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 (V95%), 100%MAV (V100%), 105%MAV (V105%), and 110%MAV (V110%). During the first set (S 1), individual stroke frequency (SF1), stroke length (SL1), and velocity (V1) were measured. Values recorded at the start and the end of each TTE were compared. In the second set (S 2), V1 and SF1 were imposed. During the third set (S 3), V1 and SF1 minored by 5% were imposed. The TTE of S 2 and S3 were expressed in percentage of TTE in S1.

RESULTS

Values of TTE are presented in Table 1. TTE of S2 and S3 were significantly shorter than TTE of S1 for all intensities (P<0.05). TTE of S2 were significantly longer than those of S 3 (P<0.05) except for V95% and V100%.

95%MAV 100%MAV 105%MAV 110%MAV
S2 (%S1) 51 74 61 69
S3 (%S1) 40 41 48 54

SL decreased significantly between the start and the end of each TTE of S1 (P<0.05). SR increased significantly (V95% and V100%; P=0.15) or remained stable throughout the TTE (V105% and V110%; 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]. Indeed, during each TTE of S1, 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 shortened. This could be due to a greater development of local muscular fatigue.

REFERENCES

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.

REFERENCES

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 (\(\hat{E}_{\text{tot}}\)), the energy cost (EC), the intra-cycle variation of the horizontal velocity of displacement of centre of mass (dv) and the mean swimming velocity (v) in the four competitive swimming strokes.

METHODS
17 elite swimmers (4 at Freestyle, 5 at Backstroke, 4 at Breaststroke and 4 at Butterfly) of national or international level were submitted to an incremental set of nx200-m swims (n \(\leq 8\)). The velocity was increased by 0.05 m.s\(^{-1}\) after each swim until exhaustion. Cardio-pulmonary and gas exchange parameters were measured breath-by-breath for each swim to analyse oxygen consumption (VO\(_2\)) and other energetic parameters by portable metabolic cart (K4b2, 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). \(\hat{E}_{\text{tot}}=\text{VO}_{2}\text{net}+2.7\text{[La-]net}\) and EC= \(\hat{E}_{\text{tot}}\cdot v^{-1}\) 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 \(\hat{E}_{\text{tot}}\) 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 \(\hat{E}_{\text{tot}}\) and v for pooled data was \(r=0.59\) (\(p<0.01\)), where increases of v promoted significant increases of \(\hat{E}_{\text{tot}}\). 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.

REFERENCES

3D UNDERWATER HAND PATH PATTERNS IN BUTTERFLY SWIMMERS.
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INTRODUCTION
The purpose of this study was to characterize underwater path patterns of the hand in a group of butterfly swimmers in non-breathing cycles in order to identify predictors of swimming velocity.

METHODS
Eight Portuguese international level male swimmers participated in this study (age: 18.75 ± 4.02 years, height: 179.50 ± 9.36 cm, body mass: 69.59 ± 6.66 kg, best time at 100m butterfly long course: 59.19 ± 3.15s), four of them competing at a junior age-group level. Each subject performed a maximal sprint of 50 m butterfly, in a 50 m pool. Swimmers were asked to retain breathing after passing the 25 m mark until the two final stroke cycles. Oblique underwater front views from below and from both sides were taken by two fixed digital and two other fixed digital cameras were positioned on the pool deck, one in front and one lateral in order to film the swimmers above the water. Images were retained for 3D kinematical analysis (APAS). The average intra-cycle 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 pronounced horizontal velocity of the hand in the upsweep, both denouncing a drag oriented propulsive pattern of the hands, seem to be related with better performances in butterfly sprint swimming.

BILATERAL AND ANTERIOR-POSTERIOR MUSCULAR IMBALANCES IN SWIMMERS.
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INTRODUCTION
Bilateral differences are common in swimmers. Anterior-posterior differences are not only common, but also related to injuries (1). The purpose of this study was to determine the relative magnitude of bilateral and anterior-posterior differences in swimmers.

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

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

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.

REFERENCES
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 (15mcrawl, 25mcrawl, 50mcrawl, 1500mcrawl), 25m crawl with head up (25mcrawlhu), 25m crawl with ball (25mcranb), 25m back (25mback), specific swimming by using legs 25m, legs crawl and breast kick and mixing with legs (25mlegcrawl, 25mlegbre, 25mmixing) and 10x50m crawl (10x50mcrawl), and the derived variables were: stork index (SI), index of specific swimming efficiency (speceffic), index of coordination of leg movement (legscrawlmix). All results were subjected to basic descriptive statistics, while the structure was defined by applying exploratory factor analysis.

