and can control it not to suffer APF.

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APPLICATION OF THE CRITICAL POWER CONCEPT IN SWIMMING?

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The concept of CP originally introduced by Monod and Scherrer (1) has been extended to swimming. However, such an application of the CP concept imposes several assumptions (2).
First, it is assumed that when performing a fatiguing exercise, energy is generated via both the anaerobic and aerobic pathways ($e = e_{anae} + VO_2max.t$; Equation 1). [Assumption 1.] The anaerobic metabolism would generate a finite amount of energy (e_{anae}). [Assumption 2.] The aerobic pathways would be solicited at its maximal power (VO_2max) throughout the duration of the exercise to enable the energy demand to be covered ($VO_2max.t$).
Second, it is assumed that the energetic cost of the activity (ml of $O_2.m^{-1}$) is constant in order to allow Equation 1 to be expressed as followed: $d = ADC + CV.t$ (d, distance; t, exhaustion time, Equation 2), with Critical Velocity (CV) and Anaerobic Distance Capacity (ADC) represented by the slope

and the y-intercept of the d-t relationship, respectively.
In swimming, the observation of a linear relationship linking d and t has been used to validate the application of the CP concept (3). However, it is known that the d-t relationship is not strictly linear. Consequently, several studies attempted to determine the distances that should be used to determine CV and ADC (4). Furthermore, whatever the cyclic activity considered Assumptions 1 and 2 would never be fulfilled in any exhaustive exercise. As a consequence, in order to partially fulfil Assumption 2., VO_2max has to be attained at the end of each trial used to plot and model the d-t relationship. Therefore, the t used to plot and model the d-t relationship should range between 2 and 20 minutes. In attempt to simplify the determination of CV, the suggestion of using only the 200m and 400m seems the most pertinent (4). Moreover, e_{anae} would always underestimate the 'anaerobic energy reserve' to the expense of the aerobic contribution to the total energy demand (5).
Despite these several limits, the CV concept has raised lots of interest from the scientific and non scientific communities. The model may provide an interesting way of investigating the energetic contributions to swimming. Coaches and swimmers could also appreciate the ease in using the model to predict performance from the d-t relationship, to set training loads, to discriminate effects of training, and to establish energetic potentials of swimmers.

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CHALLENGES OF USING CRITICAL SWIMMING VELOCITY. FROM SCIENTISTS TO COACHES.

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Critical velocity (CV), represented by the slope of the d-t relationship has been shown, in running, to correspond to the threshold intensity above which exercise of sufficient duration will lead to the attainment of VO_2max (1). This definition of has not yet been directly verified in swimming but is in line with several findings reported in the literature in swimming (2, 3).

Using CV as an intensity for setting training programs offers great potential. It would allow better planning for individuals long and short interval training compared to using a given percent of the 400-m speed. Indeed, swimming at or below CSV would induce fatigue without exhaustion while exhaustion would develop above CV. Long interval training (6-10 x 400m at CSV, 1-min rest) at or below CV may induce [H+] accumulation and may improve the oxidative potential of the muscle fibres as an acute adaptation to training. Adequate long and short interval training above CV (20-30 x 100m at 110% CSV, 30-s rest; 15s above CV, 15s below CV) would enable VO_2max to be solicited and maintained for a very long time. This could lead to optimise the improvement of VO_2max over time. Several 400-m blocks performed at CV can be swam with steady [La] values (around 3-4mmol.L^{-1}) when separated by 20-40s of rest (4). Nevertheless, stroking parameters have been shown to change, with progressive stroke rate increases and stroke length decreases within and between the 400-m blocks Brickley et al. (4). Training around CV could be set while focussing on the stroking parameters pattern in order to delay the effect of exhaustion on efficiency.

A few studies but unfortunately no one in swimming have shown that the intensity-time relationship was affected by training. Aerobic training would increase the slope while anaerobic training would increase the intercept of the relationship. Plotting the d-t relationship would enable to monitor effects of different kind of training over a season.

Further research is required to better understand the meaningfulness and to define the usefulness of the slope and y-intercept of the d-t relationship (responses at and above CV, effects of training at intensity around CV, effects of training on the d-t relationship, kicking vs full stroke CV). However, the actual knowledge on the application of the CV concept seems sufficient to underlie its interests for training.

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IRON STATUS PARAMETERS OF ELITE YOUNG WATER POLO PLAYERS AFTER THE COMPETITION SEASONS.

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INTRODUCTION

Intensive training can induce iron imbalance and development of the so called sports anaemia (1). Water polo belongs to a group of sports games with complex physical requirements, and during competitive seasons, athletes are exposed to intensive efforts which burden all energetic and muscle systems. The aim of this study is to establish iron status in elite young water polo players after the competition seasons.

METHODS

The study was carried out on 44 members of the water polo national team of SCG (aged 18 - 20 years), after the competitive season of 2004 and 2005. During the given competitive seasons, the players did not undergo iron supplementation. Hematological parameters (2) were determined from the EDTA blood samples on the HMX (Beckman-Coulter). Serum iron and TIBC were determined with feren method on the ILab 1800, while ferritin and transferin in serum were determined with the immunonephelometric method on the BN II (Dade-Behring). Raw data then underwent K-Means Cluster Analysis, in order to make three groups reflecting the iron status, and to define the parameters that differentiate the groups according to inappropriate, middle appropriate, and appropriate iron status groups.

RESULTS

The results have shown 18 players, or 40.91%, to be grouped in Cluster 1 (inappropriate iron status), 21 players, or 47.73% (middle appropriate) in Cluster 2 and only 5 players, or 11.36%, in Cluster 3 (appropriate). ANOVA has shown that, in relation to the examined population, ferritin to be the only statistically important factor of differences between the groups, and then at the level F ratio = 188.78, p = 0.000. The results of the basic descriptive statistics show the subjects of Cluster 1 to have an average ferritin level $25.76 \pm 9.85 \mu g/L$ (Min - Max = 6.8 to 40.7 $\mu g/L$), the subjects of Cluster 2 to have an average ferritin level $62.86 \pm 12.30 \mu g/L$ (Min - Max = 48.4 to 96.7 $\mu g/L$), whereas subjects in Cluster 3 have an average ferritin level $162.60 \pm 28.93 \mu g/L$ (Min - Max = 137.0 to 209.0 $\mu g/L$).

DISCUSSION

The results have shown that after the competitive season, the young elite water polo players suffer from a depletion of iron reserves which is indicated by the lowered concentration of ferritin in serum (40.91% of the tested players). Of all the observed parameters, ferritin describes best the iron status in young water polo players. Our results have shown that as a prevention of iron storage depletion in young water polo players, it is necessary to introduce iron substitution in players whose ferritin level is below 35.61 $\mu g/L$.

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CHARACTERISTICS FOR SUCCESS IN ELITE JUNIOR AND SENIOR SWIMMERS.

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INTRODUCTION
Quantifying the importance of certain characteristics in performance prediction (or 'profiling') has obvious benefits in identifying and developing talent in sport. Previous attempts to do this in swimming have focused on either elite senior (*Carter and Ackland, 1994, Kinanthropometry in Aquatic Sports*), or elite junior swimmers (*Blanksby et al., 1986, Journal of Swimming Research*. 2(2), 30-36). The purpose of this study therefore, was to describe and compare key anthropometric, physiological and socio-demographic characteristics of junior and senior elite swimmers at two levels of performance across all four competitive strokes and to determine the importance of these attributes to successful swimming performance.

METHODS
Sixty-five (34 males and 31 females) senior elite swimmers from the 2004 Olympic and Loughborough University High Performance squads and 561 elite junior swimmers (305 males and 256 females aged 11-18 and 11-17 years, respectively) from the finals at the 2004 Amateur Swimming Association British Age and Youth Championships took part in the study. Subjects undertook a battery of anthropometric and physiological measures including height, sitting height, standing reach, arm span, body mass, torso and waist circumferences, hand and foot lengths, upper arm and forearm lengths, and explosive leg power (counter movement jump). Family background was assessed using questionnaire material from the Institute of Youth Sport. Anthropometric and physiological variables were grouped together for the purposes of multivariate and univariate analysis of variance, discriminant analysis and regression analysis. Senior and junior swimmers were grouped by performance level (Olympic vs. University and Medallists vs. Non-Medallists respectively) for all analyses excluding multiple regression.

RESULTS
Both MANOVA ($P=0.001$) and discriminant analysis ($P=0.000$) showed that the combination of anthropometric and physiological parameters could successfully differentiate between the two levels of senior performance in male swimmers and regression analysis revealed that standing reach and counter movement jump were significant predictors of performance ($P<0.05$). In senior females only discriminant and regression analyses (with no significant individual predictor variables) showed significance ($P<0.05$). In junior swimmers the test battery was unable to significantly discriminate between the two performance levels in any age group. Regression analyses revealed that in junior males, arm span, waist circumference, torso to waist ratio and counter movement jump were significant predictors of performance ($P<0.05$) and in junior females, arm span, sitting height, sitting height ratio and counter movement jump were significant predictors of performance ($P<0.05$).

DISCUSSION
The characteristics that predict swimming performance differ from junior to senior level in both males and females. The inclusion of swimming specific tests in the battery may provide additional predictive power to this analysis. A longitudinal approach would provide valuable information about the importance of certain characteristics to performance during growth and development and at senior level. Results suggest that a multidisciplinary test battery combined with multivariate analyses could be useful as an important predictive and diagnostic tool for talent identification and development in elite junior swimmers.

"EPIDEMIOLOGICAL" ANALYSIS OF THE RELAY STARTING TECHNIQUES USED IN TOP LEVEL SWIMMING.

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INTRODUCTION
Relay starting techniques are those specific techniques used for the 2nd, 3rd, and 4th laps of a swimming relay event. These actions are determined by particular constrains, that provide to the swimmer the possibility of select the best motor solution in order to maximize performance. The referred particular constrains are: (i) the starting signal (t0) is a visual one; (ii) the starting signal can be anticipated by the visual inspection of the approaching swimmer; (iii) the starting swimmer is allowed to move without leaving the platform prior to t0; and (iv) movements prior to t0 are not restricted by the rules.
As a consequence of these particular constraints, several starting techniques were proposed, used, and perfected by the swimmers through time. The conventional starting technique (CS) is the most popular and well known technique to be applied in this situation. Nevertheless, some swimmers are still using the grab start (GS), at the same time that others choose other solutions, specially "moving starting solutions": SSF – single step forward, DSF – double step forward, and SST – single step track.
The purposes of this study were: (i) to make the inventory of the relay starting techniques currently used in top level swimming, and (ii) to analyse the prevalence of each one for male, and female events.

METHODS
The official FINA images of the 2005 Montreal World Championships, the 2004 Athens Olympic Games, and the 2003 Barcelona World Championships were analysed through visual inspection by a experienced researcher. All the visible 2nd, 3rd, and 4th starts per relay were considered and classified, both for male, and female events.
Relative frequency, mean and standard deviations were used as statistical procedures.

RESULTS AND DISCUSSION
The main results are presented in Table 1. It can be noticed that the CS starting techniques stills the mostly used in the 2nd

to 4th relay starts performed by world class swimmers, and specially in male events. The main reasons may be associated to: (i) better observation of the approaching swimmer, and (ii) higher momentum transfer to the centre of mass without compromising starting time (actions on platform not included in starting time). Probably by the same reasons, the "moving start" techniques, especially SSF and SST, already present incidences higher than 10%

Table 1. Percent results of the incidence of the different starting techniques in top level swimming relays.

	Fem.	Mal.	Total
CS	41,7%	62,6%	51,1%
GS	25,8%	6,1%	16,9%
TS	11,7%	2%	7,3%
SST	10%	10,1%	10%
SSF	6,7%	16,2%	11%
DSF	4,2%	3%	3,7%
	Fem.	Mal.	Total
CS	41,7%	62,6%	51,1%
GS	25,8%	6,1%	16,9%
TS	11,7%	2%	7,3%
SST	10%	10,1%	10%
SSF	6,7%	16,2%	11%
DSF	4,2%	3%	3,7%

RELATIONSHIP BETWEEN METABOLIC AND VENTILATORY THRESHOLDS IN SWIMMING.

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INTRODUCTION
Measurement of blood lactate concentration ([La-]) and ventilation (VE) to determine anaerobic threshold (AnT) are common procedures in swimming training and performance diagnosis. The purpose of this study was to establish the relationship between [La-] and VE on individual AnT velocity in order to analyse and to make comparisons between metabolic and ventilatory data attained through maximal oxygen consumption (VO_2max) test.

METHODS
Eleven elite swimmers (4 backstrokers, 5 breaststrokers and 2 butterfliers) were subjects of this study (9 males 18.3 ± 2.1 y, 176.4 ± 3.8 cm, 69.4 ± 6.7 kg, and 2 females 18.0 ± 1.4 y, 168.5 ± 4.9 cm, 60.7 ± 9.2 kg). They performed an intermittent incremental test for freestyle VO_2max assessment, with 0.05 mxs[-1] increments after each 200 m and 30s rest in-between, until exhaustion (Fernandes et al., 2003). Velocity was controlled using a visual pacer. [La-] was assessed at rest, during the 30s intervals, immediately after each 200 m stage, and at minutes 3 and 5 of the recovery period (YSI-1500L Sport auto-analyser). VO_2 was measured using a portable gas analyser (K4b[2], Cosmed, Italy) connected to the swimmers by a respiratory snorkel and valve system. Metabolic threshold (MetbAnT) was determined from [La-]/VO_2 curve by least square method. MetbAnT was assumed to be at the intersection of a combined pair (linear and exponential) of regressions (Machado et al., 2006). The same procedure was used when assessing ventilatory threshold (VentAnT) from the VE / VO_2 data.

RESULTS
Table 1 presents the mean ($\pm$SD) values for the velocities corresponding to the MetbAnT and VentAnT. No differences were observed between the metabolic and ventilatory AnT in each technique and in the pooled data. A positive significant relationship was observed between swimming velocities corresponding to MetbAnT and VentAnT for the whole sample (r=0.88, $p \leq 0.05$). Differences were statistically non-significant (p>0.05).

*Table 1. Mean (SD) values for MetbAnT and VentAnT. * $p \leq 0.05$*

Technique	vMetbAnT (m/s)	vVentAnT (m/s)	r
Backstroke	1.26 ± 0.06	1.25 ± 0.08	0.75
Breaststroke	1.00 ± 0.08	1.06 ± 0.11	0.81
Butterfly	1.18 ± 0.09	1.14 ± 0.16	-
Total	1.12 ± 1.14	1.14 ± 0.13	0.88 *

DISCUSSION
We conclude that, while strong positive relationship existed between the metabolic and ventilatory individual thresholds and the slight differences between the concurrent analyses were negligible, the assessment of performance is equally successful using both methods.

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PHYSIOLOGICAL IMPACT OF SWIMMING AND FOOTBALL ON PRE-PUBERTAL YOUNG ATHLETES.

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INTRODUCTION
Do different sports promote a metabolic specialization in pre-pubertal children? To answer this question we assessed a group of young athletes to test their physical performance (VO_{2max}) and the short-term power output (*Wingate Test- WAnT* arm and leg evaluations). The *WAnT* allows a practical assessment for both legs and arms performance (1). Assuming the specificity of the anaerobic capacity for the main requested muscle groups (2), probably, football players would perform better with their legs and the swimmers with their arms.

METHODS

A group of young athletes (n=22) with a two year of training practice was divided in two sub-groups (n=11): swimmers (age: 11,27 years ±0,47; weight: 37,82 kg ±4,14) and football players (age: 11,5 years ±0,52; weight: 41,00 kg ±5,71). *Modified Balke* maximal protocol using ergo-spirometry procedures (*Cosmed® b²*) was selected to determine VO_{2max} and the Ventilatory Anaerobic Threshold (VAT) as estimates for the aerobic capacity. The anaerobic capacity for both arms and legs was quantified using the *WAnT*, performed in a cycle-egometer *Monark® 849*. Three relative parameters were assessed: *Peak Power*, *Average Power* and *Power Drop*. The comparison data was analyzed between the groups (*T-test for independent samples*) and correlated within groups (*SPSS, ver.12.0*).

RESULTS

There were no significant differences observed for the experimental parameters between the groups. No correlations were found when relating the prolonged with the short-term power outputs between running and cycling. Nor differences were found within each group between arms and legs cycling.

Table 1. Maximal aerobic power and ventilatory anaerobic threshold and anaerobic capacity (PP, AP, PD) for football players and swimmers from the GXT test and Wingate (leg and arm cycling).

		Football		Swimming	
VO_2max (ml/kg⁻¹min⁻¹)		57,61 ± 5,67		54,39± 5,67	
VAT (ml/kg⁻¹min⁻¹)		45,09 ± 7,64		43,78 ± 8,94	
WAnT (watt.kg⁻¹)	Leg	PP_L	8,02 ± 0,1,23	PP_L	7,07 ± 2,34
		AP_L	6,05 ± 0,80	AP_L	5,54 ± 1,59
		PD_L	3,99 ± 1,35	PD_L	2,85 ± 2,100
	Arm	PP_A	4,87 ± 0,97	PP_A	4,63 ± 1,19
		AP_A	3,57 ± 0,64	AP_A	3,52 ± 0,65
		PD_A	2,55 ± 0,86	PD_A	2,59 ± 1,09

DISCUSSION

No correlations were found between the anaerobic capacity (*WAnT*) for arms and legs *within* the sport. The data found was similar to those of previous study. It seems that, during the pre-pubertal development period, different sports have no significant specific metabolic effect on athletes, confirming the hypothesis of "lack of specialization"(3).

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ANTHROPOMETRIC PROFILE OF ELITE MASTER SWIMMERS.

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INTRODUCTION

Ageing causes modifications in body composition that alter the muscle structure and reduce the ability to exercise. Master athletes, individuals who continue to train and compete well beyond middle age, have been receiving considerable scientific interest. The aim of the present study was to assess the anthropometric characteristics of high level master swimmers and to detect their age-related trend.

METHODS

115 subjects (54 men and 61 women), aged 40-96 years, were recruited from the athletes participating in the 10th Fina World Master Championships, held in Riccione (Italy), in June 2004. Height (H) and weight (W) were measured and the BMI calculated. Bicipital, tricipital, suprailiac, subscapular skinfolds were measured at the dominant side and sum of skinfolds (SSK) and fat mass (FM%) calculated. Furthermore, thigh (TV) and forearm (FAV) muscle-bone volume were estimated adopting a modified version of the anthropometric method proposed by Jones and Pearson (1969).

RESULTS

Results, according to the age groups, (group 1 to 5), are shown in Tab. 1.

Tab. 1: Anthropometric data of 54 Men and 61 Women Elite Master Swimmers (mean ± DS).

Gr./Age	N	Age	H cm	W kg	BMI	FM%	SSKF	TV ml	FAV ml
Men									
1 (40-49)	11	44.5±2.4	179.1±6.1	79.9±9.1	24.8±1.8	20.1±4.6%	37.8±13.1	4607.0±585.7	1361.6±167.4
2 (50-59)	12	54.7±3.2	178.8±6.5	82.4±11.3	25.7±3.0	24.5±4.9%	46.3±14.2	4257.3±540.7	1405.6±218.7
3 (60-69)	14	64.0±2.8	174.4±8.3	80.2±8.0	26.4±2.6	24.7±4.1%	46.4±12.2	3852.6±646.0	1308.7±135.9
4 (70-79)	12	73.7±2.1	170.9±7.5	78.7±8.7	26.9±2.4	26.6±5.1%	53.2±17.0	3546.8±718.6	1201.5±161.1
5 (≥ 80)	5	85.6±7.4	170.7±8.7	71.1±11.1	24.3±1.9	23.5±3.6%	42.3±9.8	3214.3±461.8	1177.9±131.4
Women									
1 (40-49)	15	44.4±2.8	165.5±7.3	60.5±8.2	22.1±2.6	30.7±3.8%	51.5±17.8	3207.9±744.9	858.4±104.0
2 (50-59)	21	53.8±3.2	163.1±5.1	61.3±6.5	23.0±2.5	32.7±3.9%	49.8±14.3	2988.0±616.6	892.4±133.8
3 (60-69)	12	64.5±3.3	161.1±5.5	59.2±6.2	22.8±2.0	33.3±3.9%	51.9±14.5	3032.9±489.5	888.2±103.4
4 (70-79)	11	73.9±2.7	161.0±6.6	64.3±10.9	24.9±4.1	33.9±5.8%	56.6±21.8	2849.8±626.4	955.3±106.5
5 (≥ 80)	2	89.5±3.5	151.5±3.5	53.5±6.4	23.3±1.7	33.7±2.9%	52.5±11.5	2453.4±268.6	750.1±125.1

ANOVA, with post hoc Tukey test, showed significant differences ($p < 0.05$), only for men, in FM% (1 vs 4), TV (1 vs 3, 4; 2 vs 4) and FAV (2 vs 4). The ≥ 80 years subjects, because of the reduced number, were not included in the statistics.

DISCUSSION

The decrease of whole muscle mass (loss in number of fibres and reduction in cross sectional area), as previously found in other studies, may explain the age-related decrease in TV and FAV and the increase in FM% in men. On the other hand women don't show significant differences across the age spectrum. This might be due to i) the lower muscle mass in females, whereupon the loss is reduced with aging and ii) the different loss rate in muscular mass, which is gender-associated.

STROKE RATES CORRESPONDING TO CRITICAL SPEED AND THE MAXIMAL SPEED OF 30 MIN IN SWIMMERS OF DIFFERENT TRAINING STATUS.

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INTRODUCTION
Recently, Dekerle et al. (1) verified in well trained competitive swimmers that the critical speed (CS) and critical stroke rate (SRCS) can be used in order to set aerobic training load and also to control the swimming technique during training. The objective of this study was to verify the effect of aerobic performance level on the relationship between stroke rates corresponding to CS and the maximal speed maintained for 30 min (S30) in swimmers.

METHODS
Twenty three male swimmers of 15 to 20 yr participated of this study. They were divided in groups G1 (n = 13) and G2 (n = 10) based on the S30 (G1 = 1.23 ± 0.06 m.s^{-1}, G2 = 1.07 ± 0.06 m.s^{-1}, p < 0.05). The physical characteristics of G1 (body mass = 64.74 ± 11.45 kg, stature = 174.08 ± 7.42 cm, body fat = 12.80 ± 2.99 %) and G2 (body mass = 61.56 ± 15.76 kg, stature = 169.80 ± 10.37 cm, body fat = 14.80 ± 5.27 %) were similar. They had at least 4 years of experience in the modality and a weekly training volume of 30,000 to 45,000. The CS was determined through the slope of the linear regression between the distances (200 and 400 m) and respective times. The S30 was determined through the maximal distance performed in a 30 min test. During this test, the stroke rate was measured two times along the length of the 25 m pool at each passage of 400 m. The stroke rate at CS (SRCS) was determined through the mean speed recorded during 200 and 400 m. During each test, the stroke rate was measured two times along the pool, at each passage of 50 m. SRCS was calculated by the slope of the regression line between the number of stroke cycles and time.

RESULTS
CS was higher than S30 in G1 (1.30 ± 0.04 and 1.23 ± 0.06 m.s^{-1}) and G2 (1.17 ± 0.08 and 1.07 ± 0.06 m.s^{-1}). CS and S30 in G1 were higher than G2. The blood lactate level corresponding to S30 in G1 (4.03 ± 1.40 mM) and G2 (3.88 ± 1.48 mM) was similar. There was no significant difference between SRCS and SRS30 in G1 (33.07 ± 4.34 and 31.38 ± 4.15 cycles.min^{-1}) and G2 (35.57 ± 6.52 and 33.54 ± 5.89 cycles.min^{-1}). The SRCS and SRS30 were similar between groups. The correlation between CS and S30 (G1 – r = 0.68 and G2 – r = 0.84) and SRCS and SRS30 (G1 – r = 0.84 and G2 – r = 0.88) was significant in both groups.

DISCUSSION
In conclusion, SRCS determined from the distances of 200 and 400 m can be used to predict the SRS30 irrespectively of the aerobic performance level. Thus, this index can be used by coaches to control the swimming technique during aerobic training sessions in swimmers with different aerobic status training.

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HOW DO SWIMMING COACHES SEEK INFORMATION FROM SCI-ENCE OF SWIMMING RESEARCH.

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INTRODUCTION
The main purpose of this study was to find out how swimming coaches seek useful information arising from scientific research in swimming. It was also of interest to investigate whether coaches obtain information in a 'coach friendly' form. It was deemed important to obtain the perspectives of both sport scientists and coaches and also to investigate the role of emerging techniques of disseminating information including the World Wide Web. The use of the World Wide Web was of specific interest since these electronic tools provide powerful search and retrieval abilities. Even the best papers are of no use if they cannot be located easily[1].

METHOD
Two surveys were prepared and distributed in this study - a survey of swimming coaches and a survey of sports scientists. Both surveys were prepared using software of the internet company Zoomerang.com[2]. The surveys were completely anonymous and further analysis was conducted using SPSS. The survey for coaches was distributed to over 3000 swimming coaches in USA, Europe and Australia. The information collected included frequency of seeking scientific material related to swimming, the source of the material, the 'reader friendliness' of the material, and the suitability of the World Wide Web as a source of swimming science information useful for coaches. The survey of sport scientists was distributed to over 400 sport scientists around the world. The information included frequency of submitting scientific material to sources for coaches, constraints limiting frequency of disseminating information in a form suitable for coaches, and the relative suitability of various modes of delivery including the World Wide Web.

RESULTS
Over 1100 responses have been received from swimming coaches and surveys for sports scientists were being distributed to members of sports science organisations. Almost 80% of all coaches responding had a Bachelors degree (475) or post graduate qualification (350). The responses indicated that coaches were eagerly seeking information from scientists but this information was not as readily available as they would like.

DISCUSSION
Coaches were interested and concerned about the manner in which scientific information is disseminated. Coaches' eagerness in seeking information on the World Wide Web illustrated the need for a combined web site for scientists and coaches where scientists disseminate their latest findings in a 'coach friendly' way and coaches seek information. This would aid in bridging the gap between scientists and coaches.

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SHORT TERM WATER EXERCISE EFFECTS ON THE PHYSICAL FITNESS OF ELDERLY SUBJECTS FROM COLD SNOWY REGION.

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INTRODUCTION
In cold snowy region, it is very important for citizens to acquire physical fitness before winter season to prevent slip and fall on the frozen streets. Water exercise is one of the most popular exercise styles for elderly because of the characteristics of water. Also, it is an useful exercise for citizens living in cold snowy region, because allows to exercise during the winter season in indoor swimming pools. The purpose of the present study was to investigate short term water exercise effects on the physical fitness of elderly subjects from cold snowy region.

METHODS
Eleven subjects of the water exercise (WE) group (mean age: 59.4yrs, SD: 9.2) participated in a water exercise class for 6 weeks (twice a week for 90 min session) from October to November of 2005. Nine subjects also served as a controlled (C) group (mean age: 62.1yrs, SD: 8.5). Blood pressure (BP), sitting trunk flexion (STF), grip strength (GS), whole body reaction time (RT) and the sway paths of the center of gravity (locus length: LNG, environmental area: ENV area, Romberg quotients) for 30-seconds with eyes open and closed were assessed before and after the exercise periods.

RESULT
After the experimental protocol, BP, STF and RT were significantly improved in WE group. In C group, body weight and BMI increased significantly (p<0.01). No significant changes were found in GS, LNG, ENV area and Romberg quotients in both groups.

