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

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

METHODS
Eleven women with mean values of age 21.38±1.3 years old, weight of 55.91±6.71kg and height of 161.69±6.21cm. In order to collect data properly it was used portable electromyography and oclusive tapes in surface electrodes. It was done a maximal voluntary contraction (MVC) of RF and BF for normalization. After that, they did the exercise (flexion and extension of the hip) in 40bpm and maximal velocity, with and without RE (Aquafins) on the ankle. The RMS values of EMG was analysed and normalized by MVC (%MVC).

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

<table>
<thead>
<tr>
<th>Cadence</th>
<th>Muscles</th>
<th>Agonist</th>
<th>Antagonist</th>
<th>Agonist</th>
<th>Antagonist</th>
</tr>
</thead>
<tbody>
<tr>
<td>40bpm</td>
<td>RF</td>
<td>15.46±4.11</td>
<td>14.35±8.7</td>
<td>20.97±5.16</td>
<td>18.35±7.5</td>
</tr>
<tr>
<td></td>
<td>BF</td>
<td>11.90±7.94</td>
<td>3.7±2.43</td>
<td>16.0±7.6</td>
<td>8.46±5.3</td>
</tr>
<tr>
<td>Max</td>
<td>RF</td>
<td>65.59±20.47</td>
<td>36.31±17.6</td>
<td>72.7±28.48</td>
<td>35.31±17.09</td>
</tr>
<tr>
<td></td>
<td>BF</td>
<td>58.58±22.52</td>
<td>25.6±16.6</td>
<td>69.62±20.4</td>
<td>25.45±10.64</td>
</tr>
</tbody>
</table>

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

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

REFERENCES

THE RELIABILITY OF VO2-MEASUREMENTS IN SWIMMING: A PILOT STUDY.

Aspenes S1, Kjendlie P-L2

1The Norwegian University of Science and Technology, Trondheim, Norway
2Norwegian School of Sport Sciences, Oslo, Norway.

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

METHODS
A test-retest design was conducted, including 4 subjects acting as their own controls. Oxygen uptake (VO2) was measured with the use of a respiratory valve and a mixing chamber analyzer (Cortex MetaMax II). Workload was controlled by moving pacelights below the swimmer. Swimming economy (CS) protocol was similar to the one used by Kjendlie et al. (2004)12 – using four workloads of increasing intensity. Subsequently VO2peak was measured by a 5-7 min workload with increasing velocity to exhaustion. Wilcoxon matched-pairs signed-ranks test was used to compare test and retest.

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

<table>
<thead>
<tr>
<th>Cadence</th>
<th>VO2 (l·min–1)</th>
<th>Test</th>
<th>Retest</th>
<th>CV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40bpm</td>
<td>0.6</td>
<td>1.07±0.37</td>
<td>1.12±0.23</td>
<td>13.5</td>
</tr>
<tr>
<td></td>
<td>0.8</td>
<td>1.68±0.52</td>
<td>1.75±0.40</td>
<td>10.9</td>
</tr>
<tr>
<td></td>
<td>1.0</td>
<td>2.28±0.66</td>
<td>2.55±0.68</td>
<td>13.7</td>
</tr>
<tr>
<td>Peak</td>
<td>3.28±0.72</td>
<td>3.11±0.46</td>
<td>9.7</td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td>2.28±0.66</td>
<td>2.55±0.68</td>
<td>13.7</td>
<td></td>
</tr>
<tr>
<td>Peak</td>
<td>3.28±0.72</td>
<td>3.11±0.46</td>
<td>9.7</td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td>2.28±0.66</td>
<td>2.55±0.68</td>
<td>13.7</td>
<td></td>
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<tr>
<td>Peak</td>
<td>3.28±0.72</td>
<td>3.11±0.46</td>
<td>9.7</td>
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<tr>
<td>1.5</td>
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<td>2.55±0.68</td>
<td>13.7</td>
<td></td>
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<tr>
<td>Peak</td>
<td>3.28±0.72</td>
<td>3.11±0.46</td>
<td>9.7</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Mean ± SD oxygen cost of submaximal swimming, VO2peak and velocity of VO2peak (vVO2peak) (v is velocity, CV is coefficient of variance).

DISCUSSION
No statistical differences were found, which indicate that the system is applicable for reliably measuring respiratory parameters in swimming. Established protocols for testing both CS and VO2peak were used. Valve with hose and analyzer have previously been validated, but never together. The findings are, however, weighed down by bias, relatively high coefficient of variances and few participants. As only one of the subjects had used the valve before, they were allowed a short habituation. It is rational to expect no statistical differences also for future investigations and larger samples, as this and former investigations indicate reliability.
CONCLUSION
In light of the bias and few participants, it has to be concluded that further investigations are needed to examine the reliability of the test system for swimming. Prior to testing, personnel and subjects should be properly acquainted with equipment and procedure.

REFERENCES

INTRODUCTION
The purpose of this study was to analyse the relationship between time limit at the minimum velocity that elicits maximal oxygen consumption (TLim-v VO2max) and intracyclic variations of the velocity of the centre of mass (dv) in the four competitive swimming techniques.

METHODS
Twelve Portuguese elite male swimmers (19.8 ± 3.5 y, 70.1 ± 8.0 kg and 178.3 ± 6.5 cm) swam their own best technique until exhaustion at their previously determined v VO2max to assess TLim-vO2max. TLim was considered to be the total swimming duration at v O 2max (Fernandes et al., 2003). The test was videotaped in a sagittal plan, with two cameras, that provided, after mixing and editing, a dual-media image of the swimmer. The APAS software (Ariel Dynamics Inc, USA) was used to evaluate the horizontal velocity of the centre of mass (vcm) and its intra-cyclic variation (dv) per swimming technique. A complete cycle of all techniques was analyzed, in the first and last laps of the TLim test, as well as in all the intermediate 100m laps.