RESULTS
Factor analysis has defined four factors which describe a total of 78.068% of joined variability by means of using oblimin criterion, on the statistically significant level of reliability (KMO measure of sampling adequacy = 0.748, Bartlett’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, (25mcran-0.894, 25mcran-0.880, 25mcransl-0.845, 50mcran-0.770) is the ability where players differ most, the second factor recognises coordination swimming abilities of players (crawlnin-0.942, 25mcran-0.894, legscrawlnin-0.768), the third indicates specific leg movement (25mleg-0.924, 25mixing-0.794), while in the fourth factor swimming efficiency was singled out (SI-0.876, 1500mcrawl-0.769, 10x50mcrawl-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.

REFERENCES

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 back-stroke 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, pull, push, hand lag time at the thigh, clearing and recovery and IdC (adapted from crawl, [1]) were calculated from video analysis.

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.

REFERENCES
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 VO2peak behavior (absolute and relative), among different female age-groups; b) to compare the VO2peak 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 VO2peak 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 age-groups, 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 VO2peak behavior (absolute and relative), among different female age-groups; b) to compare the VO2peak values (absolute and relative), between swimmers (Sw) and pupils (Pu) for the same age-group.

RESULTS
The mean values and standard deviation of anthropometrical, absolute and relative VO2peak data of the Sw and Pu are presented on Table 1.

Table 1: Anthropometrical, absolute and relative VO2peak data.

<table>
<thead>
<tr>
<th>N</th>
<th>S (cm)</th>
<th>BM (kg)</th>
<th>SKF (mm)</th>
<th>VO2peak (l.min⁻¹)</th>
<th>VO2peak (ml.kg⁻¹.min⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sw1 13</td>
<td>134.61 ± 7.83</td>
<td>31.76 ± 8.49</td>
<td>76.11 ± 48.72</td>
<td>1.27 ± 0.30</td>
<td>37.83 ± 7.10</td>
</tr>
<tr>
<td>Sw2 12</td>
<td>157.38 ± 7.66</td>
<td>52.03 ± 6.98</td>
<td>82.54 ± 23.45</td>
<td>2.21 ± 0.40</td>
<td>42.13 ± 6.50</td>
</tr>
<tr>
<td>Sw3 09</td>
<td>141.41 ± 6.91</td>
<td>55.56 ± 2.12</td>
<td>106.44 ± 28.86</td>
<td>2.42 ± 0.45</td>
<td>43.53 ± 6.69</td>
</tr>
<tr>
<td>Pu4 12</td>
<td>130.82 ± 8.71</td>
<td>27.97 ± 6.59</td>
<td>46.41 ± 37.44</td>
<td>0.86 ± 0.34</td>
<td>33.40 ± 6.85</td>
</tr>
<tr>
<td>Pu5 14</td>
<td>151.51 ± 8.92</td>
<td>42.04 ± 11.22</td>
<td>89.98 ± 35.01</td>
<td>1.36 ± 0.36</td>
<td>33.41 ± 5.07</td>
</tr>
<tr>
<td>Pu6 14</td>
<td>161.54 ± 3.50</td>
<td>59.91 ± 10.58</td>
<td>157.66 ± 43.00</td>
<td>1.82 ± 0.32</td>
<td>30.74 ± 3.99</td>
</tr>
</tbody>
</table>

DISCUSSION
Statistical significant differences in absolute VO2peak 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 VO2peak were identified between all age-groups, but in relative VO2peak were not observed among all age-groups of the Pu. These findings point that the absolute VO2peak 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.
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 one's own technique.

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 push 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 remains 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 trials, 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 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 thus 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 (Fratio = 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 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.

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 is 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 (SCGyp) 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 \( y = a \cdot x^b \). 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, Fratio = 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 180 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).
REFERENCES

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 years, 178.1±6.2 cm and 71.8±7.4 kg, and 8 females of 17.2±1.4 years, 166.0±3.7 cm and 59.7±4.3 kg) performed, in their best technique, an intermittent incremental protocol for \( \dot{V}_O_2 \)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 b2, 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±82.7 sec 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 \((r=-0.52, p=0.012, Figure 1)\).