DISCUSSION
Balance, RT and strength are important elements to prevent slip and fall on the frozen streets during winter season for citizens in cold snowy region. RT was significantly improved in WE group despite of the short term water exercise protocol. It seems suggested that short term water exercise was beneficial to improve some of the physical fitness of elderly subjects from cold snowy region. However, further studies are needed.

THE FUNCTION OF NASAL PRESSURE FOR BREATHING IN THE BREASTSTROKE.

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INTRODUCTION
We have studied nasal pressure on subjects submerged in water while swimming the breaststroke. We believe that nasal pressure might be an important factor for breathing control. The purpose of this study is to determine the function of the sensation of water touching the face and nasal pressure while swimming. So we attempted to determine the relationship between the sensation on the face and nasal pressure to the submersion depth of face while swimming the breaststroke.

METHODS
We measured the depth of facial submersion and the nasal pressure while doing ten breaststrokes by using two pressure gauges. The one pressure sensor was placed inside the nasal passage and the other was placed on the outside of the nose with surgical tape. For examining face sensation, skin around nose was covered with film. To study effects on the nasal pressure, we covered the nostrils with film while subjects did the breaststroke. The students swam in a swim-mill. The informed consents were obtained from each subject. Then the pressure data and other data were analyzed by the Paired T-test. Statistical significance was established at the 0.05 probability level.

RESULTS
There was no difference (t=0.398) in the depth between the skin covered with film and in the controlled swimming. When the nostrils were closed with film, the face depth (average: 30.3cm) was shallower (t=0.006) than in the controlled setting (28.0cm). We could not find any significant difference (t=0.621) between the test and controlled setting with regards to face-sustaining duration above the surface of the water and the subjects' breathing.

DISCUSSION
We paid attention to instructing novice swimmers. The most important point for beginners is having proper breathing technique. The timing of when to begin inhalation is not clear from the physiological point of view. This study showed the importance of nasal pressure for breathing control in swimming the breaststroke.

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INJURIES INCIDENCE IN BRAZILIAN SWIMMERS OF DIFFERENT STROKES.

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INTRODUCTION
The top-level competitive swimming requires raised levels of

training that expose the athlete to constant and intense stress situations. Those characteristics of training associated to innumerable repetitions of technician gestures, are considerable factors that predispose injuries, which are due to the repetitive microtraumas and overuse. The aim of this study was to identify the incidence, place and diagnosis of injuries in competitive Brazilian swimmers, according to the stroke, through the descriptive epidemiology.

METHOD
The sample of this descriptive study was composed by 137 competitive elite swimmers of both genders (77 male and 60 female), ranging from 16 to 22 years old and with 14±4 years of practice. The instrument used was a mixing questionnaire elaborated by the National Center of Sports Excellence CENE-SP for the national project Champion Profile. The questionnaire was applied during the Brazil's Trophy 2004 competition. For data analysis the descriptive statistics was used.

RESULTS
It was observed that 70 (51%) of the evaluated athletes suffered, in the past, some kind of injury. During that competition, 19 athletes referred the incidence of injury. As observed for the injuries suffered in the past, for the present injuries the most affected segment was the shoulder (53%) and the tendonitis was the most frequent diagnosis (72%). According to each kind of stroke, it was verified: a) tendonitis was the most frequent injury for the butterfly (80%), crawl stroke (86%) and breaststroke (75%) swimmers. For the medley swimmers, both the tendonitis and the muscle strain were the most frequent injuries observed (43%); b) the most affected segment was the shoulder for the butterfly (50%), backstroke (63%), crawl (56%) and medley (44%) swimmers. The knee was the most affected segment for the breaststroke swimmers (62%).

DISCUSSION
It was verified that tendonitis was the main injury in swimmers. This fact can be explained by the repetition of the technical gestures (Concatorro, 1995). The results can help to determine an injury profileaccording to the kind of stroke, considering that butterfly, backstroke and crawl stroke are characterized by a standard mechanical shoulder solicitation, the segment that presented the major frequency of injuries, while the knee injuries were more common for the breaststroke swimmers.

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THREE-DIMENSIONAL ANALYSIS OF THE EGGBEATER KICK IN SYNCHRONIZED SWIMMING.

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INTRODUCTION
The vertical eggbeater kick is the most fundamental and impor-tant technique in synchronized swimming, water polo, water rescues, and so on. In our previous study of the eggbeater kick, the rotational movement of the hip was considered to be important to control the strength and direction of movement when using the eggbeater kick. The purpose of this study was to examine the kind of kinematics parameters that are required to perform an excellent eggbeater motion and, in particular, to evaluate the rotational angle of the hip in the eggbeater kick.

METHODS
Nine female synchronized swimmers (height: 1.60 ± 0.05 m, weight: 53.2 ± 4.16 kg) served as subjects for this study. All the subjects were Japan national A team members; four were silver medalists in the 2004 Athens Olympic Games. The eggbeater kick motion was recorded using three video cameras (60 fps), including two underwater cameras. All the subjects attached an additional landmark on their left thigh to facilitate the evaluation of the rotational angle of the hip. The DLT method was used to obtain the 3-D space coordinates of the lower limbs.

RESULTS AND DISCUSSIONS
The hips of all the subjects rotated almost internally during the eggbeater kick motion, and the range of maximum internal rotation angle was 20–50 deg. This was significantly larger than the internal angle of the breaststroke kick motion studied in our previous research. The hip rotation appeared to be related to foot abduction because, as shown in Fig. 1, the phase of the angle curve between the hip rotation and foot abduction is almost identical in the reverse direction. Abduction of the foot is one of the very important movements involved in kicking the water. Therefore, hip rotation is also considered to be an important movement in generating the propulsive force in the eggbeater kick.
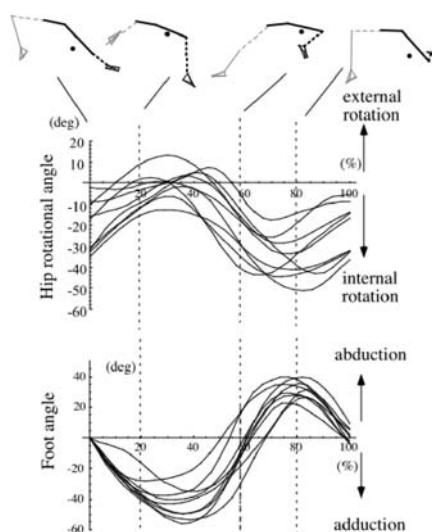

Fig. 1 The time-angle curves of the left hip (upper) and left foot (lower) of all subjects during one cycle of the eggbeater kick. The zero of the hip angle implies that the toe is pointed anteriorly.The foot angle is the relative angle of the foot from its initial position.

INVERSE DYNAMIC MODELLING OF SWIMMERS' IMPULSE DURING A GRAB START.

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INTRODUCTION
Analysis of the temporal distribution of the races shows that the start phase accounts for 15 % and 7.7 % of total time, respectively for 50 m and 100 m freestyle events (Arellano et al., 1994). Regardless of underwater factors, the start phase depends primarily on the quality of the swimmer's impulse on the starting platform (Vilas-Boas et al., 2003). However, studies carried out to date are often contradictory when it comes to defining the most efficient movement required to optimize athletes' performance impulse. A model based on inverse dynamic was developed in order to predict impulse's parameters during grab starts. The study presented here aimed to evaluate the precision of this model by comparing predicted speed and power values with experimental data collected in situ.

METHOD
Four national swimmers performed a grab start. For each start, the ground reaction force was recorded using a force platform. This one is fixed near the pool in respect of simulating start actually met in international race. The sampling frequency was 1000 Hz. Speed of the swimmer's centre of mass was obtained by integration of its acceleration. In parallel, a high speed camera (125 frames.s[-1]) was used to record the profile movements which were then analysed in order to determine the angle between the subjects' segments (right side) and the horizontal axis. The sum of segment energies was obtained using the anthropometric tables and equations of sum of segment energies as defined in Winter (1990). For each start, the kinematics and dynamics of the platform signal were synchronised (0.008 s accuracy). Based on swimmer's kinematics and morphological properties, the model permits to determine joint moment, joint power and velocity of take-off of the centre of mass.

RESULTS AND DISCUSSION
The model presented in this study was able to predict parameters, observable by kinematic and dynamic data, with the following mean dispersions: 9 % for horizontal and total speed with the force platform, 1 % for swimmer's internal joint power with the time derivative of the sum of segment energies (Winter, 1990). The main interest of this model lies in the possibility of analysing and better understanding the joint's moment of each articulation and the segmental coordination of each swimmer performing a grab start.

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SPEED VARIATION ANALYSIS BEFORE AND AFTER THE BEGINNING OF THE STROKE IN SWIMMING STARTS.

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INTRODUCTION
Few studies involving the swimming starts have been conducted to examine the transition from the underwater phase to the stroke phase. Counsilman[1] suggested that stroking should commence when the swimmer's speed has slowed to the speed achieved when stroking. The objective of this study was to evaluate the speed before and after the beginning of the stroke and its relationship to the time to 15 meters.

METHODS
Six starts of four national and state levels swimmers were evaluated. The data were collected in the Doze de Agosto Club's swimming pool and analyzed in the Aquatic Biomechanics Research Laboratory of CEFID/UDESC. Three synchronized VHS cameras (30Hz) were used. The following variables were measured: speed before the beginning of the stroke (Sb), measured in the underwater phase, in the interval of 1 second before the first movement for beginning of the stroke; speed after the beginning of the stroke (Sa), measured in the interval of 1 second after the beginning of the stroke and time in 15 meters (T15m). Spearman's correlation with $p \leq 0,05$ were used to establish the relationship between the variation of the speed and the time to 15m.

RESULTS
The speeds before the beginning of the stroke varied from 1.3m/s to 2.14m/s, and the speeds after the beginning of the stroke from 1.52m/s to 1.76m/s. Time to 15 meters varied from 6.53s to 7.4s. The standard deviation and the coefficient of variation were always smaller in the Sa when compared with the Sb. There was a negative correlation (-0.473) between variation of speed and the time to 15 meters when the speed decreased after the beginning of the stroke. When the speed increases after the beginning of the stroke was observed a positive correlation (0.940) between the variation of the speed and the time to 15 meters.

DISCUSSION
The results indicate that beyond the importance of the underwater phase, the transition phase between the underwater phase and the stroke must have special attention, therefore to begin the stroke in the correct instant is an important factor for the performance in the starts.

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PERFECTING OF THE CRAWL IN NON-SKILLED SWIMMERS: COMPARISON BETWEEN THE DRAG REDUCTION AND IMPROVEMENT OF THE PROPULSION.

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INTRODUCTION
Swimming means a compromise between propulsive actions and gliding through water.[1] The aim of this research is to observe the improvements in non-skilled swimmers learned by a specific training program mainly addressed either to actions allowing a drag reduction and a better glide (such as balance, position in the water, breath control) or to improvement of the action effectiveness (continuity and length of the armstroke, rhythm of the own actions).

METHODS
This study involved 97 subjects, non skilled, divided into four groups: 2 male (age 20.5±1.3, 20.9±1.6, weight kg 75.8±5.4, 73.6±8.6, height cm 180.6±5.4, 178.3±5.6) and 2 female (age 21±2, 21.1±1.5, weight kg 60.4±7.2, 57.8±5.2, height cm 165.2±3.8, 166.9±3.3).
Two different learning methods for the perfecting of the crawl technique have been proposed: the first one addressed to improving the position in the water ("drag reduction" groups) the second one specific to the propulsion ("propulsion" groups). Both learning methods foresaw the same work charge and the use of the same didactical supports. Before and after the research period following swimming tests have been given: a filmed 50 m. speed test (where the time from 5 to 50m, stroke rate and stroke length have been taken and an efficiency index has been calculated) and a freestyle 6min test (where the swimming distance has been recorded).
Pre and post test results within groups have been compared by paired Student's *t* test (p<0.05). Post test results among groups were observed by One-way ANOVA.

RESULTS
In the pre-post analysis within group following significant differences (p<0.05) were found: improvement of 50m speed in the female "drag reduction" group; improvement of the efficiency index in both male groups and in the female "propulsion" group; improvement of swim distance in the 6 min test in all groups.
In the post experimentation comparison among groups differences were found only between the male "propulsion" group and each female group in the efficiency index.

DISCUSSION
Even if significant differences were induced neither in the speed, nor in the stroke rate nor in the stroke length, both learning methods employed to perfecting the crawl have been effective and made an improvement of the long distance stroke and of the stroke technique (efficiency index).
The differences found in post test among groups analysis could simply depend to the different gender of the subjects.

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SWIMMING AND TRAINING: COMPARISON BETWEEN HEURISTIC AND PRESCRIPTIVE LEARNING.

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INTRODUCTION
Various experts have expressed themselves by supporting the prescriptive-cognitive theories[1] or the ecological-dynamic or heuristic methods.[2]
The aim of this research has been to verify the results of the didactic proposal made according to the two methods: the prescriptive and the heuristic one, in two groups of children attending a swimming school.

METHODS
This study has involved 20 children average age 7-8 that have passed the first level of aquatic development (settling in). The children have been divided into two groups (group A: prescriptive and group B: heuristic) that were homogenous according to the anthropometrical characteristics and the aquatic and earth neuromotor tests. At the end of the experimentation the initial tests have been repeated and further summative tests have been made, with the aim to verify if some specific abilities of the second level of aquatic development have been reached. The data have been compared by means of Student's *t* test (significance p<0.05).
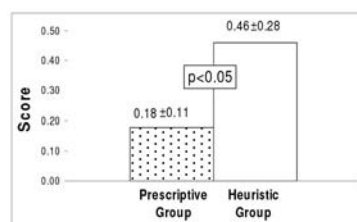
RESULTS

Figure 1. Mean and SD of score obtained in the final tests.
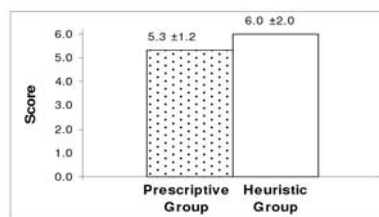

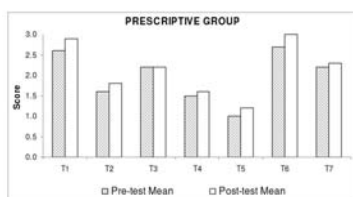
Figure 2. Summative test averages.

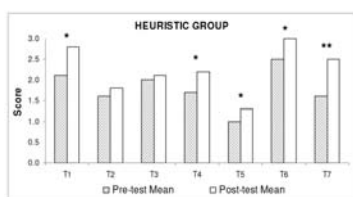*Figure 3. Comparison between pre-tests and post-tests.*

Figure 4. Comparison between pre-tests and post-tests.

DISCUSSION

From the obtained data it seems that, within the swimming teaching, an ecological dynamic approach in the learning of the technique results to be more effective than a prescribed more rigid and defined method.

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BIOMECHANICS OF TOWING IN SKILLED AND LESS-SKILLED LIFE-SAVERS.

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INTRODUCTION

Lifesaving is physically demanding and a dangerous manoeuvre both for the victim and the lifesaver. As a general rule, body contact technique should be avoided with a conscious victim (1). Lifesaving is also a very anaerobic and exhaustive manoeuvre for the performer (3). To avoid further hazards, the lifesaver must have adequate skills to perform effectively. The aim of the present study was to examine two most frequently used towing techniques in skilled (SLS) and less-skilled (LSL) lifesavers.

METHODS

Three female (20.0 ± 1 y) and five male (25.2 ± 8 y) certificated lifesavers towed an unconscious acting male victim (1.74 m, 62.0 kg) for 50 m in a 25-m pool (27º C). Cross-chest (CC) and head-neck (HN) towing grips were applied in random order. Self-chosen kicking technique was used similarly in both trials. Trials were recorded with two video cameras, above and under water, and selected body landmarks were digitized using Peak Motus system.

RESULTS

Towing time with CC grip was 78 s for SLS and 147 s for LLS; and with HN grip 83 s and 126 s, respectively. The average number of strokes using CC was 71 for SLS and 144 for LLS; and using HN 74 and 111, respectively. SLS towed with their own body close to the victim and close to the surface, while LLS had their bodies deeper in the water leading the victim's legs to sink significantly lower.

DISCUSSION

Skilled lifesavers could keep the speed high throughout the towing. The towing technique was optimal, when an effective kick was applied helping to keep the victim streamlined near water surface. LLS typically had a low towing speed leading to more upright body position in relation to water surface and hence to difficulties in keeping the victim's face above water. HN grip was found to be recommendable at least for less-skilled lifesavers. Ineffective kicking and hence poor towing aggravates drag forces in the same mechanism as during ordinary swimming. Drag forces increase especially due to the human's clothes (2, 4).

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THE BREATHING FREQUENCY CHANGES DURING SWIMMING BY USING RESPIRATORY VALVES AND TUBES.

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INTRODUCTION

Respiration during front crawl swimming is synchronised with swimming strokes. Furthermore, the breathing frequency (Bf) has to be in accordance with the stroke rate. On the contrary, the respiratory valves and tubes (RV), usually used for measuring oxygen uptake kinetics during swimming, enables optional Bf. Considering all this it could be questioned whether swimmers during swimming with RV maintain similar Bf as during swimming without RV. Therefore the purpose of the present study was to ascertain the influence of RV (1) during three different swimming tests on Bf and the selected biomechanical parameters.

METHODS

Twelve former competitive male swimmers (age: 24 ± 3 years, height: 181.3 ± 9 cm, weight: 77.4 ± 13 kg) volunteered to participate in this study. First, they performed maximal 200-m front crawl swim (MS) twice: the first with RV, and the second without RV. Thereafter, swimmers performed submaximal 200-m front crawl swim (SS) with and without RV. The velocities were determined 90% of velocity, reached at 200-m front crawl with and without RV, respectively. Finally, swimmers performed even front crawl swimming to exhaustion (SE) with and without RV. They swam as long as possible at fixed, pre-determined velocity. That was 110% of velocity, reached at 200-m front crawl with and without RV, respectively. Time and stroke rate (SR) were measured every 25-m in all the swimming tests. At the swimming tests with RV, Bf was averaged every 10 second during the swimming tests using a portable gas exchange system (Metamax 2, Cortex, Germany). At the swimming tests without RV, Bf was obtained from videotapes.

RESULTS

Swimming with RV induced slower maximal 200-m front crawl swim (1.28 ± 0.1 vs. 1.38 ± 0.1; p≤ 0.01) and shorter even front crawl swimming to exhaustion (114 ± 17 vs. 129 ± 18; p≤ 0.05) in comparison with swimming without RV. Furthermore strategies of Bf during submaximal and maximal swimming tests were also different between swimming with RV and swimming without RV (p≤ 0.01). When swimmers swam without RV, Bf was slightly increased during the swimming tests (the change of Bf during SS, MS and SE were 1.8 ± 1.83, 2.14 ± 4.34 and 1.33 ± 6.25 min[1-] per 100-m, respectively). On the contrary, increases of Bf during swimming tests were much steeper, when swimmers swam with RV (the change of Bf during SS, MS and SE were 6.28 ± 2.35, 8.75 ± 4.61 and 15.88 ± 8.3 min[1-] per 100-m, respectively). However, there were no significant differences in shapes of SR – distance curves during swimming tests comparing swimming with RV and swimming without RV.

DISCUSSION

The results of the present study show that swimmers when swimming with the RV did not maintain similar Bf as during swimming without RV. Therefore, it may be concluded that when RV is used for measuring respiratory parameters during swimming, a different pattern of breathing (comparing to swimming without RV) can occur. This conclusion suggests that in further studies which will measure respiratory parameters during swimming subjects should be instructed to keep Bf close to the Bf that they have during usual swimming without RV. During swimming with RV, they should inhale during recovery of the breathing arm.

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A TETHERED SWIMMING POWER TEST IS HIGHLY RELIABLE.

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INTRODUCTION

Measuring the force a swimmer can apply to the water is not always easy. One way to do it is using tethered swimming, and it may be discussed whether these results are transferable to normal swimming. Still tethered swimming is often used but the reliability of a tethered swimming measurement system is seldom reported. Modern load cells produce reliable measurements but within subject variation during tethered swimming is not known. The purpose of this study was to find the test-retest reliability of a tethered swimming force test, the effect of the performance level and the effect of familiarization to the procedure.

METHODS

A test-retest design was conducted, where each subject was his own control. Test and retest was conducted within one week, at the same time of day, and then repeated on two more test sessions, i.e. with and without familiarization. The 32 subjects who volunteered for the study were 22 competitive swimmers (16 males and 6 females) and 10 college sport students (9 males, 1 female). The test protocol consisted of 3 tethered trials where the maximal tethered force was registered, and the highest value was used as the test score. The subjects were connected to a load cell with peak-hold display using a rubber tube to smoothen the measured force during the stroke. The spring stiffness of the system was 20 N/m. Comparisons were done using paired and unpaired t-tests.

RESULTS

The mean (±SD) difference between the test and the retest is showed in table 1. The effect of performance level on the coefficient of variation for this kind of testing was significant – the swimmers showing significantly lower values (p<0.02). The effect of familiarization was significant for the swimmers (p=0.03) but not for students. Correlation coefficients between test-retest for all comparisons were between r=0.98 and r=0.99.

Table 1: Mean ±SD and 95% C.I. for the difference between test-retest.

	Not familiarized		Familiarized	
	Mean±SD	95% CI	Mean±SD	95% CI
Students	3.7%	2.0%	5.3%	2.6%
n=10	±3.0%	5.5%	±4.4%	8.0%
Swimmers	3.0%	1.9 %	1.6%	1.0%
n=22	±2.8%	4.1 %	±1.4%	2.2%

DISCUSSION

The within subject variation for the tethered swimming power test is small and in line with the coefficient of variation of dry land maximal isokinetic leg strength testing (<5%)[1]. The variation may be due to variations in technique, normal biological variation in performance or level of muscle recruitment at maximal effort. Swimmers seem to have lower coefficient of variation compared to students. It is concluded that a tethered swimming power test is highly reliable, assuming that the subjects perform maximally and that the protocol consists of 3 trials. Competitive swimmers have lower variation compared to college students, for whom familiarization did not reduce the variation.

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ACCIDENT STATISTICS IN AQUATIC FACILITIES.

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INTRODUCTION
Swimming for exercise and recreation is a popular activity. One of the arguments for its benefits is that the incident of accidents for accidents and injuries is very low; however the incident is seldom reported in the research literature. In the training of lifeguards, it is important to know what to expect in terms of how many accidents usually happen in and around a swimming pool, and where in the pool area these accidents take place. The purpose of this pilot study was to investigate the public accident frequency, accident types and locations, for aquatic facilities in Norway.

METHODS
The majority of public or semi public (including schools and hospitals) aquatic facilities in Norway were included in the material (n=809). In a retrospective questionnaire we asked the managers to quantify the number of personal accidents for public users in the 2003 season. Questions were organized in these categories: type of accident, type of injury, location of accident, and rescue and first aid measures performed.

RESULTS
Of the 523 returned questionnaires (65%), 70% had no reported accident of any kind. For the remaining 30% (n=156) a total of 684 accidents were reported. With a total of 20 million visits to aquatic pool facilities per annum the incident rate is 3.4 accidents per 100 000 visits. The most common types of injuries were cuts (32.5%), slipping/falling-accident (24.4%), heat stroke (5.7%) and near-drowning (5.3%). The most common medical complications were minor blood loss (56.4%), swelling (10.7%) marks/bruises (9.1%) and damage to teeth (7.2%). The locations where the injuries most commonly happened were, not surprisingly, in the pool (33.2%), at the deck of the pool (19.2%) and other wet areas in the facility (19.4%). Only 50% of the accidents were directly observed by the lifeguards.

DISCUSSION
The incident of injury for aquatic pool facilities (3.4 per 100 000) must be considered low, compared to for example the incident of alpine skiing facilities (420 per 100 000[1]). Still, measures should be taken by pool builders and aquatic management to reduce accidents. Cuts and slipping/falling accidents comprise the majority of accidents, and these accidents may easily be reduced by proper construction and maintenance of the facility. It is interesting to note that 50% of the accidents were not directly observed by lifeguards, and that these acci-dents happen in wet areas where measures of anti-skid mats would greatly reduce the number of accidents. The incident rate of accidents in aquatic pool facilities in Norway is 3.4 per 100 000 visitors. Many older aquatic facilities could probably reduce their accident rate by taking measures to reduce cuts and falling, which comprise the majority of accidents.

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THE STROKE FREQUENCY STRATEGIES OF INTERNATIONAL AND NATIONAL SWIMMERS IN 100M RACES.

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INTRODUCTION
Swimming race performance is, among other factors affected by the strategies swimmers use to control the velocity (v), stroke length (SL) and stroke rate (SR) during the various phases of the race. The strategies successful swimmers use for SR during a race is rarely investigated. The purpose of this study was to examine successful SR strategies of elite international and national junior level swimmers.

METHODS
Twenty four male finalists at the Norwegian junior national championships (NOR) and 32 male finalists at the European Short course championships (EUR) were included in the studies. International point scores for the two groups were 767 and 967 respectively ($p < 0.05$). For both championships, race analysis was performed by videography according to Thompson et al[1], where v, SR and SL are analyzed for each lap. Five models for SR strategies during a race were observed. These were model B, decreasing SR throughout the race (\\); model C no change in SR (–); model D a U-pattern (decreasing – then increasing), model E a inverted U pattern (∩) - increasing then decreasing), and model F decreasing, increasing and decreasing (\/\). The frequency of use of these models for EUR and NOR were identified for finalists (rank 4th – 6th/8th) and the top 3 performers for all 100m races in all strokes.

RESULTS
A summary of the results is displayed in table 1, showing which models are preferred for all the finalists and the top 3 performers of EUR and NOR. The most common strategy was model D for the top 3 performers and model B for the finalists.

Table 1: Fraction of swimmers (%) using each of the SR models for finalists and medallists.

modell	FINALISTS			TOP 3		
	EUR	NOR	total	EUR	NOR	total
B (\\)	35	45	39	25	50	38
C (—)	15	0	10	17	8	13
D (U)	30	45	35	50	42	46
E (∩)	10	0	6	0	0	0
F (\/\)	10	9	10	8	0	4

DISCUSSION

The results show that success in the finals coincides with SR model D - increasing SR in the end of the race. Why this strategy seems successful requires further investigations including the SL and v developments. The least successful models were model E and F, failing to keep up or decreasing the SR at the end of the race. This may be due to fatigue.

CONCLUSION

It seems that the strategies most often used by the best performers in 100m races are decreasing during the first part of the race, and increasing at the end.

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THE TEMPORAL DISTRIBUTION OF RACE ELEMENTS IN ELITE SWIMMERS.

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INTRODUCTION

Swimming race performance is, among other factors affected by the temporal distributions of the different race elements. These elements include starting, turning and finishing actions, as well as mid-pool swimming. Whether the temporal distribution of these elements is different for elite performers compared to other competitive swimmers is not well documented. The purpose of this study was therefore to examine the race strategies of elite swimmers compared to national level competitive swimmers in terms of their temporal distribution of start, turning and finishing elements of 100m races.