RESULTS
No statistical significant correlations were obtained between TLim-v VO2max and dv. Values of the r correlation coefficient for the different techniques were as follows: Butterfly (r = -0.30, p = 0.81); Backstroke (r = 0.91, p = 0.27); Breaststroke (r = -0.95, p = 0.21); Front Crawl (r = 0.20, p = 0.88). The simultaneous swimming techniques were characterized by inverse relationships between both variables, while the alternated ones showed a direct one.

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

REFERENCES

VALIDITY AND RELIABILITY OF A COMMONLY USED WATER POLO TEST: A PILOT STUDY.
Bampouras T, Marrin K
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INTRODUCTION
A number of water polo tests, relating to swimming (2) and sport-specific demands of the game, exist. Crossbar jumps (for 30 or 60 seconds) have traditionally been used for assessment of anaerobic leg power. This study aimed to examine the validity and reliability of this commonly used water polo test.

METHODS
Thirteen elite, female water polo players (mean±s: age 22 ± 4.4 years, height 168.7 ± 7.9 cm, body mass 65.9 ± 6.1 kg) performed the 30 seconds crossbar jumps test (CJ) on two separate occasions, and the Wingate anaerobic test (WAnT) to determine fatigue index (FI), mean power (mP) and peak power (pP). All tests took place with a minimum of 24 hours intervening.

Pearson’s correlation coefficient (r) was used to examine for relationships between both CJ and FI, mP and pP. Intraclass correlation coefficient (ICC) and the 95% limits of agreement (LoA) were used to examine for test-retest reliability and the degree of agreement between the two CJ tests, respectively.
RESULTS
Normality of data was examined using the Kolmogorov-Smirnov test and subsequently confirmed. No correlation was found between CJ (CJ1: 21.4 ± 2.6 jumps; CJ2: 23.3 ± 2.6 jumps) and the variables examined from the WAnT (FL: 48.3 ± 7.1%; mP: 459.1 ± 45.3 W; pP: 667.8 ± 93.7 W). The two CJ were significantly correlated with each other (P < 0.05; ICC = 0.99). The LoA for the CJ scores was -1.5 ± 2.35 jumps, producing a range of +0.85 to -2.85 jumps.

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

REFERENCES
SPEED AND PHYSIOLOGIC REPLY IN SWIMMING, CYCLING AND RUNNING.

Benavent J1, Colado JC2, Madera J1, Escudero J1, Tella V1
1Universitat de Valência, Spain
2Universidad de Alicante, Spain.

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

METHOD
Sample: 11 triathletes of amateur national level aged 25.6 ± 4.7. Material: Lactate Pro for the lactate determination as well as the Polar pulsemeter S720i for the HR determination. Protocole: 3 events of similar time length: 300 metres in swimming, 3000 in cycling and 1500 in running, at 100% and 90%. Dependent variables have been the average speed in m/s (S), the RPE, the maximum LA in mM/l (LA) and the HR minute (HR) at the end of each intensity. Method: t event for mixed samples with swimming, cycling and running through the statistic pack SPSS v.11.5 for windows.

RESULTS
Swimming at 100%: 12.8 LA; 173.1 HR; 18.1 RPE; cycling at 100%: 14.4 LA; 179.4 HR; 18.2 RPE and running at 100%: 14.2 LA; 186.3 HR; 18.3 RPE show statistically significant differences among the three disciplines (p<0,01) except for RPE in swimming, running and cycling. LA does not show any significant differences. In swimming at 90%: 5.1 LA; 152.6 HR; 13.4 RPE, in cycling at 90%: 5.9 LA; 158.3 HR; 13.5 RPE and in running at 90%: 7.2 LA; 176.5 HR; 14.7 RPE statistically significant differences are shown among the three disciplines (p<0,01) except in swimming and cycling. LA does not show any statistically significant difference in running and cycling, either. The percentage values of all variables in S at 90% in contrast to the obtained values in S at 100% only show significant differences (p<0,01) in swimming (59.9% LA; 87.5% HR; 74.1% RPE) and in running (51.3% de LA; 95.4% HR; 80.8% RPE).

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

REFERENCES

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

Benelli P1, Ditroilo M1, Giacomini F1, Del Sal M1, Fernández E1, Freddo A1, Grassi E2, Gatta G1, Stocchi V1
1Istituto di Ricerca sull’Attività Motoria, Università degli Studi di Urbino, Urbino, Italy
2Facoltà di Scienze Motorie, Università di Bologna, Italy.