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.

REFERENCES

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

Filipatou E, Toubekis A, Douda H, Plianidis T, Tokmakidis S
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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±0.6 years, height:177±5 vs. 149±5 cm,
body weight: 68.9 ± 5.4 vs. 42.9 ± 5.8 kg) 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 ± 1.11 mmol/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.

REFERENCES


2. Wakayoshi K, Yoshida T, Udo M, Harada T, Moritani T, (2013). Heart rate responses or altered rates of lactate removal during childhood, and it may be attributed to different energetic responses or altered rates of lactate removal during childhood compared to puberty.

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.

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 UUS as was expected.

REFERENCES


2. Wakayoshi K, Yoshida T, Udo M, Harada T, Moritani T, (2013). Heart rate responses or altered rates of lactate removal during childhood, and it may be attributed to different energetic responses or altered rates of lactate removal during childhood compared to puberty.

METHODS

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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 UUS as was expected.

REFERENCES

COMPETITIVE SWIMMING AND GLOSSOPHARYNGEAL INSUFFLATION 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.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Chest wall at C4 (cm)</th>
<th>VC (l)</th>
<th>Hydrostatic weight inh. (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>+ 0.95</td>
<td>Ns</td>
<td>- 0.34</td>
</tr>
<tr>
<td>FM</td>
<td>+ 0.72</td>
<td>+ 0.12</td>
<td>- 0.17</td>
</tr>
</tbody>
</table>

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.

REFERENCES
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 CD (46%) and SV (65%). 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.

REFERENCES

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 endurance 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 ms²; 1857±2269 vs. 3885±2888 ms²) 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, ps 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.

REFERENCES

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 6-channel EMG (biovision, GER) from eight Hz, 4th-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. del-
toideus 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 repeti-
tion constancy and a high reproducibility of the identified pat-
terns of muscle activity during the backstroke start. The great
similarities in the myographic behavior of the movement spe-
cific propulsion and equilibrium muscles allowed to form a
representative 2-phase model of the muscle participation in the
separate overwater and underwater movements of the back-
stroke start.

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SUPPORT SCULL TECHNIQUES OF ELITE SYNCHRONIZED SWIM-
MERS.

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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 swim-
ning 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 digi-
tized and three-dimensional coordinates were obtained using a
three-dimensional direct linear transformation method. Upper
arm angle, elbow flexion angles, wrist angles of flexion, exten-
sion, 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.

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 bot-
tom 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 hori-
zontal sculling phases. With a 1.5-kg load, fingertips and wrists
drew a sideways figure-of-eight with a large circle at the out-
side, and some swimmers traced a slanting sharp-pointed
eclipse (Fig. 2). These results indicate that as load increases,
the drag force contributes to producing a propulsive force.
**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.

**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.

**REFERENCES**


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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 proposed 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.

**REFERENCES**

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.

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 $\psi$ shown in Fig. 1. Based on the angles $\psi$, aerodynamic experiments were performed on angle of attack $\alpha$ 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 $\alpha$ 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 $\psi$ compared with the other configurations. Especially, it is found that the largest force is generated in $\psi=45^\circ$ and $135^\circ$.

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.

REFERENCE

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.

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.

REFERENCE


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.

REFERENCES

KINEMATICS AND DYNAMICS OF THE BACKSTROKE START TECHNIQUE.

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1Institute of Sport Science, University of Potsdam, Potsdam, Germany
2Institute of Sport Science, University of Bayreuth, Bayreuth, Germany

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 at 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.

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 occur between the absolute (resultant) force at the time of take off from the wall and the over all start time at 7.5 m.

REFERENCES
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>
<thead>
<tr>
<th>Large Kick</th>
<th>Small Kick</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.40 m/s</td>
<td>2.18 m/s</td>
</tr>
<tr>
<td>1.50 m/s</td>
<td>1.50 m/s</td>
</tr>
</tbody>
</table>

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 (VO2slow) during high intensity exercises in cycle ergometer. This paper aims to present a mathematical model to characterise the slow component of VO2slow in front crawl swimming.