METHODS

24 male finalists at the Norwegian junior short cource championships (NOR) and 32 male finalists at the European Short course championships (EUR) were included in the studies. International points score for the two groups were 767 and 967 respectively (p<0.05). For both championships, race analysis was performed by videography according to Thompson et al[1], where time spent starting - t_{ST} (0-15m), turning t_{TRN} (5m in and 10m out of the turn) and finishing action t_F (last 5m) of the race is calculated. The percentage of the total time spent for starting, turning and finishing is called technical score (TS), and was calculated according to this equation, TS: $(t_{TRN1} + t_{TRN2} + t_{TRN3} + t_{ST} + t_F) / t_{TOT}$. 100m distances in butterfly, backstroke, breaststroke and freestyle were compared.

RESULTS

A summary of the results is displayed in table 1. For all 4 strokes, the international level swimmers used a significantly (p<0.05) lower percent of their race time in start, turning and finishing parts of the race compared to national junior level swimmers.

Table 1: Mean±SD of total time (tTOT) in seconds and technical score (TS) in % for European championship finalists (EUR) and Norwegian junior championship finalists (NOR).

	BUTTERFLY		BACKSTROKE		BREASTSTR.		FREESTYLE	
	tTOT	TS	tTOT	TS	tTOT	TS	tTOT	TS
EUR	51.87	62.63	52.68	60.96	59.87	61.69	48.07	62.17
n=8	±0.60	±0.31	±0.86	±0.26	±0.59	±0.36	±0.30	±0.48
NOR	58.79	63.19	62.07	62.16	67.54	62.50	53.74	62.92
n=6	±1.46	±0.59	±1.75	±1.18	±2.56	±0.56	±0.83	±0.54
p<	0.001	0.04	0.001	0.02	0.001	0.01	0.001	0.02

DISCUSSION

The results show that the better performers (EUR) use a smaller portion of their total race time for turning, starting and finishing actions compared to the juniors. The relative importance of these phases is greater for international level swimmers and might be a success criterion. Among different strokes, backstroke races seem to have the smallest portion of time devoted to starts, turn and finishes. International level swimmers have better starts, turns and finishes compared to national caliber swimmers in 100m races.

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THE VALIDITY OF A NON-PACED LACTATE PROFILE TEST FOR SWIMMERS.

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INTRODUCTION

Lactate profile testing in a laboratory setting normally includes the use of workload control by electrically controlled treadmill or ergometer cycles. In the pool this is not an option unless a flume is present. Using pacer-lights has been suggested to control workload when testing swimmers [1]. The aim of this study was to examine whether swimming without pace-lights affects lactate test results compared to swimming with pacer-lights.

METHODS

A randomized crossover design was conducted, where each of the 11 competitive swimmers (mean age 20 years (range16-24)) was their own control, swimming on one day with and one day without paced workloads. The stepwise test protocol consisted of five 400m front crawl workloads with increasing velocity. Predetermined velocities for each swimmer were either controlled by the swimmer himself or paced using a set of 14 pace-lights (Optimal Controlbox Corp.) moving below the swimmer. Lactate data and velocities were collected.

RESULTS

The mean velocities of paced or non-paced workloads at lactate values of 2, 3, 4 and 5 mM showed no statistical difference (see

fig. 1). Standard deviations of the time for each pool length from the mean time was for all trials and all subjects, 0.61s using pacer lights and 0.60s swimming freely (p>0.05). No statistical difference was found between the average decrease in swimming time from workload to workload in paced compared to non-paced swimming (14.4s and 13.0s respectively p>0.05).
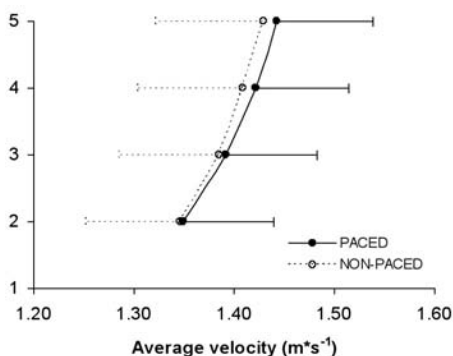

Figure 1: Average velocities (±SD) for paced and non-paced workloads (n=11) at lactate levels of 2, 3, 4 and 5mM.

DISCUSSION

The custom of lactate testing in swimming without some form of pacing control is justified by the present results. It shows that competitive swimmers may keep a fairly even pace and are able to work at the prescribed workload (velocity) without pacing help. In laboratory testing on dry land, both keeping an even pace (to attain steady state) and meeting a predetermined and well distributed increase in workload is important. Both seem to be possible to attain in swimming field testing without using any form of pacing help. However measurements of oxygen uptake and other physiological parameters may still require the use of pace-lights. The results of this study support the common practice of lactate testing in the pool for swimmers, without the use of paced workloads. Competitive swimmers are able to hold an even pace and meet predetermined workloads without this form of assistance.

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GOALKEEPER'S EGGBEATER KICK IN WATERPOLO: KINEMATICS, DYNAMICS AND MUSCULAR COORDINATION.

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INTRODUCTION

Unlike his colleagues of a waterpolo team the goalkeeper has to maintain an upright position the whole time and must be prepared to raise his body very quickly out of the water, reaching out for the ball thrown in the corner of his goal and catching it. The reaction forces necessary to meet these requirements must be generated by the interaction of the goalkeeper's body parts and the surrounding water since no rigid platform exists for a push-off of the body. Not only to avoid sinking down in the water but even more performing ascending movements out of the water the goalkeeper exerts a special leg kicking motion –the eggbeater kick- as well described by Sanders (2005) in a very detailed way.

The objectives of this study are to give some examples of kinematics of a goalkeeper's typical movements, estimates of the forces necessary for "jumping out of the water" combined with the presentation of some activation patterns of leg muscles during eggbeater kick.

METHODS

The kinematics of the goalkeeper's movements was registrated by using a Doppler-Ultrasound-Velocimeter System measuring continously the speed of vertical ("up and down") movements. From this signal, the time curves of the vertical distance covered by the jumps were obtained by integration whereas a numerical differentiation yielded the acceleration curves representing an approximation for the acceleration of the goalkeeper's centre of gravity. By multiplying with the body mass we got estimate values of the vertical forces generated by the eggbeater-kick examined by a synchronized underwater video system. Muscular coordination was observed synchronously by sub aquatic electromyograms from M. glutaeus maximus, M. vastus medialis and M. adductor longus of the subject's right hand side.

RESULTS

The different test situations (climbing acts done with and without the help of arms, performing single jumps and multiple jumps successively, maintaining of a certain height level above the water) showed height values up to 0,7 m; the vertical speed varying from +/- 0,8 m/s to 2 m/s. The force estimates yielded peak values up to 800 N – higher values than generated in "normal" swimming. The muscle activation patterns gave an insight into more or less cyclic activity up to 2 times per second announcing a high potential of muscular fatigue.

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ENERGY COST DURING FRONT CRAWL SWIMMING: PREDICTING SUCCESS IN BOYS AT DIFFERENT BIOLOGICAL AGES.

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INTRODUCTION

The ability to assess the energy cost during swimming and pre-

dicting competition success from different anthropometrical and physiological values in children are important in swimming. Accordingly, the aims of the present investigation were to: 1) assess the use of recovery oxygen consumption values for determining oxygen cost during front crawl swimming; and 2) determine the factors that best predict maximal oxygen consumption and the ability to perform a 400-m front crawl swim.

METHODS
Twenty nine prepubertal (Tanner stages 1 and 2) and pubertal (Tanner stages 3 and 4) boys (13.0±1.8 yrs; 163.6±11.9 cm; 51.6±13.0 kg; %body fat: 12.1±5.3 %) underwent different anthropometrical and physiological measurements. Swimmers also performed 400-m front crawl swimming to determine the validity of calculating exercise oxygen consumption from expired gas samples taken during the first 20 seconds of recovery after the activity. During the 400-m front crawl swimming, the average speed (v), stroke frequency (SF), stroke length (SL), stroke rate (SR) and stroke index (SI) were computed. In addition, energy cost of swimming (Cs) from the measured parameters was calculated. Dual energy X-ray absorptiometry was used to measure different body composition parameters and maximal oxygen consumption was determined on a bicycle.

RESULTS
Prepubertal children had smaller values for measured body composition and maximal oxygen consumption values except for body fat and oxygen consumption per kg body mass values compared to pubertal children. Similarly, mean v (0.99±0.12 vs 1.12±0.13 m/s), SL (0.87±0.11 vs 0.99±0.10 m/cylce), SI (0.87±0.20 vs 1.11±0.22 m²/s/cycles), Cs (2.38±0.41 vs 3.29±0.67 kJ/min) and oxygen consumption (2.53±0.50 vs 3.92±0.90 l/min) during 400-m front crawl swimming were significantly lower in prepubertal boys compared to pubertal swimmers. Relationship between directly determined maximal oxygen consumption and oxygen consumption determined after 400-m front crawl swimming was highly significant (r=0.850; p<0.001). Swimming performance at 400-m front crawl distance was best determined by specific anthropometric and body composition (height, arm span, fat free mass, bone mineral mass and density), physiological (maximal oxygen consumption) and swimming technique (v, SL and SI) parameters in boys.

DISCUSSION
It is possible to accurately determine oxygen consumption during maximal swimming using a single, 20-s expired gas collection taken immediately after 5-7 min maximal front crawl swim in prepubertal and pubertal boys. In addition, specific stroke technique parameters are important determinants of the energy cost and variations in performance during swimming in prepubertal and pubertal boys.

ENERGY COST AND INTRA-CYCLIC VARIATION OF THE VELOCITY OF THE CENTRE OF MASS IN BREASTSTROKE.

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INTRODUCTION
The purpose of the present study was to analyse the relationship between energy cost (C) and intra-cyclic speed fluctuations (dv) in breaststroke.

METHODS
Four elite breaststroke swimmers (2 males of 17.0±0.0 yy, 172.5±3.5 cm and 69.4±2.0 kg, and 2 females of 17.5±2.1 yy, 167.0±7.1 cm and 64.2±4.2 kg) performed an incremental intermittent protocol (n x 200m) for maximal oxygen consumption assessment (Fernandes et al., 2003), during which biomechanical and bioenergetical parameters were measured. The test was videotaped in sagittal plane with two SVHS cameras, providing, after mixing and editing, a dual-media image of the swimmer. The APAS software (Ariel Dynamics Inc, USA) was used to calculate the variation coefficient (dv) of the v(t) function of the centre of mass (CM) for each 200m step. Oxygen consumption was measured through a portable gas analyser (K4 b², Cosmed, Italy) connected to the swimmers by a respiratory snorkel and valve system. Capillary blood samples were collected from the ear lobe, before and after each set, to analyse blood lactate concentrations (YSI 1500L Sport, USA). The energy expenditure ($\dot{E}$) and C ($\dot{E}.v^{-1}$) were calculated for each 200m using net values of VO_2 and blood [La-], converted with a 2.7 $mlO_2.kg^{-1}.mmol^{-1}$ constant.

RESULTS

Figure 1. Relation between C and dv.

Intra-cyclic speed fluctuations (dv) decreased with mean swimming velocity (r=-0.63, p≤ 0.01). $\dot{E}$ increased with v^3, and, as it is possible to observe in Figure 1 for each swimmer, C decreased with increasing dv.

DISCUSSION
As it was expected, a cubic relationship between $\dot{E}$ and dv was found, once energy output is a function of mechanical power, and the latter is expected to be a function of v^3. The relationship obtained between C and dv do not confirm previous literature (Vilas-Boas, 1996). This finding may be due to differences in methodological procedures, or more obviously due to the higher influence of v, than dv, in $\dot{E}$.

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ACUTE EFFECTS OF THE USE OF A BIOFEEDBACK SYSTEM FOR THE TECHNICAL TRAINING IN BREASTSTROKE SWIMMING.

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INTRODUCTION
The purpose of this research was to develop, validate, and evaluate a biofeedback system for the technical training in breaststroke swimming. The system lied on the assessment of speed fluctuation curves of an anatomical landmark of the swimmer (hip).

METHODS
The research developed through the informations displayed by a cable speedometer, specifically produced for the study, which signal was synchronized with dual media video images of the swimmer's performance. The velocimetric signal was graphically registered, and acoustically provided to the swimmer and coach during the performance. For the appreciation of the utility of the biofeedback solutions proposed for the technical training of breaststrokers, the acute effect of their use was analysed. For that purpose, the acute biomechanical response of five homogeneous (speed fluctuations and sex) groups to five different technical training programs with one hour of duration were studied. All the groups intended to minimize the speed fluctuations within a stroke cycle (dv = variation coefficient (VC) of the instantaneous velocity distribution) at the mean velocity correspondent to the race pace of the 200m breaststroke event. The sample was composed by 50 swimmers distributed by five groups of 10. Group 1 used only informations provided by the swimmer's coaches, Group 2 used also the graphical data provided by the speedometer, Group 3 included also dual media video images, and groups 4 and 5 accumulated concomitant acoustic informations (Group 4 every cycle, and Group 5 once in each two cycles).

RESULTS & DICUSSION
VC ranged from 0.40 to 0.43, without statistical significant differences between groups. The mean values of stroke length (SL) were between 1.41m and 1.65m, with less homogeneity between groups. The cycle duration (T) ranged between 1.5sec and 1.7sec. The mean velocity per cycle (V) was between $0.9 m.s^{-1}$ and $1.0 m.s^{-1}$, and the Stroke Index (SI=V*SL) varied between 1.4 and $1.8 m^2.s^{-1}$. The higher positive acceleration values were observed, in all groups, during the propulsive leg action, and ranged between $4.8 m.s^{-2}$ and $5.7 m.s^{-2}$. Among the main conclusions of this research, it is possible to state that: (i) the use of the biofeedback devices (graphical and acoustic displays of the speedometer, and dual media video images) influenced the motor learning processes associated to the acute effect of the swimming technical training provided - this effect is as larger, as higher and frequent the quantity of information provided; (ii) the swimming technical training of one hour of duration, complemented or not by additional technological means, has as acute effect a depression of the subjects' technical ability; (iii) the technical changes with training, at least during a one hour process, are not temporal, but spatial, or derived ones (velocity, and acceleration), and each group distinguished from the others, in each evaluation moment, from very detailed and changing technical variables.

EVOLUTION OF BUTTERFLY TECHNIQUE WHEN RESISTED SWIMMING WITH PARACHUTE, USING DIFFERENT RESISTANCES.

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INTRODUCTION
The use of resistance training with parachute, modifying posterior diameter, produces variations in the stroke frequency (SF), the stroke length (SL), speed (S) and stroke index (SI) during swimming. It is necessary to observe the progressive modifications produced in these parameters as the resistance swimmers must drag is increased. With this data trainers can decide the type of load and period of preparation in which it should be used, in order not to negatively affect swimmers' performance. It will also permit him to know which parameters have greater variation and must be controlled during training.

METHODS
The study was carried out with 18 swimmers of national level between 19 and 22 years of age. They carried out 6 tests consisting in swimming butterfly style 25 meters at maximum intensity using normal swimming (NS) and resisted swimming with parachute (RSWP) with a front diameter of 30cm and a posterior diameter of 30cm, 22.5cm, 15cm, 7.5cm and 0cm. The lap times and number of cycles in the central 10 meters, of the 25 meter distance were registered. SF, SL, S, and SI variables were analyzed in these tests. An intra-subject design was applied and the study of the data was carried out by means of a variance analysis for repeated measures.

RESULTS
The results obtained showed how the SF does not significantly differ with different spans, but there are significant differences between NS and 0cm (p=0.015), 15cm (p=0.001) and 30cm

(p=0.022). Significant modifications (p<0.000) are produced in SL between NS and all other diameter. Significant differences (p<0.05) were also found between all diameters, except between 0cm and 7.5cm and between 22.5cm and 30cm. Speed was significantly modified (p<0.001) between NS and all resisted swims with different diameters. Differences were also observed between the different diameters (p<0.000) except between 0cm and 7.5cm, and between 7.5cm and 15cm. Significant modifications (p<0.000) were observed in SI between NS and all types of resisted swims. Significant variations (p<0.05) were also observed between the different resisted swims except between 0cm and 7.5cm.

DISCUSSION

SF, S and SI variables show a clear variation between NS and different resisted swims, significantly worsening in all parameters due to the increase in resistance. A progressive modification, though less stressed, is also observed in the different resistances. In SF the modifications are less important though significant between NS and some types of resisted swims; however, the application of different resistances does not seem to considerably affect this variable.

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BUTTERFLY LEG MOVEMENT PATTERNS IN DIFFERENT TECHNICAL EXERCISES.

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INTRODUCTION

The swimmers in the training sessions have executed different technical exercises, made up of isolated actions for the upper and lower limbs separately, some of them using support material. The exercises will help to find a completely different set of movements from those used by the swimmers when they displace in free swimming. The depth of these differences is not known with accuracy. The purpose of this study was to determine the cinematic changes in the butterfly technique in the following conditions: swim global (NG) and in "partial" exercises for the lower limbs with float (CF) and without float (SF),

METHODS

The test was carried with a group of 4 swimmers (national and international ranks).
Three trials of 25 meters, at maximum swimming speed, with a respiratory cycle for each one stroke. The underwater images where captured by 1 digital chamber video (Sony Mini DV DCR - TRV18E) fixed, that protected by "coach scope". The processing of the data and the calculation of the kinematics variable (swimming velocity, distance per stroke and stroke rate) had been used the informatics program Ariel Performance Analysis System (APAS).

RESULTS

In the stroke distance we find differences between the different conditions of execution what it indicates that the immobilization of the upper limbs is an inhibiting factor of the technique of swims global, concluding to be harmful. We verify that difference exists between the swim partial, being the execution with float to suffer a bigger space alteration, in that it respects to the speed exists significant differences between I swim it global and I swim it partial with and without float. The Speed of swim in the condition of execution without float is superior to the one with float even so not exists significant stactical differences. For swimming speed we found differences between it I swim global and both the partial swim ones.

DISCUSSION/CONCLUSIONS

We have been able to verify differences in some of the cinematic parameters analysed for all the different execution conditions.
We were able to infer that the use of the plate can be harmful in the most waving execution of the butterfly technique, because this is an exercise that does not take advantage of lower limbs action in the equilibrating oscillation of the body in the sagittal plan.
We can conclude that partial swimming with float and without float they have great alterations in the speed of displacement in relation to I swim it global. Deducing in this way that the immobilization of the upper limbs to the front has implications in the speed of displacement of the swimmer. In that it says respect to the movement structure did not exist significant modifications of the cycle in the different exercise conditions, in contrast in that it respects to the space structure where we find alterations between the partial swim ones and I swim global, as well as enters the two conditions of I partial swim.

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SIMULTANEOUS STYLES SWIM TECHNIQUE QUALITATIVE EVALUATION IN INTERNATIONAL SPANISH JUNIOR AND PRE-JUNIOR SWIMMERS: AN ANALYSIS OF ERROR FREQUENCY.

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INTRODUCTION

This is a four years study compilation of the analyses developed with the Spanish Junior National Team during the summer training camps (three-week taper) before their participation in the European Junior Championships. The purpose of this study is to determine the frequency of breaststroke and butterfly swim mistakes.

METHOD

77 junior and pre-junior male and female elite swimmers performed the butterfly swim while 55 performed the breaststroke swim. Two video cameras were used to record the turn sagital and frontal view of a 50 m trial at competitive speed through an underwater window. It was employed an 8 mm video cassette recorder with frame by frame image stop.

Turn	Butterfly				Breaststroke			
	Male		Female		Male		Female	
Group	Junior	Pre-junior	Junior	Pre-junior	Junior	Pre-junior	Junior	Pre-junior
Age	14-15	12-13	16-17	15	14-15	12-13	16-17	15
N	26	22	14	15	18	14	9	13

RESULTS

The highest number of errors found in butterfly stroke correspond to pulling with elbow dropped (42%), a common mistake even in skilled butterfly swimmers (Maglischo, 2003). In 74% of breaststroke swimmers viewed we detected hips too flexed, with similar data between female categories.

TURNING MISTAKES (%)	Male		Female	
	Junior	PreJunior	Junior	Prejunior
BUTTERFLY				
Pulling with elbow dropped	50	55	21	27
Incomplete insweep underneath the body	27	41	50	60
No complete the downbeat of the second kick	31	41	14	33
BREASTSTROKE				
Too flexed hips	83	71	67	69
Too separated elbows at arm recovery beginning	67	64	78	54
Shoulders or hips no horizontal	67	50	67	62

DISCUSSION

In this analysis, the mistakes in butterfly are related to propulsion situations; nevertheless, in breaststroke are more related to the increase of resistance problems in legs and arms recovery phases. Male butterfly swimmers apply force in a different way than female; they describe a wider trajectory with hands.

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QUALITATIVE EVALUATION OF SIMULTANEOUS STYLES TURN TECHNIQUE IN INTERNATIONAL SPANISH JUNIOR AND PRE-JUNIOR SWIMMERS: AN ANALYSIS OF ERROR FREQUENCY.

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INTRODUCTION

This is a four years study compilation of the analyses developed with the Spanish Junior National Team during the summer training camps (three-week taper) before their participation in the European Junior Championships. The purpose of this study is to determine the frequency of mistakes observed in breaststroke and butterfly turns.

METHOD

75 junior and prejunior male and female elite swimmers performed the breaststroke turn while 54 performed the butterfly turn. A video camera to record through an underwater window the turn sagital view of a 50 m trial at competitive speed and an 8 mm video cassette recorder with frame by frame image stop was used.

Turn	Butterfly				Breaststroke			
	Male		Female		Male		Female	
Group	Junior	Pre-junior	Junior	Pre-junior	Junior	Pre-junior	Junior	Pre-junior
Age	14-15	12-13	16-17	15	14-15	12-13	16-17	15
N	18	14	9	13	26	21	13	15

RESULTS

Twenty eight percent of the total group performed the turn with separated hands in push off breaststroke turn phase, and 30% did not join their hands in gliding phase. Otherwise 15% of the total group performed the turn with elbows flexed in butterfly style gliding phase.

TURNING MISTAKES (%)	Male		Female	
	Junior	PreJunior	Junior	Prejunior
BREAKSTROKE				
Separated hands in gliding phase	28	7	67	31
Separated hands during the push off phase	39	7	44	23
Separated arms in gliding phase	39	0	56	8
BUTTERFLY				
Flexed elbows in gliding phase	19	15	14	7
Misaligned head-trunk: flexed neck in gliding phase				
	8	10	31	13
Separated arms in gliding phase	19	0	38	0

DISCUSSION

The highest errors frequencies are found in push off and gliding breaststroke style phases, while in butterfly mostly occur in the gliding phase. In this style women have the most appearance errors and the highest percentage per error. The highest number of errors were found in female junior category which is not a favourable data because it imply a reduction of their technical performance level as they grow, this occur probably because of the increasing training volume in this ages. We think technique planification conception of Spanish elite swimmers in simultaneous styles, and particularly in women, must be reconsidered.

A MATHEMATICAL MODEL FOR THE ASSESSMENT OF THE INDIVIDUAL ANAEROBIC THRESHOLD.

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INTRODUCTION

Several methods have been developed to assess the exercise intensity after which the lactate production exceeds its removal, i.e., the anaerobic threshold (AnT) (Brooks et al., 2000). One of the most used methods for AnT assessment is based on the averaged value of 4 mmol/L of blood lactate concentration [La-] proposed by Mader et al. (1976). However, the [La-] corresponding to AnT has been reported to have great variability between swimmers. Other methodologies for AnT determination have been proposed to find more specific and individualized values for this parameter. This work presents in detail a mathematical model to obtain an individual value for the AnT in swimmers. This model has been used by Fernandes et al. (2005) to assess the individual AnT (IndAnT) for 32 swimmers.

METHODS

A set of N velocity-[La-] data points, were split in two groups: points 1 to k for the first group and points k+1 to N for the second group, where k ranged from 2 to N-2. Two separate least squares fits were made: a linear fit to the first group; and an exponential fit to the second group. These two separate fits were computed for all N-2 possible values of k. The computer program was implemented in MatLab, and the output consisted in N-2 plots of the velocity-[La-] data points and the fitting line and exponential, as well as, the corresponding fitting parameters, point of interception of the curves and the value of the residue.

RESULTS

Figure 1 shows an example of a fit by a line and an exponential. The value of IndAnT is obtained by the interception of both curves. The best set of fitting curves is chosen by visual inspection of the output plots and inspection of the values of the residue. Fernandes et al. (2005) found that the velocity obtained using the 4 mmol/L of [La-] was significantly different from that obtained using the present method.
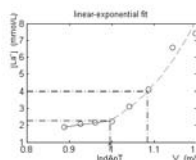

Figure 1. An example of a fit.

DISCUSSION

The main conclusion of this work is that this method seems to model in an adequate and individual way the anaerobic threshold of swimmers.

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RELATIONSHIP BETWEEN LEFT VENTRICULAR DIMENSIONS AND FUNCTION AND MAXIMAL OXYGEN UPTAKE IN YOUNG SWIMMERS.

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INTRODUCTION

In the exercising human, maximal oxygen uptake (VO_2max) can be potentially limited by each step of the oxygen pathway from the atmosphere to the mitochondria: (1) the pulmonary diffusing capacity, (2) the cardiovascular system, (3) the oxygen-carrying capacity of the blood, and (4) the muscle oxidative characteristics. Of particular importance is the cardiac system (function and/or size). The purpose of this study was to analyse the relationship between left ventricular (LV) dimensions and function and VO_2max in young swimmers.

METHODS

Twelve young swimmers (15.88 ± 0.22 years old; 64.21 ± 6.81 Kg of body mass; 1.75 ± 0.58 m of height) took part in this study. Cardiac dimensions and function were determined by two dimensional M mode and Doppler echocardiography. Echocardiographic data were expressed in absolute units and then scaled allometrically for individual differences in anthropometric data. VO_2max was determined using the modified Balke treadmill protocol. Body mass (BM), height (H), body surface area (BSA), body fat percentage (%BF) and fat free mass (FFM) were measured according to standard procedures. Pearson product–moment correlation coefficient was calculated to evaluate the relationships between LV dimensions and function and VO_2max.

RESULTS

Absolute VO_2max and VO2max/%BF correlated significantly with LV internal chamber dimension at end–diastole (LVIDd), left ventricular mass (LVM), LV internal chamber dimension at end–systole (LVIDs), LV volume at end–diastole, LV volume at end–systole, stroke volume (SV) and cardiac output (Q). VO_2max/BM correlated significantly with LV volume at end-diastole and SV, VO_2max/BM $^{0.821}$ correlated significantly with LVIDd, LV volume at end - diastole and SV, VO_2max/BM $^{0.67}$ correlated significantly with LVIDd, LV volume at end – diastole, LV volume at end – systole, SV and Q, VO2max/FFM correlated significantly with LV volume at end – diastole and SV. Non significantly correlation was observed between absolute and relative VO2max and fractional shortening (FS), ejection fraction (EF) and ratio of early passive (E) to late atrial contraction (A) filling of LV (E:A ratio).

DISCUSSION

Our study suggests that the heart size was highly correlated

with VO2max in young swimmers athletes and LVId was the main determinant factor. The relationship between LV volume at end–diastole (estimated diastolic function) and VO₂max suggested that the maximal heart pumping capacity during exercise was influenced by LV volume at end–diastole. The non relationship between EF and VO₂max suggests that the systolic function at rest do not have a relevant influence on VO2max, and that LV volume at end–systole was related to LV size and not to ejection performance.

RELATIONSHIP BETWEEN MUSCLE MASS AMOUNT AND SPECIAL STRENGTH PRODUCED BY HIGH LEVEL SWIMMERS.