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

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

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

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

<table>
<thead>
<tr>
<th></th>
<th>MIN 34</th>
<th>FIN 44</th>
<th>MIN 34</th>
<th>FIN 44</th>
<th>MIN 34</th>
<th>FIN 44</th>
<th>MIN 34</th>
<th>FIN 44</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Age</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2) SAS (m/s²)</td>
<td>-.657**</td>
<td>-.526**</td>
<td>.348**</td>
<td>.213</td>
<td>.1</td>
<td>.1</td>
<td>.1</td>
<td>.1</td>
</tr>
<tr>
<td>3) keMVC (N)</td>
<td>-.602**</td>
<td>-.390**</td>
<td>.544**</td>
<td>.213</td>
<td>.1</td>
<td>.1</td>
<td>.1</td>
<td>.1</td>
</tr>
<tr>
<td>4) hgMVC (N)</td>
<td>-.682**</td>
<td>-.348**</td>
<td>.453**</td>
<td>.422**</td>
<td>.593**</td>
<td>.363**</td>
<td>.363**</td>
<td>.363**</td>
</tr>
</tbody>
</table>

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

DISCUSSION
As expected age had a negative and significant correlation (p<0.01) with SAS, keMVC and hgMVC both in males and females. SAS resulted positively related (p<0.01) to hgMVC both in males and females, whilst it was significantly related to keMVC only in males. It is well known that in swimming upper limbs give the most important contribution to forward
propulsion. Although hGMVC does not reflect the whole muscular involvement of the upper limb action, it was found a significant relationship between hand grip and performance in male young swimmers. Lower limbs give a minor contribution to the propulsion, although they are essential in starting and turning phases. However in master swimmers these phases are much less important than in younger elite swimmers. This could be true especially in women because they have less muscle mass and strength compared to men.

REFERENCES

ACTIVE DRAG AND PHYSICAL CHARACTERISTICS IN AGE GROUP SWIMMERS.
Botelho A³, Alves F1, Rama L1, Martins-Silva A³
1Technical University of Lisbon, Faculty of Human Kinetics, Portugal
2University of Coimbra, Faculty of Sport Sciences and Physical Education, Portugal
3University of Trás-os-Montes e Alto Douro, Sports Department, Portugal.

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

METHODS
Subjects were selected from a pool of 365 age group swimmers tested with the velocity perturbation method (VPM) (Kolmogorov & Dupilishevka, 1992) in front crawl, between 1997 and 2003. The inclusion criterion was to have achieved the same free swimming maximal velocity (Vₘₐₓ) in the test. Swimmers were assigned to 2 groups: G1 (N = 17; age: 15.42 ± 0.53 years, height: 178.52 ± 7.42 cm, body mass: 66.82 ± 7.45 kg, best time at 100m front crawl: 57.26 ± 1.67s), with Vₘₐₓ = 1.78 m.s⁻¹, and G2 (N = 12; age: 15.29 ± 0.68 years, height: 172.10 ± 3.51 cm, body mass: 64.15 ± 8.74 kg, best time at 100m front crawl: 61.14 ± 1.21s), with Vₘₐₓ = 1.66 m.s⁻¹. Active drag (Dₐ), drag coefficient (Cₐ), and power output (Pₐ) determined by the VPM and anthropometric measurements were compared between the groups and relationships to competitive performance, assessed considering the swimmer’s best time in the 100 m freestyle (BT₁₀₀mF) at the moment of the VPM evaluations, verified.

RESULTS
Only BT₁₀₀mF differed significantly between groups (Mann-Whitney Test). In spite of the rather homogeneous physical

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**Table 1.** Mean values, standard deviation (σ) and participants (n) of EMG (%MVC) and angular velocity. Repeated measure test, post hoc LSD and t-test (p) of EMG for RF and BF in 4 velocity with and without equipment (p<0.05).

<table>
<thead>
<tr>
<th>Equipment</th>
<th>RF</th>
<th>BF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With</td>
<td></td>
<td></td>
</tr>
<tr>
<td>cadence</td>
<td>EMG mean</td>
<td>AV mean</td>
</tr>
<tr>
<td>40 bpm</td>
<td>51.4ǔ±4.2º</td>
<td>15.3ǔ±1.2º</td>
</tr>
<tr>
<td>60 bpm</td>
<td>50.6ǔ±1.2º</td>
<td>14.8ǔ±0.7º</td>
</tr>
<tr>
<td>80 bpm</td>
<td>50.8ǔ±0.8º</td>
<td>15.1ǔ±0.3º</td>
</tr>
<tr>
<td>Maximal</td>
<td>51.4ǔ±0.7º</td>
<td>15.3ǔ±0.3º</td>
</tr>
</tbody>
</table>
characteristics observed within each group. Hydrodynamic variables showed large variation. In G2, D was not related to physical characteristics or performance. In G1, however, D showed significant correlations (p ≤ 0.001) with body mass (r = 0.859), height (r = 0.721) and body surface (r = 0.852).

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

REFERENCES

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

Bratuša Z¹, Dopsaj M²
¹Faculty of Sport and Physical Education, Belgrade, Serbia and Montenegro
²Police Academy, Belgrade, Serbia and Montenegro.

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

METHODS
The sample of 31 players was divided into three groups: 1. players in wing positions left and right (N = 19); 2. centers (N = 6); 3. backs (N = 6). Variables were the result of the following nine swimming tests: crawl 25m, 50m and 1500m (25m_craw, 50m_craw, 1500m_craw), 25m crawl with ball (25m_crawb), 25m back (25m_back), specific swimming using legs 25m, legs crawl, breast and mixing (25m_legscre, 25m_legscr, 25m_legscrea, 25m_legscr, 25m_mix), and swimming 10x50m curl (10x50m_crawl), and three derived variables were: index of specific swimming efficiency (specific), index of coordination of crawl technique (crawa_crawl) and index of specific coordination of leg movement (legs_crawl). The results were subjected to cluster analysis and Student T-test.