METHODS

Maximal VO2 (VO2max) was determined through direct ventilatory oxygenmetry, using a portable gas analyser (K4 b4, Cosmed, Italy) connected to the swimmers by a respiratory snorkel. The swimmers swam at previously determined speed corresponding to VO2max until exhaustion (Fernandes et al., 2003). The following equation describing the mathematical model for the VO2(t) was used:

\[ VO_2(t) = VO_2_b + A_0 \times (1 - e^{(-t/TD_1) / \tau}) + A_1 \times (1 - e^{(-t-TD_2) / \tau}) \]

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 \( \tau \) 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 VO2max has been normalized to the body mass. The fast component starts 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 VO2 in swimming, discriminating it from the other components.

REFERENCES


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

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2Faculdade de Motricidade Humana, Universidade Técnica de Lisboa, Lisboa, Portugal

\[ \dot{VO}_2(t) = VO_2_b + A_0 \times (1 - e^{(-t/TD_1) / \tau}) + A_1 \times (1 - e^{(-t-TD_2) / \tau}) + A_2 \times (1 - e^{(-t-TD_3) / \tau}) \]

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 \( \tau \) 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.
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 ± 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 percentage (%BF) and fat free mass (FFM).

DISCUSSION
This study supports the influence of systematic swimming training on the diastolic function in 15/16 years old boys. As shown 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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2University of Barcelona, National Institute of Physical Education, Barcelona, Spain

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-vVO2max). 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-vVO2max 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. vVO2max was assessed from the swimming velocity versus oxygen consumption relationships. After a minimum of 24 hours rest, continuous swimming at a speed corresponding to vVO2max was performed until exhaustion to determine TLim-vVO2max (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-vVO2max 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-vVO2max 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.

REFERENCES
A kinetic analysis and recommendations for elite swimmers performing the sprint start.

Mason BR, Alcock AM, Fowlie J
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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
National Team members and 2 FINA World record holders.

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 a monofin can swim very fast. The world record of the apnea, which is 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. The important aspects of a start are to some extent determined. 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.
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 variables 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 repetition. The particle velocity vectors were calculated with the cross-correlation from sequential two images. Velocity-vorticity maps were computed by MATLAB software (The Math Works, Inc., USA).

Table 1

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean (S.D.)</th>
<th>Mean (S.D.)</th>
<th>Dif</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLa (mmol/l)</td>
<td>6.44 (2.44)</td>
<td>8.81 (2.63)</td>
<td>**</td>
</tr>
<tr>
<td>RPE (6-20)</td>
<td>15.00 (2.63)</td>
<td>16.27 (1.10)</td>
<td>*</td>
</tr>
<tr>
<td>HR (bpm)</td>
<td>161.27 (13.66)</td>
<td>168.64 (13.66)</td>
<td>*</td>
</tr>
<tr>
<td>SR (m/clic)</td>
<td>31.75 (5.49)</td>
<td>32.53 (5.74)</td>
<td>*</td>
</tr>
<tr>
<td>SL (m/clic)</td>
<td>2.29 (0.83)</td>
<td>2.23 (0.39)</td>
<td>**</td>
</tr>
</tbody>
</table>
*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.

REFERENCES

REFERENCES
1. Matsuuchi, K et al. (2004). 9th Annual Congress of the ECSS, O62Orange02, CD-ROM.
The influence of training on RBC susceptibility to peroxidation is dependent on the composition of plasma membrane lipids and on the enzymatic antioxidant defenses. The purpose of our work was to evaluate the influence of training on RBC susceptibility to peroxidation induced in vitro by H$_2$O$_2$ (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 monitoring. Blood was collected at rest, at fast. RBC Px and the antioxidant enzymes activities, which included superoxide dismutase, catalase, glutathione peroxidase and reductase and methaemoglobin reductase, were evaluated by photometry.

**RESULTS**

As expected, swimmers showed higher VO$_2$max, VO$_2$AnaT, 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: 46.3±4.79%) and high % of fat intake (S: 34.2±5.23% and AM: 33.6±5.32%). Retinol, a-tocopherol 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 methaemoglobin reductase activity (S: 7.45±2.07 and AM: 9.14±2.29 micromol.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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$^5$Faculty of Sport, University of Porto, Porto, Portugal.

**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-$
u$ turbulent model (1), implanted in a commercial code fluent®, was applied for a fluid flow around
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 in 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.

REFERENCES


“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.

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.
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 website (http://www.swum.org/).

EFFECTS OF SUPINE FLOATING ON CARDIAC AUTONOMIC NERVOUS SYSTEM ACTIVITY AFTER TREADMILL EXERCISE IN WATER.
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2Department of Health and Sports Science, Kawasaki University of Medical Welfare, Japan.