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INTRODUCTION
Dry-land strength training is an important factor for the improvement of the sprinters performance[2]. The increase in muscle volume is a morphological adaptation that contributes to significant increase in strength. Although this may decrease the speed of movement due to increase of the transversal section of the swimmer's body, many coaches believe this increase might be compensated by the application of a greater force per stroke. Then, the goal of this study was to verify the relationship between the swimmer's muscle volume and how to apply strength in special conditions.

METHODS
The study sample is compound by 6 male swimmers specialized in 50 and 100m freestyle (23,53 ± 1,05 years) and 6 male swimmers in 200m free style (21,02 ± 4,03 years), and 5 female swimmers specialized in 50 e 100m free-style (22,75 ± 2,36 years) and 7 female swimmers specialized in 200m freestyle (20,33 ± 3,50 years), all of them part of the Brazilian national team pre-selected for the 2007 Pan American Games. The swimmers' special strength has been measured by the tethered swimming, starting at 3 repetitions with 5 seconds each. The data obtained in the test were: maximum force (MF) and average force (AF). Muscle mass (MM) was estimated by the equation proposed by MARTIN et. al. (1990). To analyze the data, Pearson's moment product correlation was utilized. The level of significance was p ≤ 0.05.

RESULTS

Table 1. Correlation between MM, MF e AF.

	Male				Female		
	100m		200m		100m		200m
	MM		MM		MM		MM
MF	0.57	MF	0.09	MF	0.32	MF	0.82*
AF	0.45	AF	0.45	AF	-0.21	AF	0.66
			* significance (p≤ 0.05)				

DISCUSSION
The present study showed a small correlation between the MM and the special strength in the male group of swimmers. In the female group of swimmers, a good and moderate correlation was noticed only in the group specialized in the 200m distances, which can be explained by the great variation in muscle mass in this group (15%). According to these results, we concluded the MM presents a small relation to the swimmers capacity at the higher level in producing force in specific conditions.

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CHRONOMETRIC PARAMETERS ANALYSIS OF NATIONAL AND WORLD SWIMMING COMPETITION EVENTS.

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INTRODUCTION
The purpose of this study was to create a swimming statistical model for different groups of swimmers, based on semi-quantitative biomechanical swimming parameters: start, pure swimming, turn, and arrival times, for 100m events (Butterfly, breaststroke and freestyle). Some researches (1, 2, 3) proposed some systems of swimming competitions analysis, used in most of the international swimming events. Those systems give information about the several phases of the competition, giving valuable feedbacks to the training process.

METHODS
Subjects were swimmers from the Portuguese National Clubs Championship of the 1st and 2nd League (32 male and 32 female) in 2002 and from the World swimming Championship at Fukuoka 2001 (8 male and 8 female). Fukuoka 2001 competition observation protocol was used. Five digital cameras recorders were displayed along the swimming pool. Head was used to define the lines. The time information was obtained from the electronic chromo. All data were analysed as means ± S.D. Standard error of the estimate was used in equation prediction. Significance was set at $P<0.05$.

RESULTS
Accordingly to the results pointed out, the start time represents 11% of the competition time. The pure swimming time was the component that fulfills the competition time: 70% (100m freestyle), 71% (100m Butterfly) and 67% (100m Breaststroke). The turning time, in 100m freestyle and 100m Butterfly represents 11% and 12%, and in Breaststroke represents 14% of the total competition time. The arrival time is about 5% of the total competition time. 100m Butterfly was the longest except for the 1st league swimmers. Different regression equations, depending on the swimmers level, were obtained for each one of the chronometric variables of swimming event analysis.

DISCUSSION

Distinguished swimming models were found in every group, for the 3 swimming techniques analyzed. The swimming competition components, starts, turns and arrivals, correspond to 29% (100m freestyle) and 30% (100m butterfly) of the swimming events. The competition analysis should be an ordinary procedure that allows a construction of an individual swimming model. Their often utilization will give to the coach and the swimmer precise information about the weakest and the strongest point of each swimming competition.

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SWIMMING VELOCITY IMPROVED BY SPECIFIC RESISTANCE TRAINING IN AGE-GROUP SWIMMERS.

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INTRODUCTION

Sprint-resisted training is suggested for swimming performance improvement (2) despite altered stroke mechanics during sprinting with resistance (1). However, the effect of the sprint-resisted training on competitive performance and swimming velocity has not been examined. The purpose of the study was to examine the influence of a 12-week sprint-resisted training period on maximum swimming velocity and competitive performance.

METHODS

Eighty-two (N=82) swimmers were assigned to an experimental (E, n=53) and control (C, n=29) group. Both groups (E and C) followed three sprint training sessions per week (SPR), with and without resistance respectively, in addition to their daily training for twelve weeks. Resistance was applied by a bowl (35cm diameter, with an additional load of 170gr and 5 holes of 8mm diameter) tethered by its convex side with a rope attached to the hip of the swimmer. Swimming velocity during a 10-m maximal free swimming was evaluated before and after the training period using photocells (Lafayette instrument Model 63501IR) Swimmers were tested using their individual best swimming stroke. Swimming performance on distances of 50-100-200m was recorded during competition at the start and after the completion of the 12-week training period.

RESULTS

At the end of the 12-week training period both groups improved the 10-m sprint maximum velocity compared to pre-training (p<0.05). Group E displayed significant improvement compared to group C (7.7±3.4 vs. 1.1±1.6%, between groups, p<0.05). Similar improvements observed when each stroke was examined separately. Performance of distances of 50, 100, 200m during competition was improved more in group E compared to C (p>0.05).

DISCUSSION

The applied form of sprint-resisted training method had a positive outcome in developing speed on all four competitive strokes. Thus, it is recommended for development of maximum swimming speed. Further research is needed to examine the effect of this type of training on performance during competition.

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ANALYSIS AND COMPARISON OF RESULTS OF THE MADER TEST IN DIFFERENT STROKES IN AGONISTIC SWIMMERS.

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INTRODUCTION

In literature several studies were addressed both to analyze the blood lactate concentration after competitions and to set the optimal intensity level during the training.[1,3]
The aim of this study is to evaluate the differences of lactate production between high level male and female swimmers practicing four strokes, and the differences of lactate production among these strokes in swimmers of the same sex, using the Mader test modified.

METHODS

We have studied 40 high-level males (age 17.3±0.2) and 40 high-level females (age 16±0.2), who performed two 200m tests in their own discipline (crawl, butterfly, backstroke, breaststroke), one at sub-maximal speed ([La] < 4mmol/l) and the other at maximal speed.
The times at 4mmol/l and the peak lactate concentration (direct values by a fingertip sample of blood) have been collected. The *lactate / time at the anaerobic threshold* rate has been calculated. The results have been compared using the Student's *t* test (p<0.05).

RESULTS

	Time at threshold speed (s)			[La] peak (mmol/l)			[La] /time anaerobic threshold		
	Male	Female		Male	Female		Male	Female	
Free	145.72±13.97	159.12±8.02	**	11.00±1.59	9.34±1.91	*	0.0275±0.002	0.0251±0.001	**
Fly	171.93±10.19	178.7±5.85	**	11.24±1.30	10.17±1.46	**	0.0233±0.001	0.0223±0.007	*
Back	166.36±14.24	171.8±14.14		11.35±2.36	8.96±1.74	**	0.0241±0.002	0.0233±0.002	
Rest	180.32±7.61	198.16±9.71	***	11.93±1.15	9.01±1.76	**	0.0241±0.009	0.0202±0.001	***

DISCUSSION

The male subjects have produced much more lactate for each stroke than the female ones. Some authors explain this phenomenon because of a lower muscular mass / blood volume ratio in the female subjects, other authors claim they produce less lactate and eliminate it faster than male subjects because of a lower glycolytic activity of musculoskeletal system associated with a higher capacity of lactate oxidation.
In male athletes we have found the higher peak lactate concentration in breaststroke, according to Chatard[2], whereas in females athletes it was found in butterfly, but not in backstroke which was the finding of Chatard.

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ANALYSIS AND COMPARISON OF SOME AQUATIC MOTOR BEHAVIORS IN YOUNG CHILDREN.

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INTRODUCTION

In literature there are many studies about aquatic motor sequences in young children that interested different aspects of aquatic psychomotor development. [1,2,3]
The aim of this study was to investigate if the spontaneous swim movements following a methodological approach based on "keep doing" and on "free exploration" of the children can evolve into effective actions.

METHODS

This study involved 30 children divided into 3 groups composed of 5 males and 5 females each, respectively aged 4-12 months (group A), 12-24 months (group B) and 24-36 months (group C).
Age and anthropometric data (weight and height) were taken for each subject. Moreover a personal report about the presence of some specific swim movements (submersion, inclined body position, simultaneous and alternating actions of arms and legs) was drawn up.
The data survey was executed before and after a 10-lesson program that has been carried out following a methodological approach based on "keep doing" and on "free exploration" of the children.

RESULTS

A comparison of the pre-post status within group and a comparison among the three groups for each characteristic observed, were conducted with a Mann-Whitney non-parametric Test, for p<0.05.
No significant differences (p>0.05) were found in the comparison between the pre and post experience analysis within group. On the contrary significant differences (p<0.05) were found both in the comparison 4-12 versus 24-36 months of age and in comparison 12-24 versus 24-36 months of age.

DISCUSSION

The results lead us to contemplate that the aquatic motor development of the young children could mainly depend on the age.
On the contrary it seems that the environmental stimulation doesn't influence significantly the aquatic motor behaviors considered.

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KINEMATICS PARAMETERS OF CRAWL STROKE SPRINTING THROUGH A TRAINING SEASON.

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INTRODUCTION

Swimming performance is closely related to the stroke kinematics parameters (1). Considering that swimming velocity (SV) is the product of stroke lenght (SL) by stroke rate (SR), the purposes of this study were to verify training influence on front crawl SR, SL, SV and stroke index (SI, product between SL and SV) in sprinting trials.

METHODS

Nine swimmers (7 males and 2 females; mean age = 14.78 ± 1.48 years) participated in this study. The protocol consisted

on the evaluation of SR, SL, SV and SI in a 25 m maximal effort test, every ten weeks, before (M1), during (M2), and after (M3) five months of training. Measurements were obtained from manual counting of cycles and time from 10 to 25 m of the trials. Anthropometric data were collected. Intensity and distance swan during the training season were controlled. ANOVA repeated measures, Bonferroni post-hoc tests and Intra-Class Correlation Coefficients (ICC) were applied to the data, adopting a 0.05 significant level

RESULTS
Anthropometrics and kinematics results for the three moments are in Table 1.

Table 1. Mean ± s.d. of height, upper limb span, total body mass, SR, SL, SV and SI; M1 = before training season; M2 = during training season; M3 = after training season. Letters indicate significant differences.

Variables	n	M1	M2	M3
Height (cm)	9	168.8 ± 0.13 [a]	169.3 ± 0.13	170.0 ± 0.12 [a]
Upper limb span (cm)	9	172.1 ± 0.13 [a,b]	173.3 ± 0.13 [a,c]	174.3 ± 0.13 [b,c]
Total body mass (Kg)	9	56.2 ± 14.2 [a]	57.2 ± 13.3	58.5 ± 13.3 [a]
SR (Hz)	9	0.85 ± 0.08	0.91 ± 0.09	0.89 ± 0.08
SL (m)	9	1.79 ± 0.17	1.72 ± 0.18	1.78 ± 0.11
SV ($m·s^{-1}$)	9	1.52 ± 0.135 [a, b]	1.57 ± 0.14 [a]	1.59 ± 0.15 [b]
SI ($m^2·s^{-1}$)	9	2.73 ± 0.45	2.73 ± 0.46	2.83 ± 0.36

Kinematics data showed stability along the training season: SR: (ICC= 0.808; Ic 95%]0.40; 0.953[; p = 0.002); SL: (ICC = 0.815; Ic 95%]0.421; 0.955[; p = 0.002); SV: (ICC = 0.977; Ic 95%]0.927; 0.994[; p < 0.001); and SI: (0.939; Ic 95%]0.809; 0.989[; p < 0.001). There were improvements (p < 0.05) on anthropometric data hroughout the training season.

DISCUSSION
In this age group, anthropometric characteristics seem to be more important than kinematics adaptations due to training for sprinting. Significant increasing in SV seems to be by combinations between SR and SL (1), but these variables did not change significantly.

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OXYGEN UPTAKE AT THE LACTATE THRESHOLD IN SWIMMING.

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INTRODUCTION
Lactate Threshold (LT), the intensity above which it is observed an exponential increase in blood lactate concentra-

tions ([La⁻]), has been considered a topic of great interest in swimming literature. However, due to the difficulties related to the assessment of maximal oxygen uptake (VO_2max) in normal swimming conditions, the LT intensity has normally been interpreted using the corresponding swimming velocity, instead of the respective percentage of VO_2max. The purpose of this study is to identify, in terms of %VO_2max, the intensity of swimming associated with a non linear increase of [La⁻].

METHODS
Twenty nine trained swimmers were studied: 15 male (21.4±3.0 yy, 177.3±7.0 cm, 68.3±7.1 kg and a VO_2max of 70.9±10.2ml.kg⁻¹.min⁻¹) and 14 female (18.7±2.4 yy, 164.9±2.3 cm, 55.1±3.9 kg and a VO_2max of 59.8±8.02ml.kg⁻¹.min⁻¹). Each subject performed an intermittent incremental test for freestyle VO_2max assessment, with increments of 0.05 m.s⁻¹ each 200m stage and 30s intervals, until exhaustion (Fernandes et al., 2003). Velocity was controlled using a visual pacer with flashing lights on the bottom of the pool. In water starts and open turns were used. [La⁻] were assessed at rest, during the 30s intervals, immediately after each 200m stage, and at minutes 3 and 5 of the recovery period (YSI1500LSport auto-analyser). VO_2 was measured through direct oximetry (Sensormedics 2900). LT was assessed individually through a [La⁻]/VO_2 curve modelling method (least square method) and was assumed to be the intersection point, at the maximal fit situation, of a combined pair of regressions (linear and exponential) (Machado et al., 2006).

RESULTS
In mean terms, the non linear increase in [La⁻] with swimming intensity occurred at values of 2.99±0.8 mmol.l⁻¹, which corresponded to 73.54±8.0%VO_2max.

DISCUSSION
The present study showed that the non linear increase of [La⁻] corresponding to LT in a specific swimming situation occurred at 73.54±8.0%VO_2max. This result also seems to confirm that the best single [La⁻] value to predict LT, when testing trained swimmers, should be lower than the usual value of 4 mmol.l⁻¹.

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Machado L, Almeida M, Morais P, Colaço P, Ascensão A, Soares S, Fernandes R, Vilas-Boas JP (2006). A mathematical model for the assessment of the individual anaerobic threshold. *This Symposium*.

OXYGEN UPTAKE AND VENTILATORY THRESHOLD IN SWIMMING.

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INTRODUCTION
Due to the difficulties associated with the evaluation of ventila-

tory parameters in normal swimming conditions, the assessment of the ventilatory threshold (VT), to our knowledge, has not been tried yet. However, the determination of this parameter is essential in order to achieve a more precise knowledge of the aerobic capacity of swimmers. The purpose of the present study was to identify the swimming intensity associated to the VT, expressed as a percentage of the maximal oxygen consumption (%VO_2max).

METHODS
Twenty nine trained swimmers were studied: 15 male (21.4±3.0 yy, 177.3±7.0 cm, 68.3±7.1 kg and a VO_2max of 70.9±10.2 ml.kg^{-1}.min^{-1}) and 14 female (18.7±2.4 yy, 164.9±2.3 cm, 55.1±3.9 kg and a VO_2max of 59.8±8.0 ml.kg^{-1}.min^{-1}). Each subject performed an intermittent incremental test for freestyle VO_2max assessment, with increments of 0.05 m.s^{-1} each 200m stage and 30s intervals, until exhaustion (Fernandes et al., 2003). Velocity was controlled using a visual pacer. VO_2 and Ventilation (Ve) were measured through direct oximetry (Sensormedics 2900 oximeter). VT was assessed by Ve/VO_2 curve modelling method (least square method) – Machado et al. (2006) - and VT was assumed to be the intersection point, at the maximal fit situation, of a combined pair of regressions (linear and exponential). Mean (SD) computations for descriptive analysis were obtained for all variables.

RESULTS
The non linear increase of Ve seems to occur at 88.1±31.3 l.min^{-1}, corresponding to 84.3±8.7%VO_2max.

DISCUSSION
The non linear increase of the Ve corresponding to the VT in normal swimming conditions seems to happen at 84.3±8.7%VO_2max. The obtained result seems to be in agreement with other studies conducted in cycle-ergometers (cf. Dekerle et al, 2003). In this sense, this result seems to confirm that, nonetheless the specificity of the aquatic environment, the VT occurs at a similar absolute intensity as in running and in cycling.

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A THREE-YEAR FOLLOW-UP STUDY OF AGE GROUP SWIMMERS: ANTHROPOMETRIC, FLEXIBILITY AND CMJ FORCE RECORDINGS.

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INTRODUCTION
At the beginning of the pubertal period there are important changes in the growth and development of adolescents (1). The purpose of this study was to investigate the changes brought about both by this development and by training on anthropometrics, swim, flexibility and CMJ force recordings variables over a period of three years (2000-2003) of swimming training in a sample of age-group swimmers.

METHODS
Subjects: Twenty-one swimmers (female=12 and male=9) participated in the study (average age at beginning =12,19 years). They were included in a regular training program for national and state level swimmers. *Instrumental:* Measurement tools, video-recording and a force plate were utilized in the study at the beginning and after the three years of training. *Variables:* Are described and their results included in the next table.

	2000		2003	
	Average	S.D.	Average	S.D.
Weight (kg)	50,01	9,64	60,71**	10,12
Height (cm)	160,07	8,17	166,90**	6,02
Arm Spam (cm)	163,09	9,56	170,75**	7,88
Shoulder Flex. (º)	167,90	5,22	163,68*	7,70
Ankle Flex. (º)	10,57	11,73	9,00	26,04
Max. Force (N)	1233,73	271,47	1415,78**	238,07
Relative Force (N)	2,50	0,19	2,42	0,25
Height of jump (cm)	29,67	0,64	31,33	0,78
Take-off vel. (m/s)	2,40	0,25	2,46	0,28
50 m swim freestyle	31,32	1,90	30,29**	1,98
	* p<0.05, ** p<0.01			

RESULTS
The results obtained showed significant differences in anthropometrics (weight, height and arm span) and swim with greater values in the post-test (2003). The flexibility in shoulder decreased significantly but was not marked in the ankle. Force data recorded during the CMJ showed an increase of maximal force, but when this value is related to body-weight the averages did not change as much as height of jump and speed of take-off.

DISCUSSION
As was to be expected, the subjects after this period had increased in weight, height and arm span due to the growth process. Flexibility has very specific characteristics and slowly diminishes with age, a diminution that is accelerated if it is not worked at. These data verify previous findings (1), that argued that at the beginning of the pubertal period the amplitude of movements diminishes significantly. For this reason most authors suggested that the training of this quality should be intensified at the end of the pre-pubertal period. Our results confirm the process of the evolution of force (2). The subjects in this group obtained significant improvement in maximum force probably due to their growth and development, while the relative force and height of jump did not change. The improvement obtained in swimming times seems more related to anthropometrics factors than relative force development in spite of the initiation of a long-term force training cycle.

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COMPUTATIONAL ANALYSIS OF THE TURBULENT FLOW AROUND A CYLINDER.

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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.

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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.

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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.

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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.

DISCUSSION

The trunk flexion in maximum speed in the water can be considered an exercise of strong abdominal activity and low activity of the hip flexores. The characteristics of the external forces that act upon the body during the abdominal exercises in water provide a very special situation of reduced hydrostatic weight (1), resistance to the movement, relative support and a tendency of rotation to attain a stable balance and increase resistence to the movement.

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ENERGY COST AND INTRA-CYCLIC VARIATION OF THE VELOCITY OF THE CENTRE OF MASS IN FRONT CRAWL.

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INTRODUCTION

The purpose of the present study was to analyse the relationship between energy cost (C) and intra-cyclic speed fluctuations (dv) in front crawl.

METHODS

Four elite freestyle swimmers (2 males of 18.5 ± 0.7 yy, 176.0 ± 11.3 cm and 71.6 ± 12.7 kg, and 2 females of 16.5 ± 0.7 yy, 171.0 ± 1.4 cm and 60.7 ± 3.5 kg) performed an incremental intermittent protocol (n x 200m) for maximal oxygen consumption assessment (Fernandes et al., 2003), during which biomechanical and bioenergetical parameters were measured. The swims were videotaped in the sagittal plane with two SVHS cameras, providing, after mixing and editing, a dual-media image of the swimmer. The APAS software (Ariel Dynamics Inc, USA) was used to calculate the variation coefficient (dv) of the v(t) function of the centre of mass (CM) for each 200m step. Oxygen consumption was measured through a portable gas analyser (K4 b[2], Cosmed, Italy) connected to the swimmers by a respiratory snorkel and valve system. Capillary blood samples were collected from the ear lobe, before and after each set, to analyse blood lactate concentrations (YSI 1500L Sport, USA). The energy expenditure ($\dot{E}$) and C ($\dot{E}.v^{-1}$) were calculated for each 200m using net values of VO_2 and blood [La-], converted with a 2.7 $mlO_2.kg^{-1}.mmol^{-1}$ constant.
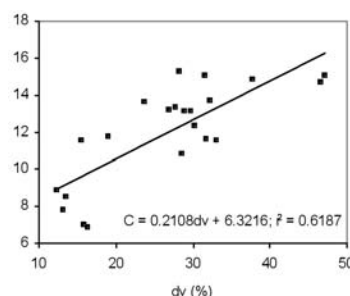

Figure 1. Relationships between C and dv.

RESULTS

Intra-cyclic speed fluctuations and $\dot{E}$ increased with v (r=0.63 and r=0.85, p≤ 0.01, respectively). C rose with the increasing of dv (cf. Fig. 1, for pooled data).

DISCUSSION

A linear relationship was found between $\dot{E}_{tot}$ and v. The relationship obtained between C and dv is in accordance with literature. In the present study it was found that, for the entire sample, C seems to be mainly influenced by dv and, at an individual level, v seems to be the C main determining factor. These two variables appear to determine 70% of the variance in C.

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EFFECT OF THE TEACHING POINTS ON TURN MOTION OF BREAST-STROKE FOR BEGINNER'S SWIMMER.

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INTRODUCTION

Breaststroke turns require a simultaneous two-hand touch at the wall, followed by the turning of the body and pushing off into the next swim. Beginning-swimmers have difficulty making breaststroke turns in a smooth motion because of that complexity. Therefore, specific skills are required in order to make the turn motion efficiently. The purpose of the present study was to evaluate the effect of the teaching points on the turn motion of breaststroke for beginning-swimmers.

METHODS

Eight non-skilled college swimmers participated in this study. They were taught the turn motion at three times for 15 minutes. Trials of the turn were conducted in order to analyze the turn motion before and after the teaching. Each test was recorded using two digital video cameras for motion analysis, and another camera for measuring a turning time (T-turn; the

time from touching with hands to pushing off with the feet), and a touching time (T-hand; the time from touching with hands to releasing). Questionnaires on subjective sensation of the turn motion were completed after the test. The turn was separated into three phases as follows, 1) the approach, 2) turning the body, 3) push off. Each content and focus point of the teaching was 1) How to touch at the wall from fingertips to palm, 2) Which direction of eyes during turning of the body, 3) How to push off the wall, respectively. Each training menu was, 1) similar touch against the wall on land, 2) stop turning at touching with feet, 3) pushing off on one's side.

RESULTS & DISCUSSION
T-turn (Pre; 1.71sec, Post; 1.84sec) and T-hand (Pre; 0.65sec, Post; 0.86sec) were significantly longer ($P < 0.05$) in comparison to before teaching. It seemed that another time except for T-touch (Pre; 1.06sec, Post; 0.98sec) was shorter. All subjects felt that the present teaching points were effective in improving the turn motion in spite of a short teaching program. There were many positive comments such as "I learned to be able to have no trouble turning the body" and "I was able to kick a wall firmly". It was suggested that the teaching program leaded the swimmers to acquire the good tips on turn motion and do turning of the body certainly.

DETECTION OF REAL-TIME INTERACTION PATTERNS IN BREASTSTROKE SWIMMING.

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INTRODUCTION
The objective of this research was to search for a particular type of repeated behaviour patterns in swimming movement cycles. The search used a new data analysis approach based on a process known as T-Pattern detection of the temporal and sequential structure of a data set (Magnusson, 1996). The temporal patterns can be related to performance specific actions (e.g. comparison intra-cycle movement patterns similar to the one described by Coleman at al. (1998). Theme can be used for the analysis by using the relevant types of swimming data files created with Themecoder or other qualitative codification set.

METHODS
Breaststroke cycles of a national champion swimmer have been recorded underwater. Thirty cycles of execution style were coded and analyzed with Theme, using a categorical system analyze known as "field format" (Weick, 1968; Anguera, 1979), composed by seven criteria representing the relevant stroke phases. Each one of those criteria includes the relevant inter-segmentar relationships observed, such as critical leg position related to body, head and arms (intra cycle components). This coding produced 162 events composed by 28 event types. The event type includes information about each segment relation of each criterion.

RESULTS
Trough the use of the theme program we could find highly reg-

ular patterns of swimming technique. Several levels of pattern complexity output allow us to analyse relations between cycles.
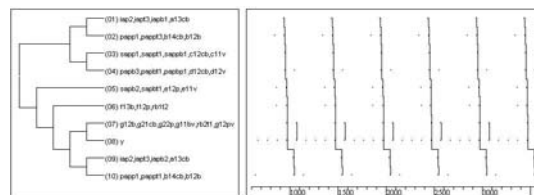

Figure 1: Specific graphics produced by Theme software. Represents one structure pattern (six occurrences, p<.005) composed with critical intra cycle breaststroke behaviour moments.

The figure 1 presents two analyzes structure plans of one of the complete patterns found in the sequence of events studied. It describes the characteristics of the Breaststroke cycle represented by a specific code system, selected by the observer in each criterion. This presented pattern reveals also the beginning of the following cycle it's interconnected with the sequence of the previous movement expressing this swimmer's high pattern synchronization.

DISCUSSION
It also allowed the detachment of some procedures to integrate in future analyses, having as an orientation the sequence of behaviours and the quality of the movement, required to gestures of advance breaststrokes variants.

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CHANGES IN CROSS SECTIONAL AREA OF INFERIOR VENA CAVA DURING ARM CRANKING EXERCISES IN WATER.

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INTRODUCTION
It is well known bradycadia and increases in strike volume occur induced by hydrostatic pressure during water immersion.

We clarified that the response of venous retune was about twenty seconds using the change of size of in the cross sectional area of inferior vena cava. However, there is still no common agreement on changes of cross sectional area of inferior vena cava during exercises in water. Therefore the purpose of the present study was to investigate the cross sectional area of inferior vena cava changes during exercises in water.

METHODS
Six subjects were voluntarily participated in this study (age of 23 ± 1 years , height of 173 ± 15 cm , body weight of 173 ± 5). We have informed concent for subjects according to the HELSINKI Ethical Principle. The study was set into four experimental conditions of 20%Vo2max, 40%Vo2max, 60%Vo2max and control. They participated in an arm cranking exercise program. The exercise program was performed for 15-min. Water temperature was 30 degrees C. Water depth was axilla. Heart rate was measured by electrocardiography. The cross sectional area of inferior vena cava was measured by using B-mode echocardiography. Data were analyzed by ANOVA and the level was set at $P<0.05$.