RESULTS
Cluster analysis (1) has singled out five variables in which the observed groups differed: 25m back (25m_back), r = 3.826, p = 0.034), specific swimming using legs crawl 25m (25m_legscrea), r = 6.068, p = 0.06), crawl swimming 1500m (1500m_crawm), r = 3.737, p = 0.036), 10x50m crawl (10x50m_crawl), r = 5.666, p = 0.009) and index of specific coordination of leg movement (legs_crawl), r = 3.963, p = 0.031). After Student T-test we found out that between groups 1. and 2. a significant difference has occurred in crawl swimming 1500m (1500m_crawm), r = 0.041), between groups 1. and 3. in swimming using legs crawl (25m_legscrea), r = 0.002), crawl swimming 1500m (1500m_crawm), r = 0.027), swimming 10x50m crawl (10x50m_crawl), r = 0.003) and coordination of crawl technique (crawa_crawl), r = 0.004) and difference between groups 2. and 3. in swimming 25m back (25m_back), r = 0.025) and specific swimming using legs crawl 25m (25m_legscrea), r = 0.030).

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

REFERENCES

BREASTSTROKE SWIMMING PATTERNS FROM VIDEO SEQUENCES ANALYZE BY SPECIFIC FIELD FORMATS.

Campaniço J, Santos J, Silva A
Universidade de Trás-os-Montes e Alto Douro, Vila Real, Portugal.

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

METHODS
Seven swimmers were recorded and analysed. The system analysis produced several stroke cycles to describe each swimmer’s particular movements. The video images were captured from side-view by classical underwater criteria and converted...
of a fixed anatomical point close to the hip, in the swimming technique expected to be the most distinguishable of all: the breaststroke.

METHODS

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

RESULTS

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

DISCUSSION

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

REFERENCES


INTRODUCTION

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

METHODS

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

RESULTS

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

DISCUSSION

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

REFERENCES


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

Statistical analysis was made with repeated measures ANOVA in a mixed 2x3 model and, when necessary, a Bonferroni post-hoc test (significant level of 0.05).

RESULTS
Table 1 SL, SR and SV results.

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

<table>
<thead>
<tr>
<th>KP</th>
<th>B1</th>
<th>B2</th>
<th>B3</th>
<th>NB1</th>
<th>NB2</th>
<th>NB3</th>
</tr>
</thead>
<tbody>
<tr>
<td>SL (m)</td>
<td>2.90±0.22</td>
<td>2.68±0.22</td>
<td>2.30±0.12</td>
<td>3.08±0.19</td>
<td>2.76±0.19</td>
<td>2.18±0.11</td>
</tr>
<tr>
<td>SR (Hz)</td>
<td>0.42±0.04</td>
<td>0.54±0.06</td>
<td>0.81±0.04</td>
<td>0.43±0.02</td>
<td>0.58±0.06</td>
<td>0.88±0.04</td>
</tr>
<tr>
<td>SV (m·s⁻¹)</td>
<td>1.21±0.07</td>
<td>1.45±0.06</td>
<td>1.86±0.08</td>
<td>1.32±0.10</td>
<td>1.60±0.08</td>
<td>1.91±0.07</td>
</tr>
</tbody>
</table>

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

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

REFERENCES

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

METHODS
Seven male international swimmers (22.6 ± 2.7 years, height 191 ± 4 cm, weight 82.7 ± 5.3 kg) realised an exhaustive test of 4*50m freestyle. An EMG system (ME 3000 P8) was used to record the electrical activity of 2 right muscles: the M. flexor carpi ulnaris (FCU) and the M. extensor carpi ulnaris (ECU). The time-frequency treatment has been realised according to the Knaflitz’ method (2). The instantaneous mean frequency (IMNF) was obtained for each stroke of each 50m. The mean IMNF was calculated for each 25m of each 50m (figure 1).

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

Figure 1: Mean of IMNF of the ECU for each 25m for one subject

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

REFERENCES
INTRODUCTION

The use of the water environment is usually determined as a methodological indication followed in this study produces an alternative and/or complementary resource to those usually applied on land. As a result, the efficiency of water resistance training as an alternative for those usually applied on land is demonstrated.

METHODS

HR - (Polar Electro, Oy, Finland), distance, repetitions, and effort perception (production of intensities of 3, 6, and 9 grades in CR10 scale). Subjects were asked to produce these 3 exercise intensities in a random order, with an elastic band. A repeated measures ANOVA (time x groups) was applied and the evidences found were considered significant at P<0.05.

RESULTS

Significant differences between both material resources concerning heart rate at exercise and the response of lactates were found.

DISCUSSION

This study aims to verify if the cardiovascular and metabolic demands of well-designed water strength training are at least comparable to their land-based equivalents.

REFERENCES

2. Colado JC (2003). Effects of an experimental strength training protocol on muscle fatigue after a twenty-five repetition set. A lactate measurer model Lactate Pro LT-1710 and a POLAR model S810i to monitor heart rate pulse were employed.
5. 37,00±14,85 4,3±3,24 25,75±14,45 1,55±0,78 0,002** 0,82
6. 47,75±18,77 2,34±1,66 33,25±16,5 1,14±1,43 0,079 0,125
7. 82,25±9,71 68,75±19,80 0,098

Table 1. Mean and standard deviation for Heart rate values with fatigue.
energy is generated via both the anaerobic and aerobic pathways. 

First, it is assumed that when performing a fatiguing exercise, 

Second, it is assumed that the energetic cost of the activity (ml 

Assumption 2, VO2max has to be attained at the end of 

A different physical effort may affect the determination of CV, 

Moreover, the CV concept has raised lots of interest from the scientific and non scientific communities. The model may provide an interesting way of investigating the energetic contributions to swimming. Coaches and swimmers could also appreciate the ease in using the model to predict performance from the d-t relationship, to set training loads, to discriminate effects of training, and to establish energetic potentials of swimmers.