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. Subjects were measured for recovery while sitting for 15 minutes.

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. Other significant increases (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

ESTIMATION THE LAP-TIME OF 200M FREESTYLE FROM AGE AND THE EVENT TIME.
Nomura T
Kyoto Institute of Technology, Kyoto, Japan.

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= (a1AGE3+a2AGE2+a3AGE+ci) TIME+ (b1AGE3+b2AGE2+b3AGE+ci).

RESULTS
The development tendency of TIME by aging could be approximated as following function for men: 46.19exp{-(AGE-10)/3.35} + 115.88 sec. Other hand, the function for women was 31.76exp{(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 reductionward 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?

Nomura T, Okura M, Wakabayashi H, Esaki K, Kaneda K
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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 5 min, then pedaled for 12 min. They underwent the trial at 40% and 60% VO2peak both on land (LE) and in water (WE). VO2, heart rate (HR), CO, and mean blood pressure (MBP) were measured during all experiments. Total peripheral resistance (TPR) was established by Toussaint et al.1. 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 (HbO2) 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, HbO2 increased and T-Hb decreased with immersion when compared with the pre-immersion. On the other hand, at both intensities (40%, 60% VO2peak) 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. HbO2 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 HbO2tended 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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2University of Professional Education Amsterdam, Amsterdam, The Netherlands.

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 freestyle event. In this experiment, maximal oxygen uptake (VO2max), maximal blood lactate concentration (MBLC), and swimming speed at onset of blood lactate accumulation (VOBLA) 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 VO2max, 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 comparatively lower in gold medalist than those in the others. Furthermore, VOBLA 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.

REFERENCE

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 warping (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.

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

REFERENCE

THE INFLUENCE OF REPEATED SPRINTING ON THE KINEMATICS OF BUTTERFLY SWIMMING.
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2English 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 ± 1.7 mmol.l⁻¹ (p < 0.01)post-test. Mean stroke over the 8 x 50 metres, while mean blood lactate concentration was 17 ± 5 mmol.l⁻¹ (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 slower stroke rate (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.
Payton C, Wilcox C
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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 ± 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 to swimmers, and, second, to evaluate three different ways to provide feedback to swimmers 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.

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.

REFERENCES

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 demonstrated oscillations of the hip and knee joints in both sagittal 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.

REFERENCES

TRAINING INDUCED CHANGES IN CRITICAL VELOCITY AND V4 IN AGE GROUP SWIMMERS.
Reis J, Alves F
Faculdade de Motricidade Humana, Lisboa, Portugal.

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.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Vcri (m.s⁻¹)</th>
<th>V4 (m.s⁻¹)</th>
<th>V2000 (m.s⁻¹)</th>
<th>T2000 (s)</th>
<th>La 2000 (mmol.l⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>1.12±0.10</td>
<td>1.11±0.086</td>
<td>1.067±0.096</td>
<td>1850±165</td>
<td>5.75±2.3</td>
</tr>
<tr>
<td>2nd</td>
<td>1.20±0.11</td>
<td>1.19±0.09</td>
<td>1.13±0.09</td>
<td>1772±128</td>
<td>4.5±1.7</td>
</tr>
</tbody>
</table>

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 is 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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2Sports School of Rio Maior, Rio Maior, Portugal
3United Faculties of Northern Minas, Montes Claros MG, Brasil

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Among the swimmers, there were no significant differences in the exercise intensity during the submaximal test (50% to 90% of each subject’s best performance over the 200m event). Each group performed the tests on their preferential style. During both tests VO2max was comprised between 50% and 90% of the subjects’ mean (±SD) VO2max of the subjects was 66.0±11.35 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 VO2 was 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 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.min-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.min-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 VO2max of the two groups, we may suggest that those differences are attributable to the swimming style rather than to physiological characteristics of the subjects.

REFERENCES

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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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²Universita di Siena, Italie

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 power 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 resis-
tive 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).

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 iso-
metric force and/or bad technical ability.

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

Sánchez J, Maañón R, Mon J, González S, Arellano R

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2E.C.C.A.F.D. University of Granada, Spain.

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 (sagittal view) until the end of a 50m at competitive speed main style trial.