RESULTS
This study indicated that the cross sectional area of inferior vena cava is decreased the during exercise program, and there is a significant relationship between the cross sectional area and intensity of the exercise program ($P\leq 0.05$). The results of recovery after the exercise program also indicated that there is a significant difference between the cross sectional area and intensity of the exercise program ($P\leq 0.05$).

DISCUSSION
We suspect the venous retune has two factors controlling the velocity and volume. The findings of the study indicated keeping volume down during the low intensity exercise program and more importantly indicated the treatment by velocity during the high intensity exercise program.

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THE EFFECT OF THE BREATHING ACTION ON VELOCITY IN FRONT CRAWL SPRINTING.

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INTRODUCTION
During a 50m freestyle race, swimmers attempt to breathe as little as possible, or not at all. For 100m freestyle races, the need for oxygen is greater; still many swimmers tend to reduce their breathing. The purpose of this study was to examine how breathing actions influence velocity during a 25m front crawl sprint using two different breathing patterns, and no breathing.

METHODS
Ten competitive, national level, adult swimmers (age 25 ± 3 years (mean ± SD), 8 males and 2 females) volunteered for this study. They all swam three 25m freestyle sprints with different breathing patterns (randomised order), starting every 4 minutes; 25m with no breathing, 25m with one breath after 15m of swimming (approximately one breath every third stroke cycle), and 25m with one breath every stroke cycle. All breathing was to the swimmers preferred side. Velocity measurements were carried out using a computerized swimming speedometer (1), connected to the swimmer using a thin non elastic line. Data from mid-pool free swimming (10-20m) was extracted and used in all analyses.

RESULTS
There was no significant difference in mean velocity (v) between 10m of mid pool sprinting when the swimmers took one breath compared to no breath. There was a significant ($p<0.05$) reduction in velocity when breathing every stroke cycle, compared to both no breath and one breath trials, see table 1.

DISCUSSION
The results indicate that swimmers at this performance level may breathe once every 3rd stroke cycle without loosing velocity due to breathing actions in front crawl sprint. If swimmers breathe every stroke cycle they may loose up to 0.1 sec pr 10m of mid pool swimming. In 100m races, swimmers tend to breathe every stroke cycle at the end of a race. Coaches should stress breath control both in training and competitions and teach effective breathing technique to avoid velocity reductions due to breathing actions. To give more accurate advice about which breathing patterns to use in 100m races, both individual differences in technique and different physiological and metabolic variables must be taken into consideration.

Table 1: Mean velocity from the three trials.

	No breath v10-20 (m·s-1)	One breath v10-20 (m·s-1)	Breath every strokecycle v10-20 (m·s-1)
Mean (±SD)	1,74 (±0,14)	1,73 (±0,14)	1,70# (±0,14)

significant different from both no and one breath trials (p<0,05)

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BIOMECHANICAL ANALYSIS ON CRAWL STROKE TURNS.

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INTRODUCTION
The time of the turns can contribute up to 20% of the total race time (3). The main objective of this study was to investigate the contribution of the dynamic and kinematic variables to the performance in crawl stroke turn.

METHOD
The turns of 38 swimmers were analyzed using an underwater

force plataform and two video cameras that supplied, respectively, dynamic and kinematic data. Each swimmer performed 8 turns. Descriptive statistics were used to characterize the data. Angle of knee flexion (AK), maximum normalized force peak (FPn) and contact time (CT) were measured as variables in the multiple linear regression to determine the effect of these variables on total turn time (TT). Pearson´s correlation was used to analyze the relationships between the variables. The data was separated in four groups, it was classified by turn times and to verify the difference between the variables, One-Way Analyses of Variance (ANOVA) and Scheffe´s post-hoc were used.

RESULTS
Through investigation of the contribution of the variables AK, PMn and CT to the variable TT it was possible to identify that PMn explains the greatest percentage of variance in turn performance (17,70%). The relation between AK and PMn indicated that larger values of AK (smaller flexions) tend to provide larger values of PMn (r = 0,38). In the relation between AK and CT it was verified that larger values of AK tend to provide smaller values of CT (r = -0,38). The relation between PMn and CT indicated smaller values of CT tend to provide larger values of PMn (r = -0,23).

DISCUSSION
Starting from the results analysis, it can be suggested that angles of knee flexion between 110 and 120 degrees tend to provide larger force peaks, smaller contact times and smaller turn times, reaching the best performance of the crawl stroke turn execution.

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"EPIDEMIOLOGICAL" ANALYSIS OF THE FREESTYLE TURNING TECHNIQUES USED IN TOP LEVEL SWIMMING.

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INTRODUCTION
The aim of this study was to conduct an inventory of the freestyle turning techniques, and an analysis of the evolution of the use of different variants, in top level swimming during the last 10 years.

METHODS
Official images of FINA from the Olympics Games and World Championships, since 1996 up to 2005 were analyzed. All the visible freestyle turns were considered being discarded those

carried through the same athlete in the only event. The turns had been analyzed and classified in accordance to the used technique variant, between men and women, the gotten ranks, and the countries they represented.

RESULTS
256 turns were analyzed. The dorsal rolling technique was the most used by 171 swimmers (66.81%). The touch in the wall is dorsal for 35.16% of the total swimmers, and lateral for 31.65%. However, the most important aspect seems to be the technique variants for the impulse out of the wall.
Independently of the rolling position, 84.77% of the swimmers adjust their body position for the ventral position during the impulse. Just 15% of the swimmers do not perform trunk rotation during the impulse, leaving to adjust the body position during the underwater glide (13%), or touching the wall in a favorable position to displacement (2%).
The USA swimmers perform their turns with dorsal rolling (16%) and the Australian swimmers, mostly perform the turns with lateral rolling (11%). The other countries present predominance of the dorsal rolling technique (31%). The impulse is characterized by a movement of trunk rotation in 41% of the turns.

DISCUSSION
One can observe the predominance of a rotational movement of the trunk along the longitudinal axis during the impulse phase of the wall, most likely for the adjustment of the body position for the beginning of the stroke. However, this action does not seem to be a biomechanicaly optimized action, once it tends to a "dispersion" of the applied force, exactly in the instant where force seem to be one of the main aspects to take into account for the performance of the turn action (Araújo et al, 2005).
More biomechanical studies of the turn movement are necessary in freestyle comparing the efficiency of the techniques used by the best swimmers of the world.

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BIOMECHANICAL ANALYSIS OF THE UNDERWATER PHASE IN SWIMMING STARTS.

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INTRODUCTION
Authors who investigate the characteristics of the swimming starts recognize the importance of the underwater phase to the start performance, suggesting the necessity of making measurements and descriptions of the variables behavior during the execution of this phase. The main objective of this study was analyse, through cinemetry, the underwater phase of the swimming start.

METHODS

The sample was composed by 4 swimmers of national and state levels. The data were collected in the swimming pool of Doze de Agosto Club and analyzed in the Laboratory of Research in Aquatic Biomechanics of CEFID/UDESC. Three VHS video cameras (30Hz) and a sign synchronizer equipment were used. Each swimmer performed 6 starts for the crawl stroke. One analyzed the following variables: maximum depth achieved (DP), time, distance and average velocity of the underwater phase (UPT, UPD and UPV respectively) and total start time in 15 meters (T15m). The relation between the variables was carried out through Pearson's Correlation.

RESULTS

It was observed significant correlation between PMA and T15m, which indicates that higher values of maximum depth correspond to higher values of T15m. The maximum depth also presented significant correlation with UPT, UPD and UPV: higher values of PMA corresponded to higher values of distance and time and, at the same time, to smaller values of average velocity during the underwater phase. It was observed a negative correlation coefficient between UPV and T15m, which indicates that higher values of average velocity during the underwater phase correspond to slower starts.

DISCUSSION

The achieved depth after the entrance in the water had influenced significantly the underwater phase. About the average velocity during this phase, it seems to be the variable which most affects the total start time in 15 meters. Both variables are important factors to be observed by athletes and coaches, that should look forward to perform great values that provide the efficient execution of swimming starts. It suggests that the swimming start analyses should contemplate, beyond the block and the flight phases, the underwatre phase that is an essential phase to be considered for the determination of performance parameters of the start in swimming.

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DIAGNOSTIC, TRAINING AND REALISATION OF STRENGTH CONDITION OF SWIMMERS WITH USE OF FEEDBACK DIAGNOSTIC SIMULATOR "ART".

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INTRODUCTION

The purpose of this article was to present results of research project in diagnostic, training and realisation of strength condition of swimmers with use of visual immediate feedback diagnostic swimming simulator "ART".

METHODS

In the study was used the computerized swimming simulator "ART" which has force-velocity characteristics with high correlation to in-water swimming (1). Different work-loads gave opportunity to change force-velocity ratio. An athlete performed simulated arm-pulling lying at swimming bench (modified training program) and it was able to receive immediate feedback on dynamical structure of the drive phase, stroke rate and power using PC display. Around 400 athletes from new to elite took part in the research.

RESULTS AND DISCUSSION

In the study in group of boys the characteristics of strokes power increase in the age of 12-14 years more than on 40%. However, the qualitative parameter (ratio power to athlete body weight) changes much less and in the group of 14-years boys, it is equal 87% from national team medium meanings. Correlation of young swimmers sport results were connected with the absolute parameters of power in force and speed work-loads in tests with maximal intensity (p<0.001) and two years later their sport results were connected with qualitative parameters (ratio of stroke power to body weight) in speed mode in analogous tests (p<0.001). In analyse of stroke dynamical structure it was determined that the stroke structure was being changed with increasing of work intensity. This fact showed that long use of swimming exercises with low intensity can form stroke dynamical structure that does not correspond to the structure on competition velocity. Use of training program of stroke dynamical structure correction using visual immediate feedback had high efficacy of such work in the increasing of sport result. Using speed mode in the same interval training the stroke rate is increased (7%) with low increase of stroke power (2,5%), but using power mode the stroke power is improved (13%) with low increase of rate (1,5%) (p<0.05). It means that we can use different modes of load depended on training aims, for correction of stroke rate and stroke lengths.

CONCLUSION

Used exerciser "ART" with visual immediate feedback in the training of swimmers allows to value qualitative and quantitative dynamical characteristics of stroke, to do trainings to increase stroke specific power, to correct stroke dynamical structure, that have difficulties in real swimming. To increase the swimmers' strengths potential into the swim power it is important to use training modes, in which the stroke velocity will correspond or exceed the record velocities of athletes.

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THE INFLUENCE OF COMPETITIVENESS LEVEL ON MATCH EXERCISE INTENSITY IN ELITE WATER POLO PLAYERS.

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INTRODUCTION
This study was designed to investigate the physiological responses that elicited in different competitive level players during water polo games. Specifically, the hypothesis that the players of Greek National Team (NTP) perform with higher intensity than the players of the 1st Greek National League (NLP) was tested.

METHODS
Thirty players, who had equally split to NTP and NLP, participated in this study. Initially, their physiological profile, which was related with their performance, was evaluated. Subsequently, heart rate (HR) was continuously monitored and blood lactate (La) was measured at the end of each period during 10 water polo games.

RESULTS
Maximum oxygen uptake, lactate threshold point as well as HR values corresponding to the threshold are presented in Table 1. In addition, Table 1 shows HR and La values attained during the water polo games and their respective significant differences. No differences were found with respect to the percentage of time spent with exercise intensity above and below the threshold between NTP and NLP. However, as Figure 1 indicates, regardless of relative terms (%), NTP swam with significant higher velocity than NLP throughout the game.

Table 1: Physiological traits of subjects during performance tests and water polo games

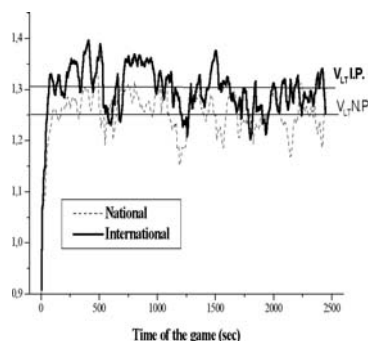|	NTP	NLP	p
Performance tests			
VO2max (ml/kg/min)	70.23±6.97	57.14±9.26	0.001
LTH (mmol/l)	3.47±0.76	4.60±0.80	0.002
HRTH (beats/min)	147.5±9.6	163.1±9.6	0.001
Water-polo match			
HR (beats/min)	149.8±8.2	162.9±9.9	0.001
La (mmol/l)	3.04±1.09	4.67±2.17	0.002

Figure 1: Mean swimming velocity of water polo players in 10 games.

DISCUSSION
Exercise intensity exhibited during the games was not affected by the level of competitiveness when values were considered relative to lactate threshold; however, NTP had higher swimming velocity than NLP. It is concluded that the players of Greek national team performed at higher absolute exercise intensity than the players of the 1st Greek national League.

ENERGY COST AND INTRA-CYCLIC VARIATION OF THE VELOCITY OF THE CENTRE OF MASS IN BACKSTROKE.

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INTRODUCTION
The purpose of this study was to examine the relationship between energy cost (C) and intra-cyclic speed fluctuations (dv), in backstroke.

METHODS
Five male elite backstroke swimmers (18.6±1.5 yy, 179.2±2.3 cm and 70.2±8.5 kg) performed an incremental intermittent protocol (n x 200m) for maximal oxygen consumption assessment (cf. Fernandes et al., 2003), during which biomechanical and bioenergetical parameters were measured. The test was videotaped in sagittal plane with two SVHS cameras, providing, after mixing and editing, a dual-media image of the swimmer. The APAS software (Ariel Dynamics Inc, USA) was used to calculate the variation coefficient (dv) of the v(t) function of the centre of mass (CM) for each 200m step. Oxygen consumption was measured through a portable gas analyser (K4 b^2, Cosmed, Italy) connected to the swimmers by a respiratory snorkel and valve system. Capillary blood samples were collected from the ear lobe, before and after each set, to analyse blood lactate concentrations (YSI 1500L Sport, USA). The energy expenditure ($\dot{E}$) and C ($\dot{E}.v^{-1}$) were calculated for each 200m using net values of VO_2 and blood [La-], converted with a 2.7 $mlO_2.kg^{-1}.mmol^{-1}$ constant.

RESULTS
The $\dot{E}$ vs v presented a linear relationship for the pooled data of the sample (r=0.67, p≤ 0.001) and for 2 subjects (0.98≤ r≤ 0.99, p≤ 0.01), and a cubic relationship for the others (0.92≤ r≤ 0.99, p≤ 0.05). For the pooled data, C increased linearly with dv (r=0.39, p≤ 0.05), despite individual relationships showed particular results (Fig. 1).
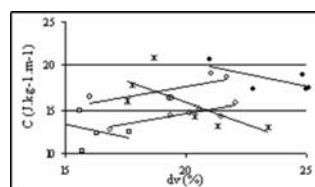

Figure 1. Individual relationships between C and dv.

DISCUSSION

As it was expected, $\dot{E}$ increased both linearly, and cubically with v. These 2 different results were previously found in literature and may both be explained through the variation of mechanical power with the cube of the swimming velocity and a non linear variation of swimming efficiency with velocity, probably related to changing intra-cyclic variation of v. The relationship between C and dv seems to be extremely individual and mostly determined by v and dv relationships.

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THE INFLUENCE OF TUCK INDEX, DEPTH OF FOOT-PLANT, AND WALL CONTACT TIME ON THE VELOCITY OF PUSH-OFF IN THE FREESTYLE FLIP TURN.

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INTRODUCTION

Effective turns play a critical role in the outcome of swimming competition. In short-course events, turns comprise up to one-third of the total race time. At elite competitive levels, mid-pool swimming velocity is the primary determinant of race performance. However, turns have the potential to determine a winner among swimmers with the same mid-pool swimming velocities. The purpose of this study was to examine the effect of three variables on the velocity of the push-off during the freestyle flip-turn. These variables are: (a) The distance from the wall a swimmer's hips should be at foot contact (Tuck Index); (b) the depth of the foot plant on the wall during push-off; and (c) The wall-contact time.

METHODS

Twelve male and eleven female members of a University (Division I) swimming team participated in the study. Their ages ranged from 19 to 25 years. Each subject was required to perform a series of trials, each trial consisting of a 50-yard freestyle swim over a 25 yard (22.5 m) course which included one turn. Subjects were instructed to perform the flip turn at race pace, swimming at maximum speed for 5 meters before and after the turn. Each turn was videotaped from underwater using a single digital camera. The camera was placed at a depth of half a meter, and located 2 meters from the end of the pool and 7 meters lateral to the turning surface. A four-point calibration rod was used as a scaling factor for the kinematic analysis. 2D analyses in the saggital plane were made using motion analysis software (Vicon/Peak, Denver, Colorado). A Pearson correlation coefficient matrix was constructed to identify the relationship between variables. Simultaneous regression analysis was conducted using the push-off velocity as a dependent variable to determine the overall predictive characteristics of the variables.

RESULTS & DISCUSSION

The mean push-off velocity was 2.47 ms^{-1}. The minimum velocity was 1.3 ms^{-1} and the maximum push-off velocity was 3.29 ms^{-1}. Tuck index is the ratio measurement used to indicate how close a swimmer is to the wall. A higher tuck index indicates straighter legs. In the present study, the mean tuck index of all turns was 0.57 + 0.14, indicating that the hips were a mean distance from the wall that was approximately 57% of the length of the swimmer's legs. The study found a significant, negative correlation between push-off velocity and tuck index, indicating that the more tucked position (lower tuck index) predicted higher push-off velocity. No significant correlations existed between push-off velocity and foot-plant. Wall Contact Time (WCT) was divided into two segments, a "preparatory" segment and an "active" segment. The mean percentage of the wall contact spent in the "active" push-off phase was 74.31%. Although previous studies have shown positive correlations indicated that longer active segments resulted in faster final push-off velocities, no significant relationship was found between "active" WCT and push-off velocities.

COMPARISON BETWEEN DIFFERENT METHODS FOR THE ASSESSMENT OF THE $\dot{V}O_2$ SLOW COMPONENT OF FREESTYLE ELITE SWIMMERS.

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INTRODUCTION

The purpose of this study was to compare different methods for the assessment of the Oxygen Slow Component (SC) in elite swimmers in a time limit test at the minimum velocity that elicits maximal oxygen consumption (TLim- v$\dot{V}O_2$max).

METHODS

Five females (16.9±1.5 yy, 59.0±3.1 kg and 165.8±3.2 cm) and two males (18.5±0.6 yy, 74.6±8.5 kg and 176.0±11.3 cm) elite front crawl swimmers swam until exhaustion at their previously determined v$\dot{V}O_2$max to assess TLim-v$\dot{V}O_2$max (Fernandes et al., 2003). $\dot{V}O_2$ was measured by a portable gas analyser (K4 b^2, Cosmed, Italy) connected to the swimmers by a respiratory snorkel. To describe the SC kinetics was used a mathematical model with three exponential functions (cf. Machado et al., 2006). This model was compared with different methods of rigid time intervals defined as the difference between the end $\dot{V}O_2$ and the one at the 2nd min ($\Delta\dot{V}O_{2[end-2]}$) or at the 3rd min of exercise ($\Delta\dot{V}O_{2[end-3]}$), with different averages around the 2nd and 3rd min, and the end of the exercise (20 s, 30 s or 40 s).

RESULTS

Table 1. Mean (± SD) values for the SC amplitude (in ml.kg^{-1}.min^{-1}) calculated from the different methods.

Mathematical model (A$_2$)	$\Delta \dot{V}O_{2[end-3]}$ 20" before 2' and final	$\Delta \dot{V}O_{2[end-3]}$ 20" before 3' and final	$\Delta \dot{V}O_{2[end-3]}$ 30" before 2' and final	$\Delta \dot{V}O_{2[end-3]}$ 30" before 3' and final	$\Delta \dot{V}O_{2[end-3]}$ 40" before 2' and final	$\Delta \dot{V}O_{2[end-3]}$ 40" before 3' and final
5.8 ± 3.4	4.0 ± 1.7	0.2 ± 2.0*	4.5 ± 1.9	0.2 ± 1.8*	4.8 ± 2.1	0.3 ± 1.9*

$\Delta \dot{V}O_{2[end-3]}$ 20"+20" around 2'and 20" before final	$\Delta \dot{V}O_{2[end-3]}$ 20"+20" around 3'and 20" before final	$\Delta \dot{V}O_{2[end-3]}$ 20"+20" around 2'and 30" before final	$\Delta \dot{V}O_{2[end-3]}$ 20"+20" around 3'and 30" before final	$\Delta \dot{V}O_{2[end-3]}$ 20"+20" around 2'and 40" before final	$\Delta \dot{V}O_{2[end-3]}$ 20"+20" around 3'and 40" before final
3.0 ± 1.7	0.3 ± 1.9*	2.8 ± 1.8	0.1 ± 1.5*	2.8 ± 1.7	0.1 ± 1.6*

* p<0.05 for differences between A$_2$ and the respective method of rigid intervals.

DISCUSSION

This study showed that the use of the $\dot{V}O_{2[end-3]}$ underestimates the results since the SC usually begins earlier than the third minute (TD2 = 104.5±6.5 s). It may also be conclude that the mathematical model is the most interesting method, although the use of the final and the second minute of exercise ($\dot{V}O_{2[end-2]}$) seems to be a good solution for the calculation of the SC, even though it is less accurate, nevertheless it is more simple to use in a day-to-day basis.

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DETERMINANT FACTORS RELATED TO PERFORMANCE IN YOUNG SWIMMERS.

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INTRODUCTION

Talent identification is one of the most pursued issues of swimming research aiming to find at very young ages, the most important markers of mastering performance. Usually sport technicians and coaches, are aware of particular traces not supported on training experience that enhance best performances on future. Often they look to the morphologic and anthropometric characteristics of the adult champions of particular style or event [1]. Coaches want their swimmers to come close to these traces. In swimming, technique is everything. To reach technical excellence experience is necessary. So, looking for good performers, falls many times, on more experienced swimmers and not necessary on those who have the best characteristics. Efforts on talent identification must concentrate at a time where swimmers show that they dominate swimming technique enough. Statistical techniques were extensively used to this intention. Models based on multi regression analyses with performance and many physical, biomechanical and psy-chological variables were used to demonstrate the importance of same of these characteristics to performance.
The main goal of this study was to find the most important characteristics to swimming performance at young ages working with different approaches namely Data Mining algorithms, and multi regression analysis.

METHODS

The sample is constituted of 420 swimmers of national Portuguese level (boys - 13 to 16 years old and girls - 12 to 14 years old). During 5 years data were collected at national and regional evaluation meetings. Anthropometric, experience of training, and same physical tests namely maximal isometric strength, power, flexibility and hydrostatic and hydrodynamic characteristics were measured. In order to compare swimmers according to their performance level we use LEN point scores tables.
Data were analyzed using different algorithms: Decision Tree, K-Means (5-clusters) and Kohonen[2]. We also used the multi regression analyses with those variables that show significant correlation with performance.

RESULTS & DISCUSSION

With multi regression analysis using only anthropometric variables we found a model that explain performance (LEN Points score) 35,2% for males and 25,4 for females. When we include on the model other variables related to work capacity and training experience the explanation reaches 68,3% for males and 63,5 for female.
Using different algorithms we found similar results with the anthropometric variables assuming particular importance for performance.

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STROKE PERFORMANCE DURING BUTTERFLY AND BREAST-STROKE SWIM AT THE LOWEST SPEED CORRESPONDING TO MAXIMAL OXYGEN CONSUMPTION.

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INTRODUCTION

Time Limit (Tlim) is a concept that has been used to diagnose effects of swimming training and performance. It is the time duration a swimmer can perform at lowest speed corresponding to maximal oxygen uptake (TLim-v$\dot{V}O_2$max). While the technical performance during this specific test has not been previously explored in butterfly and breast strokes, the aim of the present study was to analyze stroke rate (SR) and stroke length (SL) in relation to the TLim- v$\dot{V}O_2$max.

METHODS

Ten elite swimmers (7 males, 19.58 ± 2.9 y, 176.0 ± 5.0 cm, 70.5 ± 6.2 kg; 3 females, 17.6 ± 1.5 y, 166.3 ± 5.1 cm, 60.9 ± 6.5 kg) performed, in their best simultaneous technique, an intermittent incremental test consisting of a set of 200-m swims. $v\dot{V}O_2$max was assessed from the swimming velocity versus oxygen consumption relationship. After 48 hours rest, continuous swimming at a speed corresponding to $v\dot{V}O_2$max was performed until exhaustion to determine TLim- $v\dot{V}O_2$max (Fernandes et al., 2003). SR and SL were analyzed from underwater video recordings for each 25-m lap throughout the test.

RESULTS

The two strokes differed so that the TLim-$v\dot{V}O_2$max was higher in breaststroke (331.4 ± 82.7 versus 277.6±85.6 s) with lower speed (1.10 ± 0.1 versus 1.29 ± 0.0 m·s^{-1}), SR (30.00 ± 2.7 versus 36.5 ± 1.2 cycles·min^{-1}) and SI (2.48 ± 0.4 versus 2.76 ± 0.1 m²·s^{-1}) but with longer SL (2.23 ± 0.2 versus 2.14 ± 0.1 m·cycle^{-1}). All differences were statistically non-significant. When the two samples were pooled together (6 breaststroke, 4 butterfly) an inverse relationship between TLim-$v\dot{V}$O$_2$max and SR (r=-0.54, p≤ 0.05) was observed.

DISCUSSION

The results of other studies concerning the relations between TLim- $v\dot{V}O_2$max and stroke parameters in front crawl pointed out inverse relationships between TLim- $v\dot{V}O_2$max and SR (Fernandes et al., 2005), and TLim- $v\dot{V}O_2$max and $v\dot{V}O_2$max (Fernandes et al., 2003). For butterfly and breaststroke it was not found any relationship between the above-referred parameters, which can be justified by the low number of swimmers studied for each technique. When both strokes were considered together, n rose, and the relationships became similar to the ones previously obtained for front crawl.

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INFLUENCE OF TIMING DELAY ON MONOFIN INTRACYCLE SWIMMING VELOCITY.

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INTRODUCTION

The aim of this study is an analysis of temporal delay in the structure of the body and monofin segments during swimming. On the theoretical basis of the mechanics of propulsion [1,2,3], it has been accepted that delays in the structure of biokinemat-ic chain movement are an objective measurement of the quality of monofin swimming technique on a high level

METHODS

16 high-class swimmers were filmed over a distance of 50m, under water. The filming procedure and analysis of movement were performed in accordance to ISO 9002. Output data, as a timed series of kinematic parameters of cycle chosen randomly, were analysed. A cross correlation of coefficients (CC) and retardations (R) were obtained over a range of functions, which illustrated the movement of the leg joints, and defined points on the fin with respect to the horizontal velocity of the swimmers CM (VHOR). The results were verified empirically.