APPLICATION OF THE CRITICAL POWER CONCEPT IN SWIMMING?

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The concept of CP originally introduced by Monod and Scherrer (1) has been extended to swimming. However, such an application of the CP concept imposes several assumptions (2).

First, it is assumed that when performing a fatiguing exercise, energy is generated via both the anaerobic and aerobic pathways (\(e = e_{anae} + VO_2max \cdot t\), Equation 1). [Assumption 1.] The anaerobic metabolism would generate a finite amount of energy (\(e_{anae}\)). [Assumption 2.] The aerobic pathways would be solicited at its maximal power (\(VO_2max\)) throughout the duration of the exercise to enable the energy demand to be covered (\(VO_2max\)).

Second, it is assumed that the energetic cost of the activity (ml of \(O_2\) m\(^{-1}\)) is constant in order to allow Equation 1 to be expressed as followed: 

\[d = ADC + CV \cdot t\] (d, distance; t, exhaustion time, Equation 2), with Critical Velocity (CV) and Anaerobic Distance Capacity (ADC) represented by the slope and the y-intercept of the d-t relationship, respectively.

In swimming, the observation of a linear relationship linking d and t has been used to validate the application of the CP concept (3). However, it is known that the d-t relationship is not strictly linear. Consequently, several studies attempted to determine the distances that should be used to determine CV and ADC (4). Furthermore, whatever the cyclic activity considered Assumptions 1 and 2 would never be fulfilled in any exhaustive exercise. As a consequence, in order to partially fulfill Assumption 2., VO2max has to be attained at the end of each trial used to plot and model the d-t relationship.

Therefore, the t used to plot and model the d-t relationship should range between 2 and 20 minutes. In attempt to simplify the determination of CV, the suggestion of using only the 200m and 400m seems the most pertinent (4). Moreover, \(e_{anae}\) would always underestimate the ‘anaerobic energy reserve’ to the expense of the aerobic contribution to the total energy demand (5).

Despite these several limits, the CV concept has raised lots of interest from the scientific and non scientific communities. The model may provide an interesting way of investigating the energetic contributions to swimming. Coaches and swimmers could also appreciate the ease in using the model to predict performance from the d-t relationship, to set training loads, to discriminate effects of training, and to establish energetic potentials of swimmers.

REFERENCES


CHALLENGES OF USING CRITICAL SWIMMING VELOCITY.

FROM SCIENTISTS TO COACHES.

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Critical velocity (CV), represented by the slope of the d-t relationship has been shown, in running, to correspond to the threshold intensity above which exercise of sufficient duration will lead to the attainment of VO2max (1). This definition of has not yet been directly verified in swimming but is in line with several findings reported in the literature in swimming (2, 3).
Using CV as an intensity for setting training programs offers great potential. It would allow better planning for individuals long and short interval training compared to using a given percent of the 400-m speed. Indeed, swimming at or below CSV would induce fatigue without exhaustion while exhaustion would develop above CV. Long interval training (6-10 x 400 m at CSV, 1-min rest) at or below CV may induce (H+) accumulation and may improve the oxidative potential of the muscle fibres as an acute adaptation to training. Adequate long and short interval training above CV (20-30 x 100 m at 110% CSV, 30-s rest; 15s above CV, 15s below CV) would enable VO2max to be solicited and maintained for a very long time. This could lead to optimise the improvement of VO2max over time. Several 400-m blocks performed at CV can be swam with steady [La] values (around 3-4mmol·L⁻¹) when separated by 20-40s of rest (4). Nevertheless, stroking parameters have been shown to change, with progressive stroke rate increases and stroke length decreases within and between the 400-m blocks Brickley et al. (4). Training around CV could be set while focussing on the stroking parameters pattern in order to delay the effect of exhaustion on efficiency.

A few studies but unfortunately no one in swimming have shown that the intensity-time relationship was affected by training. Aerobic training would increase the slope while anaerobic training would increase the intercept of the relationship. Plotting the d-t relationship would enable to monitor effects of different kind of training over a season. Further research is required to better understand the meaningfulness and to define the usefulness of the slope and y-intercept of the d-t relationship (responses at and above CV, effects of training at intensity around CV, effects of training on the d-t relationship, kicking vs full stroke CV). However, the actual knowledge on the application of the CV concept seems sufficient to underlie its interests for training.

REFERENCES

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

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²Institute for Medical Biochemistry, Clinical Centre of Serbia, Belgrade, SCG
³Special Physical Education I & II, Police Academy, Belgrade, SCG.

INTRODUCTION

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

METHODS

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

RESULTS

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

DISCUSSION

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

REFERENCES

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

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

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

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

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

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2State University of Santa Catarina, Florianópolis, Brazil
3University of Ceará and University of Fortaleza, Fortaleza, Brazil
4Federal University of Rio Grande do Sul, Porto Alegre, Brazil.

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

The purposes of this study were: (i) to make the inventory of the relay starting techniques currently used in top level swimming; and (ii) to analyse the prevalence of each one for male, and female events.

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

Relative frequency, mean and standard deviations were used as statistical procedures.