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>Junior</td>
<td>Pre-junior</td>
</tr>
<tr>
<td>Age</td>
<td>14-15</td>
<td>12-13</td>
</tr>
<tr>
<td>N</td>
<td>48</td>
<td>39</td>
</tr>
</tbody>
</table>

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 errors (%)

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head not between arms (neck flexed/shoulders extended)</td>
<td>79</td>
<td>72</td>
</tr>
<tr>
<td>Head not down in preparatory position</td>
<td>48</td>
<td>70</td>
</tr>
<tr>
<td>Excessive knee flexion (knee angle &lt;140°)</td>
<td>44</td>
<td>74</td>
</tr>
<tr>
<td>Misaligned trunk-legs at the take-off</td>
<td>27</td>
<td>30</td>
</tr>
<tr>
<td>Hands not apply force in the block, push phase</td>
<td>31</td>
<td>30</td>
</tr>
<tr>
<td>Arms/hands are separated in the entry moment</td>
<td>40</td>
<td>36</td>
</tr>
</tbody>
</table>

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.

REFERENCES

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

Seifert L, Payen V, Vantorre J, Chollet D

C.E.T.A.P.S. Laboratory UPR3 EA 3432: University of Rouen, Faculty of Sports Sciences, France.

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 medalist 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.
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 throughout 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 on their own study and contributed questionnaires 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.

REFERENCES

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

Shimizu J, Miyaji C, Ito K
Japan Institute of Sports Sciences, Tokyo, Japan.

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.

REFERENCES

DOES THE LONG-TERM ORAL CREATINE SUPPLEMENTATION IMPROVE REPEATED SPRINT PERFORMANCE IN ELITE SWIMMERS?
Shiraki T, Nomura T
University of Tsukuba, Ibaraki, Japan.

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. 31P-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 100m 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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2Superior School of Sport, Rio Maior, Portugal
3United Faculty of Montes Claros MG, Brasil
4Faculty of Human Movement, Technical University of Lisbon, Lisbon, Portugal
5Centre of Studies, Technology, Environment and Life, CETAV, Portugal.

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 (±SD) age, weight, height, arm span and fat percentage of the subjects were, respectively: 17.7±2.4 years, 71.9±6.95 kg, 1.79±6.28 m, 1.87±4.57 m and 10.05±0.76 %. The subjects’ mean (±SD) VO2max was 65.1±6.31 ml.Kg-1min-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 VO2 was 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 VO2 by the total energy cost. Anaerobic fraction of energy release was calculated by dividing the accumulated oxygen deficit by the total energy cost. Accumulated VO2 was calculated by integrating the VO2 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 ≤ 0.05).

RESULTS
The anaerobic and aerobic fractions of total energy released during the 200m crawl event were ≈15% and ≈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 VO2 measurements.

**REFERENCES**

**MENTAL TRAINING IN SWIMMING: APPLYING A NEW GOAL DEFINITION MODEL.**
Simões P, Silva A, Rushall B, Vasconcelos-Raposo J

**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.

**REFERENCES**

**VELOCIMETRIC CHARACTERIZATION OF A 30 SEC MAXIMAL TEST IN SWIMMING: CONSEQUENCES FOR BIOENERGETICAL EVALUATION.**
Soares S1, Machado L1, Lima A2-3, Santos I1, Fernandes R1, Correia M1, Maia J1, Vilas-Boas JP1

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2University of Ceará and University of Fortaleza, Fortaleza, Brazil;
3University of Porto, Faculty of Engineering, Porto, Portugal;

**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 seems 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.

<table>
<thead>
<tr>
<th>One threshold</th>
<th>Two thresholds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st threshold</td>
<td>1st threshold</td>
</tr>
<tr>
<td>Post-pubertal</td>
<td>12.5±1.58</td>
</tr>
<tr>
<td>Pubertal</td>
<td>8.94±1.55</td>
</tr>
<tr>
<td>Pre-pubertal</td>
<td>10.22±1.65</td>
</tr>
<tr>
<td>2nd threshold</td>
<td></td>
</tr>
<tr>
<td>Post-pubertal</td>
<td>9.42±1.88</td>
</tr>
<tr>
<td>Pubertal</td>
<td>17.50±2.24</td>
</tr>
<tr>
<td>Pre-pubertal</td>
<td>17.06±2.95</td>
</tr>
</tbody>
</table>

REFERENCES

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.

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.