RESULTS

*Tab.1. The average values of CC and R [in brackets] for the most crucial parameters connected to VHOR. (**S**houlder; **H**ip; **K**nee; **A**nkle; **T**ail; **M**iddle; **E**dge; **d**-vertical displacement; α-Angle of a join/fin sagging; **HOR**-Angle of a fin attack ω-Angular velocity of join/fin sagging/attack.*

Hd 0,90[1]	S-H-Kω 0,77 [-2]	Kd 0,86 [-3]	H-K-Aα 0,79 [-2]	Ad 0,69 [-8]	K-A-Tω -0,71[0]	Td -0,58 [0]

| A-T-Mω 0,76 [0] | T-M-HOPα 0,68 [0] | T-M-HORω 0,75 [-5] | M-E-HORα 0,79 [-7] | M-E-HORω 0,76 [-1] |
| | A-T-Eα - 0,71 [0] | A-T-Eω 0,71 [-6] | T-E-HORα -0,68 [0] | T-E-HORω 0,78 [-4] |

DISCUSSION

The CC between VHOR and the vector sum of the vertical velocity of the hip, knee, ankle, tail, middle and the edge of the fin (-0,48 [0]) show a relationship between the swimming movements and stability - a clear criterion of quality technique. The definition of stability, understood as the reduction of delay in the cycle, justifies the parameters connected most essentially with VHOR [4]. The analysis of R presents the time sequence of movements of the segments in the chain (whip effect). Similar delays within the parameters of the segment pairs show that the shape and the trajectory of fin are a consequence of leg actions. Of particular importance is that the structure of the ankle-tail movement (the location of direct transfer of the muscle energy to the fin surface) has a relationship to VHOR and its stability (no delay vs. VHOR). This practical aspect allows for interpretation based on the momentum balance governing force generated during the up and downward actions of the body and the fin.

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DIAGNOSING PERFORMANCE BY APPLYING SWIMMING TESTS.
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INTRODUCTION
Determining the level of preparedness, as a significant factor in training, represents the feedback information about the current condition of an athlete. It plays an important role since it provides the information about the changes of the athlete's conditions caused by the training load and other factors with the objective to regulate the impact the training process on the athlete. To monitor the level of both endurance and pace a set of swimming tests has been compiled. Some of the tests used by the Slovak Swimming Federation have been taken into consideration.

METHODS
From March to April 2005 a testing of 62 'performance' swimmers aged 13/14 and 56 'performance' swimmers aged 15/16 took place, using the 3000m test. The testing had been deliberately arranged so that it came at the end of the special summer yearly makrocycle training program 2004/05. In June 2005 of the same macrocycle an altered version of 4x50m test have been used; recordings and timings were conducted in the groups of 35 swimmers of 13-14 years, and 36 swimmers aged 15-16 respectively.

RESULTS
The blood lactate level was being probed after completing each particular test with time allowance of 3 and 10 minutes. Based on the results the applied 3000m test for both men and women in particular age-groups it is possible to assume that it provides a relatively exact anaerobic threshold pace of a swimmer. The 4x50m test, based on the results achieved, thus seems an appropriate to evaluate the level and changes in anaerobic capacity.

DISCUSSION
Based on the results gained by the blood lactate level it is possible to state that the 3000m test is useful when evaluating both the level and changes in aerobic capacity. The threshold pace (arrived at during 3000m test of maximal effort) can be used to determine the training load intensity when repeating various parts of the endurance working load. There are only few tests that can be used for evaluation of the changes in anaerobic metabolism, even though it is this metabolism that is often dominant in majority of the swimming disciplines. The reason for using and realizing these tests is estimation of the changes that take place over the anaerobic threshold as much as evaluation of the anaerobic capacity progress during the training process through the season. However, all methods and tests have both strong and weak spots. Nevertheless, all the information provide coaches with the data that can help them when determining the efficiency of the training process.

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INFLUENCE OF EXCESS WEIGHT ON IMPROVEMENT IN PHYSICAL CONDITION THROUGH AN AQUAEROBIC PROGRAM.

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INTRODUCTION
The purposes of the present study were: (i) to establish the differences in physical condition based on the existence or not of excess weight and (ii) to discover whether the application of an aquaerobics program improves the different components of physical condition.

METHODS
The sample was made up of 20 women (43.1±9.7 years), and was subclassified according to the existence (BMI>25) or not (BMI<25) of excess weight into a group of overweight women (OW, n=9) and a group without excess weight (OW, n=11). All the subjects carried out a program of low-impact aquaerobics twice a week for 8 months. In addition, they carried out pre- and post-tests, which consisted of the following: height, weight, body mass index, waist-hip ratio (WHR), modified sit and reach, two-hand dynamometry, modified curl-ups, one-leg balance with closed eyes and UKK 2-km walking test. The basic descriptions (mean and standard deviation) were determined; the differences between the pre- and post-tests were calculated using a Student t-test for related samples, and the differences between both groups were found by means of a one-factor ANOVA (Table 1).

RESULTS

Table 1. Basic descriptions (M, SD) and differences between pre- and post-tests (Student t-test for related samples) and ANOVA of one factor between WOW-WOW.

Variable	WOW (n=9)			OW (n=11)			ANOVA (WOW-OW)
	Pretest	Postest	t	Pretest	Postest	t	F
Height (m)	1.6 ± 0.2	1.6 ± 0.2	1.903	1.60 ± 0.5	1.60 ± 0.5	0.869	1.816
Weight (kg)	57.2 ± 0.5	56.3 ± 5.4	1.818	70.4 ± 8.8	68.3 ± 8.7	2.283*	2828*
BMI (kg/m2)	21.8 ± 1.0	21.9 ± 1.5	-0.422	27.5 ± 2.0	26.4 ± 1.9	1.397	12.467**
WHR	0.7 ± 0.1	0.7 ± 0.1	-1.496	0.7 ± 0.6	0.7 ± 0.4	-2.479*	0.009
Modified sit and reach (cm)	11.6 ± 8.2	12.8 ± 7.6	0.622	11.5 ± 9.3	11.3 ± 7.1	0.138	5.810**
Two-hand dynamometry (kg)	55.4 ± 9.1	57.8 ± 10.1	-1.850	53.3 ± 8.7	54.3 ± 9.7	-0.848*	3.349*
Modified curl-ups (repetition)	66.8 ± 15.6	70.0 ± 14.1	-3.000	43.6 ± 21.6	47.6 ± 22.3	-0.688	5.105*
One-leg balance with closed eyes (attempt)	6.1 ± 2.5	4.2 ± 4.0	2.007	8.1 ± 6.0	10.5 ± 4.7	-1.338	4.462*
UKK 2-km walking test VO2 (ml/kg)	43.2 ± 4.3	45.3 ± 5.5	-1.699	33.4 ± 5.6	35.2 ± 5.9	-1.064	7.551**

DISCUSSION
With regard to improvement in physical condition, surprisingly none of the studied factors improved significantly, although it seems that in the OW group, there exists a no significant tendency towards improvement. However, the OW group was able to reduce its weight and BMI. It should also be pointed out that group WOW is in better physical condition than group OW (1).

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IMPROVEMENT IN QUALITY OF LIFE OF HEALTHY ADULT WOMEN THROUGH THE APPLICATION OF AN AQUAEROBIC PROGRAM.

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INTRODUCTION
The purpose of the present study was to discover whether the application of a program of low-impact aquaerobics influences the quality of life of the participants.

METHODS
The sample was made up of 20 women (43.1±9.7 years old), who participated in a program of low-impact aquaerobics twice a week for 8 months. At the same time, they completed the SF-36 questionnaire (3), which consists of eight dimensions (physical function, physical role, corporal pain, general health, vitality, social function, emotional role, and mental health), the day before and the day after the activity. The normality of each of the variables was calculated by means of the Kolmogorov-Smirnov test; the basic descriptions (mean and standard deviation) were determined; and the differences between the pre- and post-tests were calculated by means of a Student t-test for related samples (Table 1).

RESULTS

Table 1. Basic descriptions (M, SD) and differences between pre- and post-tests (Student t-test for related samples).

Dimensions	Pre-test		Post-test		t
	Mean	SD	Mean	SD	
Physical function	85.50	15.88	98.50	13.75	-4.772***
Physical role	81.25	33.31	93.75	14.90	-2.032
Corporal pain	69.25	21.99	91.45	12.21	-4.106***
General health	72.51	20.95	75.40	12.21	-0.723
Vitality	61.87	17.03	79.75	11.82	-4.511***
Social function	83.12	22.31	93.75	10.25	-2.286**
Emotional role	80.26	34.78	96.66	7.32	-2.208*
Mental health	70.74	16.34	81.00	2.85	-2.103*

*p<0.05; **p<0.01; ***p<0.001

DISCUSSION
All the dimensions from questionnaire SF-36 showed values greater than the 75th percentile of the normative reference values (1), except for "general health". A significant improvement in all the dimensions for quality of life was observed, except for "general health" and "physical role". These improvements agree with other studies (2).

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ALTERNATIVE STYLES TURN TECHNIQUE QUALITATIVE EVALUATION TO INTERNATIONAL SPANISH JUNIOR AND PRE-JUNIOR SWIMMERS: AN ANALYSIS OF ERROR FREQUENCY.

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INTRODUCTION
This is a four years study compilation of the analyses developed with the Spanish Junior National Team during the summer training camps (three-week taper) before their participation in the European Junior Championships. The purpose of this study is to determine the frequency of mistakes observed in front and back crawl turns.

METHODS
176 junior and pre-junior male and female elite swimmers performed the front crawl turn and 55 performed the back crawl turn. All swimmers were video-recorded through an underwater window in order to obtain a sagital view while a 50 m-front crawl or back crawl trial at competitive speed were performed. It was employed an 8 mm video cassette recorder with frame by frame image stop.

Turn	Front crawl				Back crawl			
	Male		Female		Male		Female	
Group	Junior	Prejunior	Junior	Prejunior	Junior	Prejunior	Junior	Prejunior
Age	14-15	12-13	16-17	15	14-15	12-13	16-17	15
N	48	39	47	42	11	12	17	15

RESULTS
Seventy-eight percent of the group performed an anticipated turn on the longitudinal axis previous to contact with feet on the wall; differences between categories were found. Starting the turn far from the wall and the lack of support for hands during the turn were problems found in over 40% of the analysed swimmers in crawl. Otherwise, the biggest frequency found in backstroke turning was localized in glide and push-off phases due to a wrong neck position (29%).

TURNING ERRORS (%)		Male		Female	
		Junior	PreJunior	Junior	Prejunior
FRONT CRAWL					
Turning on the long. axis earlier (previous feet support)		63	72	90	93
Unsupported hands during the turn of the transversal axis		44	40	31	43
Start the turn far from the wall		35	38	41	40
BACKSTROKE					
Neck flexed during gliding phase		27	17	53	13
Neck flexed during impulse phase		36	8	35	0
Using the head like a rudder (flexion extension of neck)		45	17	12	13

DISCUSSION
The highest percentage of mistakes detected in the front crawl turning corresponds to turn and approximation phases, while in backstroke turning corresponds to gliding phase. The highest mistakes percentage detected in front crawl regarding backstroke could be attributed to no specificity whose were not crawl swimmers.

AIDNAT: AN INTELLIGENT DATA ANALYSIS TOOL FOR THE SWIMMING DOMAIN.

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INTRODUCTION
Data analysis is an important task in any kind of science, and the biomechanics domain is no exception. Dealing with complex data is a hard task, especially when using statistical tools, due to the huge number of situations to analyze, and available variable combinations. An alternative to statistical tools is the use of new analysis tools, which can explore the space of possible analysis situations, and variable combinations. The field of Data Mining [1] has developed several algorithms that enable a new way to analyze data, searching for patterns in data repositories. These algorithms are able to work with complex data. One scientific domain in which the analysis of data constitutes a challenge is the swimming competition domain. Not only the number of variables is high, but also the nonlinearity of relations between variables is huge, making the search for patterns in data a hard task, even for the most experienced researchers. This paper presents a data analysis tool that uses a Data Mining approach, enabling a more efficient search for patterns in data. We also present a study using this tool in the domain of pre-junior swimming athletes. The main goal of this study was to build a model for each swimming style, related to swimming performance (scoring LEN points)

METHODS
We developed a tool called AIDNat, which uses Data Mining algorithms to search for patterns in data. The tool is generic and is able to work with any kind of domain. The tool is simple to use and is thought to be used by non-expert users, guiding the analysis with a wizard. This wizard aids the user defining the data analysis to be executed in several steps: choosing the data file to analyze, pre-processing the data (for example, eliminating data rows in which there are missing values), selecting the input and target variables, and selecting the data mining algorithm to be used. In the end, the system generates a report with the analysis generated from the data, which describes the patterns found in the selected data file.
AIDNat was used for analyzing data of pre-junior swimming athletes. We have done three iterations in the analysis of data, each one exploring and focusing specific aspects of the swimming domain. The study involved about 90 variables and 420 individuals.

RESULTS & DISCUSSION
After three data analysis iterations, the tool presented several detailed models, one for each study goal. These models describe the most important characteristics for a swimmer, and they have accuracies from 40% to 60%, depending on the used algorithm. We have also identified the most important variables for each model. For example, the main characteristics for

determining the adequate style for a swimmer are anthropometric, namely: upper limb length, sitting height, height, mass, lower limb length.

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MOVEMENT ANALYSIS IN CAD-PATIENTS.

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INTRODUCTION
The relevance of physical activity in Patients with Coronary Artery Disease (CAD) is undisputable. The aim of rehabilitation is to develop an optimal sport specific program depending on the current conditions of individuals. Nevertheless such programs primarily almost always focus on physiological adaptations although it is well known that changes in the movement may influence these adaptations. Therefore the goal of this study was to assess the movement parameters of CAD patients under different load conditions during swimming.

METHODS
2-dimensional movement analysis (SIMI-Motion) was done in a flume "load-step-test" in breaststroke of 27 male CAD-patients. The movement analysis was based on the breaststroke phase model by Jähnig et al.[1]. All in all 57 movement-parameters were analysed for each patient recorded. To describe the complex movement, time-discrete and time-continuous characteristics, timing of the swim-movement (Phase Structure Quotient-PSQ by Blaser et al.[2]) and a factor analysis were done.

RESULTS
Based on the time-discrete findings 9 parameters (e.g. duration of propulsion-pause between main phase of arms and legs and angle of attack of hip-shoulder-water surface) were found to be relevant to describe the swim-movement of the CAD-patients examined. From the time-continuous point of view individual patterns were observed of arm and leg movements. The calculated PSQ described some problems of these patients to react to increased load conditions. As a result of factor analysis 4 factors of relevance (time-structure, velocity-regime, posture of upper part of the body, angle of attack of thigh) provide indications to organise swim rehabilitation programs with a special view on movement-coordination.

DISCUSSION
The movement patterns of CAD-patients react in diverse ways to increased loads. Based on these findings the importance of movement analysis in swimming of CAD-patients was underlined in order to guarantee an adapted sport-specific rehabilitation program as an additional way to control the load-stress situation and to develop movement skills.

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INTRACYCLIC VELOCITY SIGNAL AS A TOOL TO EVALUATE PROPULSIVE PHASE DURATION.

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INTRODUCTION
In the front crawl, Chollet et al. (1) defined the Index of Coordination (IdC) as the lag time between propulsive phases from one arm to the other. The calculation of IdC was based on the duration of 4 swimming phases. The duration of the propulsive phase was the sum of the durations of the pull and push phases, whereas the duration of the non-propulsive phase was the sum of the catch and recovery durations. But the key points that delimit these swim phases were determined visually on the basis of video analysis. This study determines the effect of using an intracyclic velocity signal on IdC calculation.

METHODS
Nine subjects of national and international level performed 8 swim trials at different speeds. Four mini-dv videos were mixed with the intracyclic velocity signal (Speedometer Fahnemann Inc, Germany). The duration of the propulsive phase was first analyzed only on the basis of the video data (visual) and then with the help of the speedometer to assess the end of the propulsive phase. The third analysis used only the speedometer. The mean values of IdC and the standard deviations obtained with these 3 methods were compared with ANOVAs

RESULTS
Table 1 presents the mean values of IdC and SDs of IdC obtained with the different methods.

Table 1. Mean values of IdC obtained with the 3 methods.

	Visual	Mixed	Speedometer
IdC (%)	-9.5±5.9 a, b	-15.2±6.7 b, c	-21.5±5.3 a, c
SD of IdC	4.1±1.6 NS	5.3±1.7 NS	4.2±1.6 NS

a : significant difference with mixed method
b : Significant difference with speedometer method
c : significant difference with visual method
NS: non-significant difference p<0.05

DISCUSSION
The type of method had a significant effect on the calculation of IdC. The more visual the method, the higher the values of IdC were. One explanation is that the visual method considers the push phase to be propulsive until the arm exits the water, whereas data from Monteil et al. (2) showed a drastic decrease in propulsive force before the hand exits. The visual method may thus overestimate the duration of propulsive phases. Our data in fact indicate that the visual determination of propulsive phases, as proposed by Chollet et al. (1), can overestimate duration by 5.2 to 12%. On the other hand, Table 1 indicates that the variation in IdC (Sd of IdC) with changes in self-selected speed was statistically non-significant, whatever the method of calculation. It seems thus that the visual method appear adequate for practical applications like training but for pure research into coordination, the intracyclic velocity signal provides more precise data and should be used.

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THE STABILITY OF IDC DURING MAXIMAL AND SUB-MAXIMAL SWIM TRIALS QUESTIONED.

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INTRODUCTION
The Index of Coordination (IdC) represents the lag time between propulsive phases from one arm to the other, based on 4 swimming phases in front crawl: catch, pull, push and recovery (Chollet et al., 2000). The change in IdC was evaluated during 8 self-paced simulation of race paces swum on a 25-m distance. The reliability of this indicator obtained on this basis can be questioned, especially as race distance increases. We thus investigated how IdC changes with distance during a 400-m trial and, second, we determined whether the magnitude of effort to be performed has an influence on the mean IdC value.

METHODS
Twenty-two subjects of 3 levels of expertise [8 expert, 93.0±3.1% of world record (WR); 6 mid-level, 78.5±4.2% WR; 8 recreational, 69±1.5% WR] performed a maximal 400-m freestyle swim trial. The expert population then performed 100-m, 200-m and 300-m trials at the speed of the previous 400-m. Four video cameras placed in both underwater and aerial planes allowed the calculation of IdC every 50-m. ANOVAs were completed for the different comparisons.

RESULTS
Table 1 presents the changes in IdC with swimming distance during a maximal 400-m trial.

Table 1. Change in IdC (%) with swimming distance as a function of expertise.

Distance (m)	50	100	150	200	250	300	350	400	
IdC Expert (%)	-13.5	-14.7	-14.4	-15.1	-15.2	-13.7	-13.9	-12.2	NS
IdC Medium (%)	-13	-12.9	-12.6	-12.8	-13.1	-12.2	-12	-11	NS
IdC Recreational (%)	-11.5	-10.5	-10.7	-10.3	-11.26	-10.23	-10.6	-10.5	NS

* p<0.05   NS: non-significant (p>0.05).

Table 2 presents the mean values of IdC obtained after swim trials of different distances.

Table 2. Mean values of IdC during sub-maximal swim trials.

Distance of the swim trial (m)	100	200	300	400	
IdC (%)	-14.2±1.7	-13.8±2.2	-14.1±1.7	-14.2±1.8	NS

* p<0.05   NS: non-significant.

DISCUSSION
The first part of the experiment showed that IdC did not change during a maximal 400-m swim trial for any level of expertise. The second part showed that mean IdC values were not modified even when the swim distance was reduced. The evaluation of IdC on the basis of short-distance swim trials, as proposed by Chollet et al. (2000), appears to be reliable and reproducible.

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USE OF INDEX OF COORDINATION TO ASSESS OPTIMAL ADAPTATION: A CASE STUDY.

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INTRODUCTION
In the front crawl, Chollet et al. (1) defined the Index of Coordination (IdC) as the lag time between propulsive phases from one arm to the other. A higher value of IdC with an increase in self-selected speed was considered to be an optimal adaptation to environmental constraints since it indicates that the continuity of propulsion is maintained (1). However, a large inter-individual effect was noted in the IdC values within the same expertise level. In another study, Ria et al. (2) showed that lower velocity fluctuation (VVI) was linked to better performance in swimming. This study examines how the combination of IdC and VVI could help to determine the optimal adaptation in competitive swimming.

METHODS
Two highly-trained female swimmers were compared: "international" (95.3% of world record on 100-m, WR) vs. "national" (87.9% of WR), according to the protocol from Chollet (1). IdC was determined from 4 mini-dv cameras, and the underwa-

ter lateral view was synchronized with the intracyclic velocity signal (speedometer Fahnemann, Inc). The IdC and VVI of these subjects were compared with parametric statistics (ANOVAs).

RESULTS
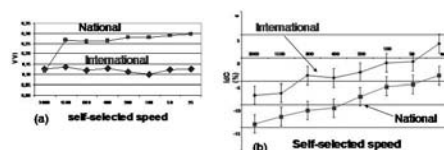
Figure 1. Changes in VVI (a) and IdC (b) with increases in self-selected speed.

The "international" swimmer had lower VVI (p<0.05) (except on V3000) and higher IdC (p<0.05) than the "national" swimmer at all self-selected speeds.

DISCUSSION
The results tend to confirm that the best swimmers are characterized by greater continuity in propulsive actions and thus higher IdC, which lowers VVI. The analysis of both IdC and VVI values at self-selected speeds can be used to evaluate how adequate a swimmer's adaptation is and thus may serve as a basis for optimizing performance at an individual level.

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ANALYSIS ON LEARNING THE FRONT CRAWL STROKE BY USE OR NON-USE OF INSTRUCTIONAL FLOTATION DEVICES.

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INTRODUCTION
A very current methodological problem for Italian swimming teachers is the suitability of the employment of instructional flotation devices during the learning of swimming. In literature there are several contrasting studies claiming their efficiency or their inconvenience.[1,2,3]
This study analyses the results of the front crawl stroke learning in Italian children aged 8-9 years, carried out by use or non-use of instructional flotation devices.

METHODS
The testing involved 20 Italian children aged 8-9 years. Subjects were divided into two groups (height 130.7±3.6, 132.3±3.9; weight 28.8±3.3, 29.4±3.2) of the same stroke level.
The protocol observed the same program for both groups: 10

lessons of 40 minutes each with the same analytical didactic progression with or without instructional flotation devices. At the end of each lesson, all subjects were tested by an 18 meters of length stroke, filmed and timed.
Both a qualitative (by MERS-F scale) and a quantitative (armstroke cycles, breathings, stroke rate, stroke length, efficiency index) analysis have been carried out by the Student's *t* test (p<0.05).

RESULTS

In the qualitative stroke analysis, the group using buoyancy achieved better results only in the armstroke evaluation at the end of the second (p<0.05) and the third (p<0.01) lesson. The quantitative stroke analysis pointed out a significant difference in the armstroke average number per breathing (p<0.05), lower in the group non-using flotation devices.

DISCUSSION

From the analysis of the results, it appears that after a 10 lesson program the learning of front crawl in beginners isn't significantly affected by use or non-use of instructional flotation devices.
The significant difference in armstroke average number per breathing (no guidelines were given about armstroke and breathing action to follow in the tests) could depend on fact that subjects taught by kickboard used a short armstroke, whereas subjects taught without flotation devices kept a slow and stretch armstroke.

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LONGITUDINAL EVALUATION OF BREASTSTROKE SPATIAL-TEMPORAL AND COORDINATIVE PARAMETERS: PREPARING OF THE 100-M BREASTSTROKE BRONZE MEDALLIST OF THE ATHENA 2004 OLYMPIC GAMES.

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INTRODUCTION

Arm to leg coordination has recently well analysed to point out his impact on velocity, as regards skill level, gender and race paces (1, 2, 3). In this way, our study shows how a model of arm to leg coordination was used to prepare an elite swimmer for the Athena 2004 Olympic Games in the 100-m breaststroke. His coordination was periodically evaluated as regards velocity (V), stroke rate (SR) and stroke length (SL) and the detailed information provided by this model served to guide the subsequent training decisions.

METHODS

Seven evaluations (E1 to E7) were made over a two-year period and assumed a parallel with the competitive performances during this period. At each evaluation, the swimmer performed 25-m at his 100-m race pace where V, SR, SL and the coordination (temporal gaps between the stroke phases of the arm and leg: T1 assessed glide, T2, T3 and T4 assessed the superposition of arm to leg recoveries) were calculated over three stroke cycles identified from underwater cameras with lateral and frontal views (50Hz). The differences between the evaluations were assessed by one-way ANOVAs and a post hoc Tukey test with *p* set at 0.05.

RESULTS

V decreased at E3 and E4 because of a shorter SL and an increase in SR. The glide (T1) was decreased at E2, E3 and E4 in comparison with E1, E5, E6, E7, while T2 and T3 showed a negative increase (at E3, E4 and E5 in comparison with E1, E2, E6, E7).

DISCUSSION

The evaluations at E1 and E2 were made during the period in which the swimmer was setting his personal world record. Then at E3 and E4, his coordination showed a degradation, with contradictory superposed movements (T2: leg recovery before the end of arm propulsion; T3: beginning of leg propulsion before the end of arm recovery), that resulted in a reduced glide (T1) and increased SR. Finally, following the change of spatial-temporal and coordinative parameters enabled to detect any degradation in technique.

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COMPARISON OF SUBJECTIVE AND OBJECTIVE METHODS OF DETERMINATION OF STROKE PHASES TO ANALYSE ARM COORDINATION IN FRONT-CRAWL.

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INTRODUCTION

Arm coordination in front crawl was most of time quantified by an index of coordination (IdC), based on the time lag between the end of the push phase of the first arm and the beginning of the pull phase of the second arm (1). The stroke phases in the sagital plane were subjectively defined from hand

postitions appreciated by an operator. This study evaluated the reliability of this subjective method 1) by studying the influence of the expertise level of the operator on the phase determination, and 2) by comparing the phases results determined sujbectively by an operator with data obtained from a digitizing process.

METHODS
Elite swimmers were filmed by two synchronised frontal and sagital underwater video cameras (50Hz). Six expert operators (which have more than 30 hours of experience) and eighteen novice operators video-determined the hand positions for three strokes of the central portion of swims. The hand was then digitised frame by frame for one arm stroke, using Schleihauf's software (2004). The coordinates corresponding to the hand positions were extracted from the smothed 3D hand trajectory. ANOVA method was used to compare the phases and the IdC obtained 1) from novice and expert operators, and 2) from the expert and the digitising process.

RESULTS
The IdC values assessed by the novice operators were higher than those of the expert operators, due to an overestimation of the pull phase duration and to a smaller catch phase duration. Smaller standard deviations of IdC were observed for expert operators compared to novice operators. No significant differences of stroke phases and of IdC were observed between the results obtained from the expert operators and the digitising process.

DICUSSION
The overestimation of the pull phase duration and the large standard deviations of IdC for the novice operators related to their confusion to determine the beginning of this phase. For them, the phase started when the hand went downward instead of downward and backward. These results showed the non-reliability of the subjective method for operators without experience and underlined the necessary training process to use this method. Conversely, the visual determination of the hand positons from the expert was sufficiently accurate to evaluate the stroke phases in regard to the similar results obtained from the digitsing process. Consequently, the phases determination did not automatically required the digitising method and thus allowed to minimise the time process.

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THE FACTORS AFFECTING VELOCITY AT OBLA IN WELL-TRAINED COMPETITIVE SWIMMERS.

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INTRODUCTION
The velocity at blood lactate accumulation of 4 mmol/L (V@OBLA) measured by the lactate curve test have been widely conducted for evaluating the effects of endurance training. V@OBLA might increase when stroke would become more efficient as well as when aerobic capacity would improve by endurance training. The purpose of present study was to investigate the factors affecting the change in V@OBLA by endurance training in well-trained competitive swimmers.