RESULTS AND DISCUSSION
The main results are presented in Table 1. It can be noticed that the CS starting techniques stills the mostly used in the 2nd
to 4th relay starts performed by world class swimmers, and especially in male events. The main reasons may be associated to: (i) better observation of the approaching swimmer, and (ii) higher momentum transfer to the centre of mass without compromising starting time (actions on platform not included in starting time). Probably by the same reasons, the “moving start” techniques, especially SSF and SST, already present in intermit-

ting starts. Probably by the same reasons, the “moving start” techniques, especially SSF and SST, already present in intermit-
in top level swimming relays.

Table 1. Percent results of the incidence of the different starting tech-
niques in top level swimming relays.

<table>
<thead>
<tr>
<th>Technique</th>
<th>Fem.</th>
<th>Mal.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS</td>
<td>41.7%</td>
<td>62.6%</td>
<td>51.1%</td>
</tr>
<tr>
<td>GS</td>
<td>25.8%</td>
<td>61%</td>
<td>16.9%</td>
</tr>
<tr>
<td>TS</td>
<td>11.7%</td>
<td>2%</td>
<td>7.3%</td>
</tr>
<tr>
<td>SST</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>SSF</td>
<td>6.7%</td>
<td>16.2%</td>
<td>11%</td>
</tr>
<tr>
<td>DSF</td>
<td>4.2%</td>
<td>3%</td>
<td>3.7%</td>
</tr>
</tbody>
</table>

**RELATIONSHIP BETWEEN METABOLIC AND VENTILATORY THRESHOLDS IN SWIMMING.**

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**INTRODUCTION**

Measurement of blood lactate concentration ([La]) and ventil-

**RESULTS**

Table 1 presents the mean (±SD) values for the velocities corres-
ponding to the MetbAnT and VentAnT. No differences were observed between the metabolic and ventilatory AnT in each technique and in the pooled data. A positive significant relation-
ship was observed between swimming velocities correspon-
ding to MetbAnT and VentAnT for the whole sample (r=0.88, p<0.05). Differences were statistically non-significant (p>0.05).

Table 1. Mean (SD) values for MetbAnT and VentAnT. * p<0.05

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

**DISCUSSION**

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

**REFERENCES**


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

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²Faculdade de Matriculdade Humana, Universidade Técnica de Lisboa, Portugal.

**INTRODUCTION**

Do different sports promote a metabolic specialization in pre-
pubertal children? To answer this question we assessed a group of young athletes to test their physical performance (VO2max) and the short-term power output (Wingate Test - WAnT arm and leg evaluations). The WAnT allows a practical assessment for both legs and arms performance (1). Assuming the specificity of the anaerobic capacity for the main requested muscle groups (2), probably, football players would perform better with their legs and the swimmers with their arms.
METHODS
A group of young athletes (n=22) with a two year of training practice was divided in two sub-groups (n=11): swimmers (age: 11.27 years ±0.47; weight: 41.00 kg ±5.71) and football players (age: 11.5 years ±0.52; weight: 41.00 kg ±5.71). Modified Balke maximal protocol using ergo-spirometry procedures (Cosmed® b) was selected to determine $\text{VO}_{2\text{max}}$ and the Ventilatory Anaerobic Threshold (VAT) as estimates for the aerobic capacity. The anaerobic capacity for both arms and legs was quantified using the $\text{WAnT}$, performed in a cycle-egometer Monark® 849. Three relative parameters were assessed: Peak Power, Average Power and Power Drop. The comparison data was analyzed between the groups (T-test for independent samples) and correlated within groups (SPSS, ver.12.0).

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

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

REFERENCES

ANTHROPOMETRIC PROFILE OF ELITE MASTER SWIMMERS.
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2Istituto di Ricerca sull’Attività Motoria, Università degli Studi di Urbino, Urbino, Italy.

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

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

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

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Men</th>
<th>Football</th>
<th>Swimming</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dep.</td>
<td>Youth</td>
<td>Adult</td>
</tr>
<tr>
<td>1 (40-49)</td>
<td>11</td>
<td>44.5±2.4</td>
<td>179.1±6.1</td>
</tr>
<tr>
<td>2 (50-59)</td>
<td>12</td>
<td>54.7±3.2</td>
<td>178.8±6.5</td>
</tr>
<tr>
<td>3 (60-69)</td>
<td>14</td>
<td>64.0±2.8</td>
<td>174.4±8.3</td>
</tr>
<tr>
<td>4 (70-79)</td>
<td>12</td>
<td>73.7±2.1</td>
<td>170.9±7.5</td>
</tr>
<tr>
<td>5 (80+)</td>
<td>5</td>
<td>85.6±7.4</td>
<td>151.5±3.5</td>
</tr>
</tbody>
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ANOVA, with post hoc Tukey test, showed significant differences (p<0.05), only for men, in FM% (1 vs 4), TV (1 vs 3, 4 vs 2) and FAV (2 vs 4). The ≥ 80 years subjects, because of...

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

STROKE RATES CORRESPONDING TO CRITICAL SPEED AND THE MAXIMAL SPEED OF 30 MIN IN SWIMMERS OF DIFFERENT TRAINING STATUS.
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Human Performance Laboratory, Rio Claro, Brazil.
INTRODUCTION
Recently, Dekker et al. (1) verified in well trained competitive swimmers that the critical speed (CS) and critical stroke rate (SRCS) can be used in order to set aerobic training load and also to control the swimming technique during training. The objective of this study was to verify the effect of aerobic performance level on the relationship between stroke rates corresponding to CS and the maximal speed maintained for 30 min (S30) in swimmers.