REFERENCES

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 PaCO2 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 CO2 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 (VE, VCO2, VO2) and some parameters in the blood (pH, [LA -], PCO2, PO2) 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 VE 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 VO2 (80% = 2.65±0.5 l x min-1, 100% = 2.76±0.6 l x min-1) and VCO2 (80% = 3.17±0.4 l x min-1, 100% = 4.44±0.6 l x min-1). Excess VCO2 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 PCO2 and PO2 measured when resting and those measured during the 1st minute after exercise.

DISCUSSION
In our research we were not able to demonstrate that limited VE during exercise in swimming is a limiting factor; however, we were able to demonstrate that it does occur and that limited VE is a possible influence on increased acidosis during maximal and supramaximal swimming. We found notable excess VCO2 after exercise at these intensities. We can not conclude that hypercapnia was caused because values of PCO2 were similar to those during rest; however, it has to be considered that these values were obtained with significantly increased VE.

REFERENCES

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).
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, $\phi$: 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 ($V_{rt}$) and extensional component ($V_{et}$). This model was shown in Fig. 1.

RESULTS
Kinematic variables were shown in Table 1. Block time was significantly shorter in track start. $V_{rt}$ was significantly faster in track start and $V_{et}$ was significantly faster in grab start.

<table>
<thead>
<tr>
<th></th>
<th>Grab start (m/s)</th>
<th>Track start (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block time</td>
<td>0.78</td>
<td>0.71</td>
</tr>
<tr>
<td>$V_t$ (rotational)</td>
<td>4.38</td>
<td>4.26</td>
</tr>
<tr>
<td>$V_{ ETF}$ (extensional component at take-off)</td>
<td>1.99</td>
<td>2.56</td>
</tr>
<tr>
<td>$V_{ EFT}$ (extensional component after take-off)</td>
<td>3.91</td>
<td>3.42</td>
</tr>
<tr>
<td>Flight distance</td>
<td>3.25</td>
<td>3.15</td>
</tr>
<tr>
<td>$\theta$ (body angle)</td>
<td>-16.1</td>
<td>-3.4</td>
</tr>
</tbody>
</table>

* 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 $V_{rt}$ was caused by its feet placements in track start. As for velocity change of center of gravity to the take-off, $V_{et}$ was added to $V_{rt}$. It was suggested that the block time shortened because track start was faster than grab start for $V_t$.

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. 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 VO2 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.

REFERENCES

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 intracycle 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 frequency 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 variables: 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 Sph1 for 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.

REFERENCES

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

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2German Sport University Cologne, Germany.

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 backwards - the body is moved forward instead (the trunk/arm muscles mediates between the effects and the body centre of mass).

REFERENCES

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 Rushall1 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 Rushall2 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.

REFERENCES

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-
eroxer 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 (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 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.

REFERENCES

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 sub-maximal (low and moderate) exercise intensities. Esophagus temperature (Te), skin temperatures (Ts) and oxygen uptake (V̇O₂) were measured. Total insulation (Iₚₜ) and tissue insulation (Iₜₚₜ) were estimated by dividing the difference between Te and Ts or Ts and Ti with heat loss from the skin (Hₜ). Suit insulation (Iₚₚ) was calculated by subtracting Iₚₜ from Iₚₚ. Cardiac output (Q̇t) and blood pressure were measured to calculate total peripheral resistance.

RESULTS
During low intensity exercise (V̇O₂=11-12 ml/min/kg) Te were maintained in TSS. On the other hand, Te decreased in NSS. Moderate exercise (V̇O₂=20-22 ml/min/kg) increased Te with both swimsuits. Iₚₜ during moderate exercise was lower than that of low intensity exercise with both swimsuits. TSS decreased Iₚₜ es compared to NSS during moderate exercise. Iₚₜ/total and skin fold thickness (SFT) showed a negative correlation.

DISCUSSION
The lower Iₚₜ during moderate exercise were caused by the higher Qₜ due to increased exercise intensity. However, the increased metabolic heat production during moderate exercise and added Iₚₜ could offset the decreased Iₚₜ and decrement of Te. Peripheral blood flow could be increased due to reduced vasoconstriction so that the Iₚₜ was decreased during moderate exercise with TSS. The negative correlation between Iₚₜ/total and SFT indicated that the lower fat subjects could have more benefit of TSS to Iₚₜ. 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.

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 momentum 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.

REFERENCES

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

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INTRODUCTION
Schleihaufl 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 under-side 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.

REFERENCES