METHODS
Twelve well-trained male college swimmers participated in this study. The tests were conducted at three times (pre-, mid- and post-test). The subjects carried out the endurance training for 6 week among those tests. The tests consisted of a continuous progressive swimming (CON) for measuring VO2max and an intermittent progressive swimming (INT) for V@OBLA using the swimming flume. INT were nine stage swims which consisted of 3 minutes swimming and 5 minutes rest. The velocities of the nine swims were identical among pre-, mid- and post-test. Stroke length (SL) and stroke rate (SR) at each velocity during INT were measured from video image. From these results, SL@OBLA and SR@OBLA were calculated.

RESULTS
VO2max at mid- and post-test were significantly higher (p < 0.05) than that at pre-test, but there was no significant difference between mid- and post-test. V@OBLA at mid- and post-test were significantly higher (p < 0.05) than that at pre-test, but there was no significant difference between mid- and post-test. SR@OBLA was significantly higher (p < 0.05) at mid-test than that at pre-test. There were no differences in SR@OBLA between pre- and post-test, and between mid- and post-test. There were no significant differences in SL@OBLA between the three tests.

DISCUSSION
The result of VO2max suggested that aerobic capacity improved by endurance training from pre- to mid-test. However, from the results of SL@OBLA, it was likely that stroke efficiency would not improve by endurance training. Therefore the improvement of V@OBLA in the present study seemed to be almost caused by aerobic capacity indicated on VO2max.

ASSISTED VELOCITY SWIMMING TRAINING IN TWO AND SIX BEATS AGE GROUP FRONT CRAWL SWIMMERS.

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INTRODUCTION
Swimming velocity (SV) is the product of stroke lenght (SL) and stroke rate (SR) (2). Assisted velocity training (AVT) can increase SR and, as a consequence, enhacing SV (1). The aim of this study was to verify and to compare the effects of an AVT program on SR and time to perform 25 m in front crawl stroke in two and six beats age group front crawl swimmers.

METHODS
Ten swimmers (both sex; age = 13 to 15 years old; height =

1.66 ± 0.8 m, body mass = 52.7 ± 7.4 kg; upper limb span = 1.70 ± 5.4 m), allocated in group two beats (TB; n = 5) and group six beats (SB; n = 5) participated in this study. Front crawl kick characteristics were defined by the coach. All swimmers were participating in competitive official events, at least, for three years. Subjects performed a 25 m maximal effort in front crawl stroke, after a 1000 m swimming warm up, twice: before and after a six weeks training program. First five stroke cycles, after 10 m, to obtain SR and time to perform the 25 m were recorded with a manual chronometer. AVT program was applied twice a week (six weeks) and consisted of eight trials of 20 m (1 min rest interval). It was used a 7 m length and 203 mm thickness rubber band fixed by its extremities to the swimming pool edge and to a belt around the swimmer's waist. Subjects were towed by the coach and assistants untill the mark to perform 20 m in high velocity assisted by the rubber band. Statistical analyses were made assuming a 0.05 significant level: Wilcoxon and Mann-Whitney Tests.

RESULTS
Table 1 summarizes SR and time to perform 25 m (T25) results, before and after the AVT program.

*Table 1: Mean ± sd of SR and T25, before and after the AVT program, * indicates difference (p < 0.05).*

Groups	n	SR (Hz) before	SR (Hz) after	T25 (s) before	T25 (s) after
TB	5	1.00 ± 0.11*	1.07 ± 0.10*	14.1 ± 1.3	14.0 ± 1.4
SB	5	0.92 ± 0.07	0.97 ± 0.06	14.1 ± 0.8	14.07 ± 0.3

DISCUSSION
The only significant difference found was in SR for the TB group, which has enhanced after the AVT program. However, this increased in SR values has not affected the time to perform the 25 m. Perhaps this result is related to a concomitant decreasing in SL (1), variable that has not been assessed in this study. Thus, AVT, in age group, should be performed under a rigid technique and stroke lenght control.

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ENERGY EXPENDITURE AND FOOD INTAKE OF COMPETITIVE SWIMMERS DURING TRAINING.

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INTRODUCTION
Poor daily dietary habits can influence the performance of swimmers during training. Repetitive sessions of high intensity training can deplete glycogen stores and important vitamins, minerals and other nutrients. The great emphasis placed on nutritional supplements underestimates the importance of nutrition. The purpose of this study was to evaluate whether dietary intakes of elite swimmers can match the energy and nutrient requirements of training.

METHODS
Sixteen, elite teenage swimmers participated in this study. Food intake and energy expenditure were calculated through the completion of three-day weighed dietary records and activity records. Food intake was analyzed by computer analysis (Food Processor II, Esha Research) for its caloric content, carbohydrate, fat, protein, dietary fiber, and saturated fat. Energy expenditure estimations were based on the Food and Agricultural Organization equations and exercise metabolic rate was calculated through the reported training records (on types, duration and intensity of training). Data were statistically analyzed by a Pearson's r correlation coefficient test.

RESULTS
Swimmers mean age was 18 ± 1,4 years. Their three day training distance averaged 7568 meters per day. The mean dietary intake was significantly lower than the energy cost of swimming and protein intake was almost double the energy cost of swimming. Carbohydrate content and fat didn't demonstrate any significant differences (table 1).

Table 1. Dietary Intake and Energy Cost during a 3-day training period.

Variables	Calories(Kcal)	Protein (g)	Carbohydrate (g)	Fat (g)
Dietary Intake	2182,25*±964,14	103,23*±41,59	262,38±125,08	88,43±49,67
Energy Cost	3146,88±494,10	52,96±11,18	456,19±71,57	104,89±16,25

*Denotes that means are significantly different (p<0.05) from the Energy Cost values.

DISCUSSION
If energy intake is high and a varied diet is consumed, supplementation of the diet with vitamins and minerals is not necessary, unless a specific deficiency is identified (1). Caloric deficiency which was noted in this study can eventually lead to carbohydrate deficiency, whereas the excess of protein intake may unnecessarily tax the system. Swimmers, are usually not well informed on balanced nutritional practices that would give them an edge during training and eventually during competition. Swimmers, need to be educated on nutritional practices and the importance of meeting the energy demands (calories) of swimming. Even if nutrient requirements are met the amount of food daily consumed may be more important on its effect on preformance in terms of energy supply.

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THE IMPACT OF VELOCITY ON PULL AND RECOVERY TIMES AND AVERAGE PULL FORCE IN FREESTYLE SWIMMING.

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INTRODUCTION

The purpose of this study was to evaluate the impact of two different velocities on arm pull and recovery characteristics as well as to evaluate the force exerted by the arms. So far, the stroke characteristics that have been extensively studied are the stroke rate and the stroke length with no major emphasis on pull and recovery times. And despite the fact that force exerted is directly related to speed there is limited research.

METHODS

Twelve, non-competitive swimmers participated in this study. Arm pull characteristics and forces were measured by a hydro-dynamic measuring device incorporated in a portable laptop (Aquanex by swimming technology research, Inc., Florida, Tallahassee). Prior to entering the water, cables with sensors were secured with elastic bands from the back of the swimmers' waist to their fingers. The swimmers performed two consecutive 25 meter trials a slow (SS) and a fast (FS) at their fastest perceived velocity with a 2 minute rest in between the trials.

RESULTS

As expected the average force (N) and the swimming velocity (yds/sec) were greater in the FS. The stroke rate (strokes per second) was greater in the FS, while the stoke length (yards per stroke) was smaller. The average pull time and the recovery times of the FS were shorter than the SS. However, the decrease in pull time of the FS was of a magnitude of 15.4% when compared to the SS while the decrease of the recovery time was a magnitude of 45.7% when compared to the SS freestyle.

Table1. Arm Pull and Recovery times and Average force at two velocities.

VARIABLE	SLOW SWIM	FAST SWIM	P
Swimming Velocity (yds /sec)	0.48±0.05	0.60±0.07	P<0.0001
Average Pull Time (sec)	0.91±0.17	0.77±0.12	P<0.05
Free Recovery Time (sec)	1.03±0.28	0.56±0.13	P<0.0001
Average Pull Force (N)	18.05±8.1	28.96±13.3	P<0.01

DISCUSSION

Great emphasis has been placed on the effects of stroke rate and stroke length on velocity and generally stroke rate increases while stroke length decreases with increasing velocity (1). However, no attention has been drawn to the contribution of speed of pulling and recovery on velocity. The important finding of this study was that in the freestyle swim the increment of speed of the recovery phase was much greater (45.7%) than the increment of speed of the pulling phase (15.4%) during the fast swim in freestyle. It appears that the non-propulsive phase is a key factor for better performance as evidenced in other strokes as well (2).

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SWIMMING FUNCTIONAL CLASSIFICATION SYSTEM: A PROPOSAL FOR CORRECTIONS USING PROPULSIVE FORCE.

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INTRODUCTION

The relevance of a classification system is not questionable on the context of sport for persons who are physically disabled. However, the ability of the Functional Classification System (FCS) to define correctly in what extent the physical disability of the athletes interferes with the specific sport proficiency is recurrently questioned, mainly in swimming. Once the FCS is a subjective process, we decided to search for more precise, objective and accurate procedures, in order to contribute for a more consistent assessment of the physically disabled swimmer's functionality. The purpose of this study was to analyze the adequacy of swimming FCS to discriminate different levels of proficiency, relating it with the mean values of tethered propulsive force. We further essayed to correct the FCS with tethered propulsive force values to improve its discriminative power.

METHODS

The backstroke tethered propulsive force (P) was measured using a *Globus* stain gauge (Figure 1) in 60 Brazilian physically disabled swimmers, classified by the FCS. The statistical procedures used were common descriptive statistics, linear regression and the Pearson's correlation coefficient.
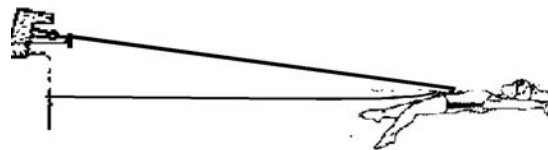
Figure 1. An illustrative scheme of the test procedure for assessing the propulsive force on tethered swimming resorting to a Globus strain gauge and a cable/belt set for attaching to the swimmer.

RESULTS

The FCS analysis with a correction factor based on the tethered propulsive force (FCSpf) was strongly correlated with P (r^2 =0.80) than the simple FCS (r^2 =0.25). With FCSpf it was also observed a more adequate distribution of the swimmers' propulsive capacity within the functional classes, with a consistent and progressive increase of P with class raise.

DISCUSSION

Adding the tethered propulsive force measurement to the pres-

ent swimming FCS seems to allow a more effective discrimination of the swimmer's specific ability, what demonstrates the relevance of using more accurate tests for assessing the athlete's motor capacity for its classification into competitive categories.

STROKE LENGTH, FREQUENCY AND VELOCITY AMONG UNIVERSITY PHYSICAL EDUCATION STUDENTS AND ITS USE AS A PEDAGOGICAL TOOL.

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INTRODUCTION
Much is known about the relationship between stroke length, stroke frequency and velocity among competitive swimmers [1]. Little, however, is known about this phenomenon among non-competitive young adults. What can and should we expect from non-competitive swimmers? Can the concept of stroke length be used as a pedagogical tool in a teaching situation?

METHODS
Two hundred and forty (240) university physical education students, 120 males and 120 females, swam a 50m crawl maximal time trial, with the start in the water. The time and the number of strokes were recorded for each 25m. Stroke length and frequency were calculated. This was done at the start and end of a period of 36 lessons (18wks). The concept of stroke length was then introduced. The elementary back stroke was introduced initially, to demonstrate the concept. As skill improved, other strokes were introduced, with constant reference to stroke length. As concrete efforts were made, for example to increase purchase on the water by improving the high elbow position, or to reduce resistance by improving the streamlining of the body, the subjects were encouraged to regularly monitor progress by counting strokes and to relate this to their tactile experience. Practicing in pairs was commonly used also to allow visual feedback in relation to the partner's technique.

RESULTS
The mean stroke length (crawl) for men at T1 was 2.2 m. For women, it was 1.8. Stroke frequency for men was 38.3 and for women 35.5 strokes·min^{-1}. Mean velocities were 1.3 and 1.1 m·s^{-1} for men and women respectively. Stroke length, given the circumstances was surprisingly comparable to competitive swimmers. After 18 weeks of instruction, the test-retest differences showed significant improvement (p< 0.01).

DISCUSSION
Coaches are generally well versed in the importance of stroke length and its consequences. They routinely control this parameter and intuitively see changes which might indicate improvement or even temporary negative influences (over training, sickness, etc). The instructor has a larger number of students and meets them less often. The kind of close monitoring available to the coach who meets his/her charges daily, is often not possible. Therefore, any tool which can be used to convey these concepts and to transfer enthusiasm and respon-

sibility to the learner is valuable.
It was concluded that the concept of stroke length can be a useful tool, both as an instructional device and as periodic monitoring, which can provide individual feedback. Further, a start has been made at establishing norms for these parameters among non-competitive swimmers.

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A RELIABILITY STUDY OF A LACTATE PROFILE TEST FOR RUNNING IN THE WATER WITH "WET VEST".

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INTRODUCTION
A blood lactate (La) profile test for step wise work loads can be used to assess changes in physical capacity and to a certain extent, monitor training [1]. This can be applied to any activity. The purpose of this study was to test the reliability of a given protocol for the La profile, while running in the water with the "Wet Vest", by test retest design.

METHODS
The test protocol was performed on two occasions with at least one day in between. Fifteen subjects, mean age, 24yrs. participated. The test protocol was an adaptation of the standard test used in our laboratory for treadmill running and consisted of 6-7 step wise progressive work loads guided by HR. The heart rate values used were 120, 130, 140, 150, 160 and if necessary, 170 and 180 bpm. Each effort was 5min with a 1 min pause between efforts. HR was continuously monitored by a test assistant on the pool side using a HR monitor (Polar). The "run" was performed on a 15m course at the deep end of a 25m pool. The assistant provided continuous feedback to help the subject maintain the specified work load. Blood samples were drawn during each pause for La analysis. Mean HR was recorded and compared to the stipulated HR for each effort. Test & retest were compared using Pearson PM correlation and Students t-test for paired differences was applied.

RESULTS
Mean deviation of HR and the corresponding SD for each workload was within 2bpm±5 of the stipulated HR for all considered subjects. The Mean SD for HR values within each 5 min effort was 1.6 bpm. The curves generated by the recorded La values for test and retest were compared. The HR differences at 2, 3 and 4 mmol La between tests over all subjects and all La levels were 3.88, 3.86 and 3.54 bpm respectively. The mean coefficient of variation was 1.456.

DISCUSSION
The ability to meet the designated work load while running in the water was demonstrated by the low variation in HR over all subjects at all loads. The ability to hold a given level of intensity (by HR) within each 5min effort was demonstrated by the

low variation over all subjects and all work loads.

CONCLUSIONS
The La profile test protocol examined was found to be reliable for running in the water and can be recommended for use in assessing physical capacity and for monitoring training.

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THE RELIABILITY OF A PEAK VO2 TEST PROTOCOL FOR RUNNING IN THE WATER WITH "WET VEST".

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INTRODUCTION
Peak VO_2 has been measured for many activities. Testing peak VO_2 while running in the water presents certain practical problems and choosing an appropriate protocol is necessary. The test protocol examined in this study was an adaptation of the standard test used in our laboratory for treadmill running. The purpose of the study was to test the reliability of the chosen protocol by a test – retest design.

METHODS
Sixteen subjects, mean age 24yrs, performed the test protocol on two occasions with 2-3 days in between tests. The test protocol consisted of five sub maximal 5 min efforts at predetermined and increasing levels of HR, with one min between efforts. After the 5th effort the final (peak) effort started with a gradually increasing HR for the first minute followed by a HR level which the subject judged they could continue for 2-3 minutes more. The HR was continuously monitored and displayed on a Polar pulse monitor mounted on the helmet which also supported the mouthpiece and respiratory hose. Classic Douglas Bag respirometry was used. The bags were mounted on a trolley at pool side and the hose was suspended from above. Two bags of expired air were collected during the last (estimated) two minutes of the effort. Blood samples were drawn for La analysis immediately after cessation of work.

RESULTS
For all 16 subjects mean peak VO_2 value was 3.57l/m (range=2.03-4.52; SD=0.69) or 51.47ml/kg/min (range 42.6-61.9:SD=5.68). The mean peak HR was 176 BPM, blood La 6.2 mmol and mean peak RQ 1.10. Pearson PM correlations and Students T test for significant difference were performed. The following table gives the results of the test- retest comparison for reliability.

	VO_2	HR	La
r	0.99	0.96	0.98
p<	0.001	0.001	0.001

DISCUSSION
The values obtained for peak VO_2 and HR, corroborate previ-

ous findings; values for running in the water tend to be appr. 10-20% lower than that obtained on land. Peak La values on the other hand were higher than on land, as also seen in previous findings [1]. The test-retest comparison showed exceptionally high reliability. The test protocol examined can be recommended as reliable and can be used in attempts to measure Peak VO_2 while running in the water with the wet vest.

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THROWING WITH DIFFERENT KINETIC CHAIN.

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INTRODUCTION
Overarm throw is determined by a so called proximal-to-distal principle (1). This principle has been mostly studied by using kinematical analysis and electromyography. Our concept of studying kinetic chain was to gradually add the active muscles in the throwing kinetic chain and measure the throwing velocity. This way the contribution of the newly added muscles to the final velocity of the ball could be estimated.

METHODS
Seven national team waterpolo players were asked to throw the ball with maximum velocity three times in four different body positions: P1:arm only (sitting, trunk (chest) fixed on the back of a chair); P2:sitting (pelvis fixed on a chair); P3:standing (opposite leg stepped forward); and P4 in the water. Throws were executed with two balls of different weight – normal (N) water polo ball (0,43 kg) and 3 kg medicine (H) ball. The ball was thrown in the direction of the 5m distant radar which measured the velocity of the ball. The highest velocity of the three throws was used for further analysis.

RESULTS
Throwing the ball with arm only (P1), resulted in a 68% and 70% of the maximal (100% was P3 position) velocity of the ball, for normal and 3 kg ball respectively. By activating the trunk muscles (P2) the average ball velocity increase was 11% (P2N) and 9% (P2H) respectively. In standing position (P3N and P3H) the velocity was further increased by 20%. In the water the throwing velocity of the normal ball was further increased by 3% while the velocity of the heavy ball decreased by more than 20%! Maximal ball velocity was measured in the water (P4n) - 84 km/h (23,3 m/s). The highest correlations *r1* and *r2* were obtained between P2 and P4, for N and H respectively.

DISCUSSION
As kinetic chain was prolonged from P1 to P3, the throwing velocities increased with both balls. However, in water throw (P4) normal ball velocity was additionally increased while in heavy ball decreased, very likely due to insufficient leg/pelvis stabilization in water during heavy ball throw where greater

forces are produced. The highest correlation between P2H and P4H showed on smaller pelvis/leg action involvement in water throws. The player that threw the ball with the highest velocity was able to increase ball velocities from P1 to P4 most proportionate with both the normal and heavy ball. On individual basis, players playing in different positions (driver, center forward, goal-keeper) had different velocity increase due to changed kinetic chain. Accordingly, individual differences were observed in normal/heavy ball index as well which may point to conditional or technical specificities. It is concluded that main characteristics of the water throw was related to reduced pelvis/leg fixation and high adaptation to specific water conditions.

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STATE OF PRE-COMPETITIVE ANXIETY AMONG SWIMMERS AND WATER POLO PLAYERS IN RELATION TO CONTEST EXPERIENCE.

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INTRODUCTION
There is a great interest in analysing the psychological factors which affect the performance of athletes. Their reaction to the state of anxiety experienced before, and during a game have been considered important psychological factors in athletic performance. This research aims at examining differences in the intensity of pre-competition anxiety state based on contest experience between a) the two sexes (male and female) and b) the two sports (swimming and water polo).

METHODS
In the research participated 601 male and female athletes, aged 13-26 years old (M=16.9±3.2) and competitive experience M=4.4±2.8 years. They were divided in five (5) groups, according to experience, and 425 were coming from swimming and 176 from water polo. As regards the sample sex, it consists of 288 male and 313 female athletes. The athletes 30- 45 min completed, before the prime games of the competition season, the Greek version of the Competitive State Anxiety questionnaire (CSAI – 2) (1, 2). In parallel, in order to evaluate their competitive experience, they replied to question concerning the years of participation in competition games. The MANOVA with the criterion full factorial and the model 2 x 2 x 5 was used to analysed the results obtained.

RESULTS
The results show that: 1) there is statistically significant differences in the intensity of contest anxiety concerning contest experience and sex $F = 26.693$, ($P = 0.000$); 2) statistically significant differences were found $F= 6.865$, ($P = 0.000$) as regards contest experience and short of game for all three anxiety factors (Somatic $F=13.32$, $P=0.000$, Cognitive= $F=7.391$, $P=0.000$, and Self Confidence $F =15.29$, $P = 0.000$).

DISCUSSION
The results demonstrate that there is statistical significant difference in all three anxiety factors (cognitive, somatic, self confidence) concerning experience and game. This proves that for swimmers (individual game) and water polo players (team game), self confidence increases with more contest experience that is to say with more years in contest participation.

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THE RELATIONSHIP OF ANTHROPOMORPHOLOGICAL CHARACTERISTICS OF CRAWL SPRINT SWIMMERS OF BOTH GENDERS WITH CRITICAL SPEED AT 50 AND 100 M.

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INTRODUCTION
The elite results in swimming depend on a number of factors including the efficiency of the swimming technique, various functional and metabolic characteristics of swimmers, the level of training accomplishment - but they also depend on a number of features of the swimmer's body (1). The aim of this work is to establish the link of various anthropo-morphological ($A_{nth}M_{orph}$) characteristics of crawl sprint swimmers of both genders in relation to critical speed at 50 and 100 meters (as a sprint distances).

METHODS
The research has been carried over a sample of 25 swimmers (13 male and 12 female). All of them were members of swimming clubs in Athens. The given value of the critical speed (CSS) at 50 ($V_{crit}50$) and 100 meters ($V_{crit}100$) was obtained applying the mathematical modeling of Distance – Time ratio, calculated from the 15, 25, 50 and 100m swim in crawl style (measured by start from water during an one training session). The $A_{nth}M_{orph}$ characteristics of swimmers are evaluated over a set of eight variables: BMI, LBM, and percentage of fat, leg-length and arm-length index, the shape of the chest, the trunk and the body. The results have been analyzed applying descriptive and multiple regression statistics where the variables of the CSS represented the criteria and, the $A_{nth}M_{orph}$ characteristics represented the predictor system.

RESULTS
For men, the given $V_{crit}50$ is explained at the level of 56.85% (AdjR^2 = 0.5685), and statistically in a significant way ($F = 4.95$, $p = 0.026$) it was defined by the following predictors, namely index of the body shape, the shape of trunk, LBM and

BMI. The $V_{crit}100$ is explained at the level of 57.79% (AdjR^2 = 0.5679), and it was defined in a significant way statistically (F = 5.10, p = 0.024) by the following predictors, i.e. index of the body shape, the shape of trunk, LBM and the percentage of fat. For women, the $V_{crit}50$ is explained at the level of 57.09% (AdjR^2 = 0.5709), and it was defined in a significant way statistically (F = 8.31, p = 0.009) by the following predictors: arm-length index and LBM. The $V_{crit}100$ is explained at the level of 47.29% (AdjR^2 = 0.4729), and was defined in a significant way statistically (F = 5.93, p = 0.023) by the same predictors, that is arm-length index and LBM.

DISCUSSION
The results have shown the existence of important differences between indices of $V_{crit}50$ and $V_{crit}100$ and $A_{nth}M_{orph}$ characteristics between genders. As regards men, at the critical speed faster were those who have a rectangular shape of trunk and higher LBM. With regard to women, at the critical speed faster were those who have a longer arm length in relation to body height and higher LBM. The results lead to the conclusion that the above mentioned $A_{nth}M_{orph}$ characteristics can be used as the one of selection criteria for the sprint swimmers.

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THE DIURNAL EFFECTS OF A TETHERED SWIMMING POWER TEST.

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INTRODUCTION
Research has shown that diurnal differences in maximal swimming performance exists (100m time trial)[1]. None have to our knowledge yet tested the diurnal effect for shorter trials. The aim of this study was to investigate the diurnal effect of a tethered swimming power test.

METHOD
15 national level competitive swimmers (13- 25 years old) were tested both in the morning and in the afternoon on the same day. The test protocol consisted of 3 tethered trials where the maximal force was registered and the highest measurement was used as the test score. Force was measured using a load cell with peak-hold display (AEP Italy). The swimmers were connected to the load cell using a rubber tube to smoothen the force during the stroke – resulting in a possibility to measure the peak force during a stroke. Maximum work time was approximately 10 seconds. The spring stiffness of the system was 20 N/m. All the morning tests took place between 6:00am-9:00am, and the afternoon tests took place between 4:00mp-7:00pm the same day. Standardized warm up procedures were conducted and subjects were accustomed to the testing procedure.

RESULTS
The mean (SD) morning and afternoon tethered swimming force was 151.5 (29.1) and 152.8 (28.5) respectively. No statistical difference was found between the two test situations (p=0.30, paired t-test). The correlation coefficient between morning and afternoon testing was r=0.99. Average absolute coefficient of variation was 2.7% (1.7%).
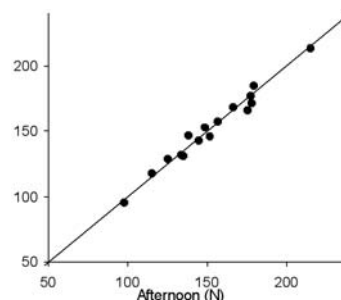
Fig. 1: Tethered swimming force of morning (y-axis) and afternoon (x-axis).

DISCUSSION
The results indicate that for a maximal tethered swimming force test the time of day for testing may be of less importance. The variation was almost identical to test-retest on the same time of day. This is under the assumption that 3 trials are used in the testing protocol, the subjects are accustomed to the testing procedures by prior familiarization and that no exhaustive training was done prior to testing. However some variations may occur for different individuals and the largest difference between morning and afternoon test for the included subjects was 5.7%.

CONCLUSION
Tethered swimming force testing may be done without diurnal effects affecting performance, assuming that proper warm up is conducted, and 3 trials is used for protocol.

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DIFFERENT LEVELS OF HYDRATION FOLLOWING A TRAINING SESSION ON SWIMMING PERFORMANCE.

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INTRODUCTION
During swimming training sessions an amount of fluids could be lost (1). This may affect swimming performance as has been observed in cycling (2) and proper hydration is advisable. The purpose of the study is to examine the effect of two different levels of hydration after a training session on performance eight hours later in a following afternoon session.

METHODS

Eight swimmers (mean±SD, age:21.4±1.2 years, height:179±6 cm, body weight:74.8±4.3 kg, VO_{2max}:3.9 l/min) performed a morning swimming training session of 4800m (intensity range: 95-105% of critical velocity). Eight hours later, an afternoon testing session consisting of 4x200m at intensity 95% of the critical velocity (4x200submax) and 200m maximum effort (200max) was performed. In two separate trials a week apart, swimmers consumed a fluid volume (isostar® 6%) of either 150% (F150) or 50% (F50) of the morning post-training body weight loss. Blood lactate was determined at the end of each training set and blood glucose was measured before and after each training session. Heart rate was recorded continuously during both sessions. Diet was recorded two days before the testing days and prescribed with equal carbohydrate content (solid and fluid) during the eight hours of recovery.