METHODS
Twenty-three male swimmers of 15 to 20 yr participated of this study. They were divided in groups G1 (n = 13) and G2 (n = 10) based on the S30 (G1 = 1.23 ± 0.06 m.s⁻¹, G2 = 1.07 ± 0.06 m.s⁻¹; p < 0.05). The physical characteristics of G1 (body mass = 64.74 ± 11.45 kg, stature = 174.08 ± 7.42 cm, body fat = 12.80 ± 2.93%) and G2 (body mass = 61.56 ± 15.76 kg, stature = 169.80 ± 10.37 cm, body fat = 14.80 ± 5.27%) were similar. They had at least 4 years of experience in the modality and a weekly training volume of 30,000 to 45,000.

The CS was determined through the slope of the linear regression between the distances (200 and 400 m) and respective times. The S30 was determined through the maximal distance performed in a 30 min test. During this test, the stroke rate was measured two times along the length of the 25 m pool at each passage of 400 m. The stroke rate at CS (SRCS) was determined through the mean speed recorded during 200 and 400 m. During each test, the stroke rate was measured two times along the pool, at each passage of 50 m. SRCS was calculated by the slope of the regression line between the number of stroke cycles and time.

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

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

REFERENCES

HOW DO SWIMMING COACHES SEEK INFORMATION FROM SCI-
SHORT TERM WATER EXERCISE EFFECTS ON THE PHYSICAL FITNESS OF ELDERLY SUBJECTS FROM COLD SNOWY REGION.

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1Asai Gakuen University, Ebetsu, Hokkaido, Japan

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

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

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

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

THE FUNCTION OF NASAL PRESSURE FOR BREATHING IN THE BREASTSTROKE.

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2Atomi University, Faculty of Literature, Saitama, Japan
3Tokyo Metropolitan Akiruno Special Education School, Tokyo, Japan
4Department of Sports & Health Science, Tokyo Gakugei University, Tokyo, Japan
5Kawasaki University of Medical Welfare, Kurashiki, Okayama, Japan

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

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

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

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

REFERENCES

INJURIES INCIDENCE IN BRAZILIAN SWIMMERS OF DIFFERENT STROKES.

Haupenthal A, Schutz G, Ruschel C, Faquin A, Menezes F, Pereira S
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INTRODUCTION
The top-level competitive swimming requires raised levels of
training that expose the athlete to constant and intense stress situations. Those characteristics of training associated to innumerable repetitions of technician gestures, are considerable factors that predispose injuries, which are due to the repetitive microtraumas and overuse. The aim of this study was to identify the incidence, place and diagnosis of injuries in competitive Brazilian swimmers, according to the stroke, through the descriptive epidemiology.

**METHOD**

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

**RESULTS**

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

**DISCUSSION**

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

**REFERENCES**


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

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**INTRODUCTION**

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

**METHODS**

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

**RESULTS AND DISCUSSIONS**

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

**Fig. 1** The time-angle curves of the left hip (upper) and left foot (lower) of all subjects during one cycle of the eggbeater kick. The zero of the hip angle implies that the toe is pointed anteriorly. The foot angle is the relative angle of the foot from its initial position.
INVERSE DYNAMICAL MODELLING OF SWIMMERS’ IMPULSE DURING A GRAB START.

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

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

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

REFERENCES


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

Hubert M, Silveira G, Freitas E, Roesler H
Santa Catarina State University, Center of Physical Education, Physiotherapy and Sports, Florianópolis, Santa Catarina, Brazil.

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

METHODS
Six starts of four national and state levels swimmers were evaluated. The data were collected in the Doze de Agosto Club’s swimming pool and analyzed in the Aquatic Biomechanics Research Laboratory of CEFID/UFSC. Three synchronized VHS cameras (30Hz) were used. The following variables were measured: speed before the beginning of the stroke (Sa), measured in the underwater phase, in the interval of 1 second before the first movement for beginning of the stroke; speed after the beginning of the stroke (Sb), measured in the interval of 1 second after the beginning of the stroke and time in 15 meters (T15m). Spearman’s correlation with p ≤ 0.05 were used to establish the relationship between the variation of the speed and the time to 15m.

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

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

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

Invernizzi PL, Scurati R, Michielon G, Pizzini G

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

METHODS
This study involved 97 subjects, non skilled, divided into four groups: 2 male (age 20.5±1.3, 20.9±1.6, weight kg 75.8±5.4, 73.6±8.6, height cm 180.6±5.4, 178.3±5.6) and 2 female (age 21±2, 21.1±1.5, weight kg 60.4±7.2, 57.8±5.2, height cm 165.2±3.8, 166.9±3.3).

Two different learning methods for the perfecting of the crawl technique have been proposed: the first one addressed to improving the position in the water (“drag reduction” groups) the second one specific to the propulsion (“propulsion” groups). Both learning methods foresaw the same work charge and the use of the same didactical supports. Before and after the research period following swimming tests have been given: a filmed 50 m. speed test (where the time from 5 to 50m, stroke rate and stroke length have been taken and an efficiency index has been calculated) and a freestyle 6min test (where the swimming distance has been recorded).

Pre and post test results within groups have been compared by paired Student’s t test (p<0.05). Post test results among groups were observed by One-way ANOVA.

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

In the post experimentation comparison among groups differences were found only between the male “propulsion” group and each female group in the efficiency index.

DISCUSSION
Even if significant differences were induced neither in the speed, nor in the stroke rate nor in the stroke length, both learning methods employed to perfecting the crawl have been effective and made an improvement of the long distance stroke and of the stroke technique (efficiency index).