RESULTS

Blood lactate and glucose as well as heart rate were similar during the morning session in both trials (p>0.05). Body weight was reduced by 0.9±0.2% and 0.8±0.3% after the morning session in F150 and F50 trials respectively (between trials, p>0.05). At the beginning of the afternoon session, body weight had recovered in the F150 but remained low in the F50 trial (p<0.05). Heart rate showed a tendency to increase at the end of the 4x200submax (p=0.08) and was higher in the afternoon testing compared to the morning session in the F50 trial (p<0.05). Performance of the 200max was not different between trials (p>0.05).

DISCUSSION

The volume of fluid consumed after a swimming training session should exceed 150% of the total body weight loss. Dehydration of about 1% may not be severe enough to impair performance during a maximum 200m swimming effort. This level of dehydration may, however, alter cardiac responses during a prolonged sumbaximal swimming.

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MENTAL REPRESENTATION OF SWIMMING STROKES.

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INTRODUCTION

Biomechanics in aquatic space is an important tool to better understand how corporal actions determines locomotion of the body based on flow physics. An understanding how actions are represented mentally might also be of value, e.g. when communicating about swimming strokes (the interaction between limbs and surrounding water). The purpose of this paper is a first attempt to apply a new experimental method: Structural Dimensional Analysis-Motoric (SDA-M) (1) to self-propulsion in water.

METHODS

SDA-M contains four steps: basically people are asked to judge the functional relation between adjacent BACs (Basic Action Concepts) according to their present knowledge. BACs can be viewed as the mental counterparts of functionally relevant elementary components of complex movements, recognisable perceptual features. They can be described verbally as well as pictorially. Finally, the hierarchical structure is measured according to cluster-analysis approach presenting the results in a dendogram.

RESULTS

The following figures represents the hierarchic cluster analysis for two swimmers.
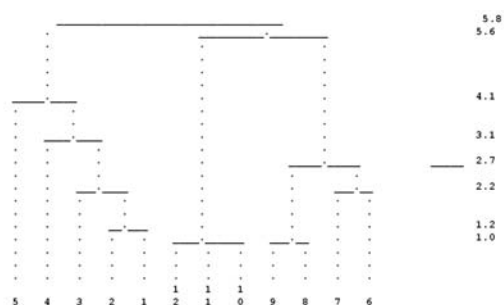
The hierarchic cluster analysis for the mental representation structure of arm action in butterfly reveals four clusters: 1) forward rotation, head enters water, hands enter water, 2) supination of hands, backward rotation starts, 3) bending of elbow, in-sweep of the hand, 4) pronation of the hands, extension of elbows, slicing hands before leaving water.

DISCUSSION

The individual mental representation of swimming action can be shown experimentally by uncovering the distances between selected basic action concepts which are closely related to functional items as shown by Ungerechts (2). The knowledge of this very individual aspect of locomotion will assist to communicate much more effectively aspects of stroking beyond to create flow, transfer momentum and raise efficiency.

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IS THERE A DIFFERENCE? – THE GENDER ISSUE IN PSYCHO-SOCIAL CHARACTERISTICS OF SWIMMING CHAMPIONS.

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INTRODUCTION
Gender distinctions in the preparation of athletes have received increasing attention[3] commensurate with the recognition of gender issues generally in post-modern society. The present study investigates this dimension in the psycho-social arena at the high performance level in swimming.

METHODS
The investigation analyzed the responses to the Rushall[1] Psychological Inventories for Competitive Swimmers (PICS) of 18 Norwegian elite swimmers (9 women and 9 men) who had won individual titles at Senior National Championships and had represented Norway in international competition. The Rushall[2] methodology from the development of the Champion Characteristics Checklist (based on elite athlete responses to a series of specific sport inventories) was utilized whereby items answered in a like manner by 75% or more of the champion swimmer sample were judged as indicative of commonality. These resulting items were then assessed for clustering tendencies.

RESULTS
Of the 242 PICS items in the four inventories, those meeting the inclusion criterion were distributed in 7 theme clusters: General Features, Relationship with Coach, Relationship with Swimmers, Training, Pre-Competition, Competition, and Motivational Features. Items were listed as specific to women, specific to men, and common to both.

DISCUSSION
Coaching and swimmer developmental implications are discussed in terms of the gender differences and commonalities. The primary function of this map of variegated characteristics is to enhance the appreciation of the nuances in the psycho-social dimension of the aquatic arena, as based on the modelling characteristics of champions. As a research tool for swimmer and coach development, it lends itself well to longitudinal application.

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DETERMINATION AND APPLICATION OF INTERVAL SWIM CRITICAL VELOCITY AND CRITICAL REST TIME IN THE 50M INTERVAL SWIM TRAINING.

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INTRODUCTION
Critical velocity (V_{cri}) determined by the relationship between the swimming distance and the swimming time, has been defined as the maximal speed which could theoretically be maintained without exhaustion during swimming. Moreover, the interval swim critical velocity (V_{cri-IS}) defined as the maximal average speed to be able to swim repeatedly without exhaustion in the 50m interval swim training at one swimming velocity higher than anaerobic threshold could be determined and the critical rest time (t_{cri}), which could theoretically be repeated the interval swims without exhaustion could be estimated by using V_{cri-IS} (Wakayoshi & Ogita, 2003). Therefore, the purpose of this study was to determine V_{cri-IS} and t_{cri} for interval swim training at four velocities higher than anaerobic threshold and to apply those data to an index for setting the combination of velocity and rest time for the interval training.

METHODS
The subjects were 11 well-trained college male swimmers. Experiments were carried out in the 50m pool. The maximal swim test (T_{max}) and 50m interval swim test (T_{int}) were performed. In T_{max}, the subjects swam 50m and 2000m at maximal effort, and the mean velocity of each swim was determined (V_{50}, V_{2000}). The velocity in T_{int} were set at four paces of $V_{30\%}$, $V_{40\%}$, $V_{50\%}$ and $V_{60\%}$ for each subject, which were calculated by the following equation, $V_{30\%}$ as an example, $V_{30\%}=0.3(V_{50}-V_{2000}) + V_{2000}$. If the subject could not complete interval swim 30 times in each T_{int}, the rest time was increased by 2-10 s in the next trial, until the subjects could complete T_{int}. Finally, the subjects performed four to six sets of T_{int} at each velocity. The total time (t_T) of T_{int} including interval swims and rest periods and the total swim distance (D_{int}) of T_{int} were determined. C_{cri-IS} at each velocity ($V_{30\%}$, $V_{40\%}$, $V_{50\%}$ and $V_{60\%}$) could be determined by the relationship between D_{int} and t_T. V_{cri-IS} multiplied by the cycle time that added swimming time (t_s) to t_{cri} makes repeated distance of T_{int} (50m) and t_{cri} can be estimated by the following equations, $V_{cri-IS*}(t_s + t_{cri})=50$ and $t_{cri} =50/V_{cri-IS} - t_s$.

RESULTS
The relations between D_{int} and t_T were expressed in the general form, $D_{int}=a+b*t_T$ in all subjects. V_{cri-IS} and t_{cri} at $V_{30\%}$, $V_{40\%}$, $V_{50\%}$ and $V_{60\%}$ were 1.16±0.08 m/s and 8.5±2.2 s, 1.04±0.09 m/s and 14.2±3.5 s, 0.92±0.08 m/s and 22.3±4.0 s, and 0.85±0.09 m/s and 28.7±5.4 s, respectively. Moreover, there was a tendency that t_{cri} at four paces of the long distance swimmers were shorter than those of the short distance swimmers.

DISCUSSION
It was thought that the combinations of velocity and rest period which imply interval swim fatigue threshold (ISFT) could be defined from the results of V_{cri-IS} and t_{cri}, and ISFT could be applied as a helpful index to prescribe the interval training program.

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SWIMMERS POSTURE: SCREENING NORTHEAST BRAZILIANS.

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INTRODUCTION
It is estimated that 70% to 80% of individuals had suffered of low back pain in their lives. At EUA, low back pain is the first functional limitation cause. One of the most frequent recommendations to treat this problem, and to increment posture, is to swim. Although, many studies (1, 2, 3) have demonstrated that cyclic and repetitive activities, such as competitive swimming, may induce posture changes in the most solicitated joints.

METHODS
The aim of this study was to identify the most frequent postural changes in competitive swimmers, analyzing the scapular waist, the spine, the knees and the hips. Thirty two male swimmers from Northeast of Brazil, who participated in a Northeast Swimming Cup in December 2004, had their posture assessed. The participants were included in the age categories infantile, juvenile and senior (M= 17.9 years; mv= 13 years; Mv= 32 years). With the purpose of characterize swimmers, some anthropometric data was collected: weight (M= 65.2 kg; mv= 39.0kg; Mv= 85.0kg), height (M= 1.74m; mv= 1.48m; Mv= 1.87m) and body fat (M= 14.3%; mv= 10.4%; Mv= 24.3%). The posture was measured through an adaptation of the Portland State University Posture Analysis Form. The swimmers were photographed in orthostatic position in anterior, posterior and sagital plan and anterior back inclination. Their pictures were compared with the Portland State University Posture Analysis Form. Descriptive statistics was used for data analysis.

RESULTS & DISCUSSION
The results revealed that the most frequent postural changes were: (i) scapular waist- unleveled shoulders (90,6%) and protuse shoulders (31,2%); (ii) spine - scoliosis (59,3%), hiperkiphosis (75,0%) and hiperlordosis (37,5%); (iii) knees - genovaro (37,5%), genovalgum (21,9%) and genorecurvatum (15,6%) and (iii) hips - unleveled hips (31.2%) these findings are in agreement with other studies (1).
It were formulated three recommendations: (i) it should be employed specific exercises to improve swimmers posture or maintaining good alignment; (ii) explanation why posture is an important consideration should be used and (iii) coaches should diversify the train methodologies.

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ABILITY OF COMPETITIVE SWIMMERS TO MODIFY START DEPTH IS NOT DEPENDENT UPON EXPERIENCE.

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INTRODUCTION
There is a distinct paucity of research relating to safety concerns in competitive swimming starts. Blitvich, McElroy, Blanksby, Clothier, and Pearson [1] found that competitive swimmers complete significantly shallower starts in a 1.2m depth pool than a 2m depth pool. The purpose of this study was to expand upon this and compare the ability of inexperienced and experienced competitive swimmers to modify on request the maximum head depth achieved during a competitive swimming start.

METHODS
Twelve experienced (age = 20.2 ± 1.2 years, height = 1.79 ± 0.08 m, mass = 76.3 ± 10.3 kg) and 13 inexperienced (age = 14.8 ± 1.1, height = 1.68 ±0.06 m, mass = 57.1 ± 6.2 kg) swimmers were filmed underwater during completion of two competitive starts from a 0.75 m block with a 10 degree angle into 3.66 m of water. Experienced swimmers were collegiate swimmers. Inexperienced swimmers were high school swimmers in the first month of their first season of competitive swimming. Swimmers completed one start and subsequent freestyle sprint without instruction. Prior to the second start the swimmers were asked to make the start as shallow as possible while still completing the sprint. For each start, the maximum depth of the center of the head was determined using 2D DLT analysis.

RESULTS
A two-way mixed design ANOVA for maximum depth of the center of the head yielded no interaction between instruction and experience, but significant main effects for both instruction ($F_{2,2,12}$ = 28.0; $p<0.01$) and experience ($F_{2,2,12}$ = 29.7; $p<0.01$). The experienced swimmers attained a significantly deeper maximum head depth than the inexperienced swimmers (0.91 ± 0.05 m vs. 0.55 ± 0.05m respectively). As there was no significant interaction between experience and instruction, the experienced and inexperienced groups were combined in an analysis of the ability to modify depth. When instructed to dive shallowly, the maximum head depth decreased significantly ($p<0.01$) from 0.83 ± 0.04 m to 0.64 ± 0.03 m. Similar results were seen for the absolute velocity of the head at maximum depth, with experienced athletes moving significantly

faster than inexperienced (3.06 ± 0.10 m/s vs. 1.98 ± 0.10 m/s) and the shallower start having a significantly faster head velocity at maximum depth than the deeper start (2.69 ± 0.08 m/s vs. 2.36 ± 0.09 m/s).

DISCUSSION
The ability of inexperienced swimmers to modify start depth implies that in a post-pubescent population spinal cord injuries during competitive swimming starts are not necessarily due to an inability to control the depth of the start. Future study will focus on the ability of a pre-pubescent population to control competitive swimming start depth.

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AUTHOR INDEX

Author Index

NORMAS DE PUBLICAÇÃO

Tipos de publicação

Investigação original
A RPCD publica artigos originais relativos a todas as áreas das ciências do desporto.

Revisões da investigação
A RPCD publica artigos de síntese da literatura que contribuam para a generalização do conhecimento em ciências do desporto. Artigos de meta-análise e revisões críticas de literatura são dois possíveis modelos de publicação. Porém, este tipo de publicação só estará aberto a especialistas convidados pela RPCD.

Comentários
Comentários sobre artigos originais e sobre revisões da investigação são, não só publicáveis, como são francamente encorajados pelo corpo editorial.

Estudos de caso
A RPCD publica estudos de caso que sejam considerados relevantes para as ciências do desporto. O controlo rigoroso da metodologia é aqui um parâmetro determinante.

Ensaios
A RPCD convidará especialistas a escreverem ensaios, ou seja, reflexões profundas sobre determinados temas, sínteses de múltiplas abordagens próprias, onde à argumentação científica, filosófica ou de outra natureza se adiciona uma forte componente literária.

Revisões de publicações
A RPCD tem uma secção onde são apresentadas revisões de obras ou artigos publicados e que sejam considerados relevantes para as ciências do desporto.

Regras gerais de publicação

Os artigos submetidos à RPCD deverão conter dados originais, teóricos ou experimentais, na área das ciências do desporto. A parte substancial do artigo não deverá ter sido publicada em mais nenhum local. Se parte do artigo foi já apresentada publicamente deverá ser feita referência a esse facto na secção de Agradecimentos.
Os artigos submetidos à RPCD serão, numa primeira fase, avaliados pelos editores-chefe e terão como critérios iniciais de aceitação: normas de publicação, relação do tópico tratado com as ciências do desporto e mérito científico. Depois desta análise, o artigo, se for considerado previamente aceite, será avaliado por 2 "referees" independentes e sob a forma de análise "duplamente cega". A aceitação de um e a rejeição de outro obrigará a uma 3ª consulta.

Preparação dos manuscritos

Aspectos gerais
Cada artigo deverá ser acompanhado por uma carta de rosto que deverá conter:
– Título do artigo e nomes dos autores;
– Declaração de que o artigo nunca foi previamente publicado;

Formato
– Os manuscritos deverão ser escritos em papel A4 com 3 cm de margem, letra 12 e com duplo espaço e não exceder 20 páginas;
– As páginas deverão ser numeradas sequencialmente, sendo a página de título a nº1;
– É obrigatória a entrega de 4 cópias;
– Uma das cópias deverá ser original onde deverá incluir as ilustrações também originais;

Dimensões e estilo
– Os artigos deverão ser o mais sucintos possível; A especulação deverá ser apenas utilizada quando os dados o permitem e a literatura não confirma;
– Os artigos serão rejeitados quando escritos em português ou inglês de fraca qualidade linguística;
– As abreviaturas deverão ser as referidas internacionalmente;

Página de título
A página de título deverá conter a seguinte informação:
– Especificação do tipo de trabalho (cf. Tipos de publicação);
– Título conciso mas suficientemente informativo;
– Nomes dos autores, com a primeira e a inicial média (não incluir graus académicos)

– "Running head" concisa não excedendo os 45 caracteres;
– Nome e local da instituição onde o trabalho foi realizado;
– Nome e morada do autor para onde toda a correspondência deverá ser enviada;

Página de resumo
– Resumo deverá ser informativo e não deverá referir-se ao texto do artigo;
– Se o artigo for em português o resumo deverá ser feito em português e em inglês;
– Deve incluir os resultados mais importantes que suportem as conclusões do trabalho;
Deverão ser incluídas 3 a 6 palavras-chave;
– Não deverão ser utilizadas abreviaturas;
– O resumo não deverá exceder as 200 palavras;

Introdução
– Deverá ser suficientemente compreensível, explicitando claramente o objectivo do trabalho e relevando a importância do estudo face ao estado actual do conhecimento;
– A revisão da literatura não deverá ser exaustiva;

Material e métodos
– Nesta secção deverá ser incluída toda a informação que permite aos leitores realizarem um trabalho com a mesma metodologia sem contactarem os autores;
– Os métodos deverão ser ajustados ao objectivo do estudo; deverão ser replicáveis e com elevado grau de fidelidade;
– Quando utilizados humanos deverá ser indicado que os procedimentos utilizados respeitam as nor-

mas internacionais de experimentação com humanos (Declaração de Helsínquia de 1975);
– Quando utilizados animais deverão ser utilizados todos os princípios éticos de experimentação animal e, se possível, deverão ser submetidos a uma comissão de ética;
– Todas as drogas e químicos utilizados deverão ser designados pelos nomes genéricos, princípios activos, dosagem e dosagem;
– A confidencialidade dos sujeitos deverá ser estritamente mantida;
– Os métodos estatísticos utilizados deverão ser cuidadosamente referidos;

Resultados
– Os resultados deverão apenas conter os dados que sejam relevantes para a discussão;
– Os resultados só deverão aparecer uma vez no texto: ou em quadro ou em figura;
– O texto só deverá servir para relevar os dados mais relevantes e nunca duplicar informação;
– A relevância dos resultados deverá ser suficientemente expressa;
– Unidades, quantidades e fórmulas deverão ser utilizados pelo Sistema Internacional (SI units).
– Todas as medidas deverão ser referidas em unidades métricas;

Discussão
– Os dados novos e os aspectos mais importantes do estudo deverão ser relevados de forma clara e concisa;
– Não deverão ser repetidos os resultados já apresentados;

– A relevância dos dados deverá ser referida e a comparação com outros estudos deverá ser estimulada;
– As especulações não suportadas pelos métodos estatísticos não deverão ser evitadas;
– Sempre que possível, deverão ser incluídas recomendações;
– A discussão deverá ser completada com um parágrafo final onde são realçadas as principais conclusões do estudo;

Agradecimentos
Se o artigo tiver sido parcialmente apresentado publicamente deverá aqui ser referido o facto;
Qualquer apoio financeiro deverá ser referido;

Referências
– As referências deverão ser citadas no texto por número e compiladas alfabeticamente e ordenadas numericamente;
– Os nomes das revistas deverão ser abreviados conforme normas internacionais (ex: Index Medicus);
– Todos os autores deverão ser nomeados (não utilizar et al.)
– Apenas artigos ou obras em situação de "in press" poderão ser citados. Dados não publicados deverão ser utilizados só em casos excepcionais sendo assinalados como "dados não publicados";
– Utilização de um número elevado de resumos ou de artigos não "peer-reviewed" será uma condição de não aceitação;

Exemplos de referências
ARTIGO DE REVISTA
1 Pincivero DM, Lephart SM, Karunakara RA (1998). Reliability and precision of isokinetic strength and muscular endurance for the quadriceps and hamstrings. Int J Sports Med 18: 113-117
LIVRO COMPLETO
Hudlicka O, Tyler KR (1996). Angiogenesis. The growth of the vascular system. London: Academic Press Inc. Ltd.
CAPÍTULO DE UM LIVRO
Balon TW (1999). Integrative biology of nitric oxide and exercise. In: Holloszy JO (ed.). Exercise and Sport Science Reviews vol. 27. Philadelphia: Lippincott Williams & Wilkins, 219-254
FIGURAS
Figuras e ilustrações deverão ser utilizadas quando auxiliam na melhor compreensão do texto;
As figuras deverão ser numeradas em numeração árabe na sequência em que aparecem no texto;
Cada figura deverá ser impressa numa folha separada com uma legenda curta e concisa;
Cada folha deverá ter na parte posterior a identificação do autor, título do artigo. Estas informações deverão ser escritas a lápis e de forma suave;
As figuras e ilustrações deverão ser submetidas com excelente qualidade gráfico, a preto e branco e com a qualidade necessária para serem reproduzidas ou reduzidas nas suas dimensões;
As fotos de equipamento ou sujeitos deverão ser evitadas;

QUADROS
Os quadros deverão ser utilizados para apresentar os principais resultados da investigação.
Deverão ser acompanhados de um título curto;
Os quadros deverão ser apresentados com as mesmas regras das referidas para as legendas e figuras;
Uma nota de rodapé do quadro deverá ser utilizada para explicar as abreviaturas utilizadas no quadro.

PUBLICATION NORMS

Working materials (manuscripts)

Original investigation
The PJSS publishes original papers related to all areas of Sport Sciences.

Reviews of the literature (state of the art papers)
State of the art papers or critical literature reviews are published if, and only if, they contribute to the generalization of knowledge. Meta-analytic papers or general reviews are possible modes from contributing authors. This type of publication is open only to invited authors.

Commentaries
Commentaries about published papers or literature reviews are highly recommended by the editorial board and accepted.

Case studies
Highly relevant case studies are favoured by the editorial board if they contribute to specific knowledge within the framework of Sport Sciences research. The meticulous control of research methodology is a fundamental issue in terms of paper acceptance.

Essays
The PJSS shall invite highly regarded specialists to write essays or careful and deep thinking about several themes of the sport sciences mainly related to philosophy and/or strong argumentation in sociology or psychology.

Book reviews
The PJSS has a section for book reviews.

General publication rules

All papers submitted to the PJSS are obliged to have original data, theoretical or experimental, within the realm of Sport Sciences. It is mandatory that the submitted paper has not yet been published elsewhere. If a minor part of the paper was previously published, it has to be stated explicitly in the acknowledgments section. All papers are first evaluated by the editor in chief, and shall have as initial criteria for acceptance the following: fulfilment of all norms, clear relationship to Sport Sciences, and scientific merit. After this first screening, and if the paper is firstly accepted, two independent referees shall evaluate its content in a "double blind" fashion. A third referee shall be considered if the previous two are not in agreement about the quality of the paper.
After the referees receive the manuscripts, it is hoped that their reviews are posted to the editor in chief in no longer than a month.

Manuscript preparation

General aspects
The first page of the manuscript has to contain:
– Title and author(s) name(s)
– Declaration that the paper has never been published

Format
– All manuscripts are to be typed in A4 paper, with margins of 3 cm, using Times New Roman style size 12 with double space, and having no more than 20 pages in length.
– Pages are to be numbered sequentially, with the title page as nr.1.
– It is mandatory to send 4 copies;
– One of the copies is the original that has to have original illustrations.

Size and style
– Papers are to be written in a very precise and clear language. No place is allowed for speculation without the boundaries of available data.
– If manuscripts are highly confused and written in a very poor Portuguese or English they are immediately rejected by the editor in chief.
– All abbreviations are to be used according to international rules of the specific field.

Title page
– Title page has to contain the following information:
– Specification of type of manuscript (but see working materials-manuscripts).
– Brief and highly informative title.
– Author(s) name(s) with first and middle names (do not write academic degrees)

– Running head with no more than 45 letters.
– Name and place of the academic institutions.
– Name, address, fax number and email of the person to whom the proof is to be sent.

Abstract page
– The abstract has to be very precise and contain no more than 200 words, including objectives, design, main results and conclusions. It has to be intelligible without reference to the rest of the paper.
– Portuguese and English abstracts are mandatory.
– Include 3 to 6 key words.
– Do not use abbreviations.

Introduction
– Has to be highly comprehensible, stating clearly the purpose(s) of the manuscript, and presenting the importance of the work.
– Literature review included is not expected to be exhaustive.

Material and methods
– Include all necessary information for the replication of the work without any further information from authors.
– All applied methods are expected to be reliable and highly adjusted to the problem.
– If humans are to be used as sampling units in experimental or non-experimental research it is expected that all procedures follow Helsinki Declaration of Human Rights related to research.
– When using animals all ethical principals related to animal experimentation are to be respected, and when

possible submitted to an ethical committee.
– All drugs and chemicals used are to be designated by their general names, active principles and dosage.
– Confidentiality of subjects is to be maintained.
– All statistical methods used are to be precisely and carefully stated.

Results
– Do provide only relevant results that are useful for discussion.
– Results appear only once in Tables or Figures.
– Do not duplicate information, and present only the most relevant results.
– Importance of main results is to be explicitly stated.
– Units, quantities and formulas are to be expressed according to the International System (SI units).
– Use only metric units.

Discussion
– New information coming from data analysis should be presented clearly.
– Do no repeat results.
– Data relevancy should be compared to existing information from previous research.
– Do not speculate, otherwise carefully supported, in a way, by insights from your data analysis.
– Final discussion should be summarized in its major points.

Acknowledgements
– If the paper has been partly presented elsewhere, do provide such information.
– Any financial support should be mentioned.

References
– Cited references are to be numbered in the text, and alphabetically listed.
– Journals' names are to be cited according to general abbreviations (ex: Index Medicus).
– Please write the names of all authors (do not use *et al.*).
– Only published or "in press" papers should be cited. Very rarely are accepted "non published data".
– If non-reviewed papers are cited may cause the rejection of the paper.

Examples
PEER-REVIEW PAPER
1 Pincivero DM, Lephart SM, Kurunakara RA (1998). Reliability and precision of isokinetic strength and muscular endurance for the quadriceps and hamstrings. In J Sports Med 18:113-117
COMPLETE BOOK
Hudlicka O, Tyler KR (1996). Angiogenesis. The growth of the vascular system. London:Academic Press Inc. Ltd.
BOOK CHAPTER
Balon TW (1999). Integrative biology of nitric oxide and exercise. In: Holloszy JO (ed.). Exercise and Sport Science Reviews vol. 27. Philadelphia: Lippincott Williams & Wilkins, 219-254
FIGURES
Figures and illustrations should be used only for a better understanding of the main text.
Use sequence arabic numbers for all Figures.
Each Figure is to be presented in a separated sheet with a short and precise title.

In the back of each Figure do provide information regarding the author and title of the paper. Use a pencil to write this information.
All Figures and illustrations should have excellent graphic quality I black and white.
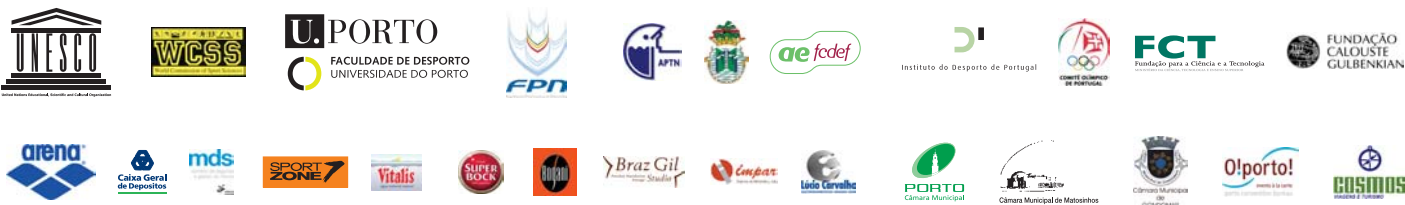Avoid photos from equipments and human subjects.
TABLES
Tables should be utilized to present relevant numerical data information.
Each table should have a very precise and short title.
Tables should be presented within the same rules as Legends and Figures.
Tables' footnotes should be used only to describe abbreviations used.

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INVITED LECTURES
POOLSIDE DEMONSTRATIONS
ORAL PRESENTATIONS
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