The differences found in post test among groups analysis could simply depend to the different gender of the subjects.

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

REFERENCES

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

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2Finnish Institute of Occupational Health
3Finnish Society for Research in Sport and Physical Education.

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

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

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

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

REFERENCES

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

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

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

### RESULTS

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

### DISCUSSION

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

### REFERENCES


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**Norwegian School of Sport Sciences, Oslo, Norway.**

### INTRODUCTION

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

### METHODS

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

### RESULTS

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

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### DISCUSSION

The within subject variation for the tethered swimming power test is small and in line with the coefficient of variation of dry land maximal isokinetic leg strength testing (<5%)[1]. The variation may be due to variations in technique, normal biological variation in performance or level of muscle recruitment at maximal effort. Swimmers seem to have lower coefficient of variation compared to students. It is concluded that a tethered swimming power test is highly reliable, assuming that the subjects perform maximally and that the protocol consists of 3 trials. Competitive swimmers have lower variation compared to college students, for whom familiarization did not reduce the variation.
INTRODUCTION
Swimming for exercise and recreation is a popular activity. One of the arguments for its benefits is that the incident of accidents and injuries is very low; however the incident is seldom reported in the research literature. In the training of lifeguards, it is important to know what to expect in terms of how many accidents usually happen in and around a swimming pool, and where in the pool these accidents take place. The purpose of this pilot study was to investigate the public accident frequency, accident types and locations, for aquatic facilities in Norway.

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

RESULTS
Of the 523 returned questionnaires (65%), 70% had no reported accident of any kind. For the remaining 30% (n=156) a total of 684 accidents were reported. With a total of 20 million visits to aquatic pool facilities per annum the incident rate is 3.4 accidents per 100 000 visits. Many older aquatic facilities could probably reduce their accident rate by taking measures to reduce cuts and falling, which comprise the majority of accidents.

ACCIDENT STATISTICS IN AQUATIC FACILITIES.

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2The Norwegian Institute for Parks, Sports and Recreation.

DISCUSSION
The incident of injury for aquatic pool facilities (3.4 per 100 000) must be considered low, compared to for example the incident of alpine skiing facilities (420 per 100 000[1]). Still, 100 000) must be considered low, compared to for example the incident of injury for aquatic pool facilities (3.4 per 100 000[1]).

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

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REFERENCES

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

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<td></td>
</tr>
<tr>
<td>D ((U) )</td>
<td>30</td>
<td>45</td>
<td>35</td>
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<td>42</td>
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<td>E ((\Pi) )</td>
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<td>F ((\backslash) )</td>
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<td>0</td>
<td>4</td>
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</table>
DISCUSSION
The results show that success in the finals coincides with SR model D - increasing SR in the end of the race. Why this strategy seems successful requires further investigations including the SL and v developments. The least successful models were model E and F, failing to keep up or decreasing the SR at the end of the race. This may be due to fatigue.

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

REFERENCES

THE TEMPORAL DISTRIBUTION OF RACE ELEMENTS IN ELITE SWIMMERS.
Kjendlie P-L1, Haljand R2, Fjørtoft O1, Stallman R1
1 Norwegian School of Sport Sciences, Oslo, Norway.
2 Tallin University, Tallin, Estonia.

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

METHODS
24 male finalists at the Norwegian junior short course championships (NOR) and 32 male finalists at the European Short course championships (EUR) were included in the studies. International points score for the two groups were 767 and 967 on championships (EUR) were included in the studies.

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

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

REFERENCES

THE VALIDITY OF A NON-PACED LACTATE PROFILE TEST FOR SWIMMERS.
Kjendlie P-L, Stallman R
Norwegian School of Sport Sciences, Department of Physical Performance, Oslo, Norway.

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

METHODS
A randomized crossover design was conducted, where each of the 11 competitive swimmers (mean age 20 years (range 16-24)) was their own control, swimming on one day with and one day without paced workloads. The stepwise test protocol consisted of five 400m front crawl workloads with increasing velocity. Predetermined velocities for each swimmer were either controlled by the swimmer himself or paced using a set of 14 pace-lights (Optimal Controlbox Corp.) moving below the swimmer. Lactate data and velocities were collected.

RESULTS
The mean velocities of paced or non-paced workloads at lactate values of 2, 3, 4 and 5 mM showed no statistical difference (see Table 1: Mean ± SD of total time (tTOT) in seconds and technical score (TS) in % for European championship finalists (EUR) and Norwegian junior championship finalists (NOR).

<table>
<thead>
<tr>
<th>BUTTERFLY</th>
<th>BACKSTROKE</th>
<th>BREASTSTR.</th>
<th>FREESTYLE</th>
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<tbody>
<tr>
<td>EUR</td>
<td>BUTTERFLY</td>
<td>BACKSTROKE</td>
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<tr>
<td>tTOT</td>
<td>TS</td>
<td>tTOT</td>
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<tr>
<td>EUR</td>
<td>61.69</td>
<td>48.07</td>
<td>62.17</td>
</tr>
<tr>
<td>NOR</td>
<td>62.50</td>
<td>53.74</td>
<td>62.92</td>
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<tr>
<td>p&lt;</td>
<td>0.001</td>
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<thead>
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<th>BUTTERFLY</th>
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<tr>
<td>EUR</td>
<td>BUTTERFLY</td>
<td>BACKSTROKE</td>
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<td>tTOT</td>
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<tr>
<td>EUR</td>
<td>59.87</td>
<td>62.63</td>
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<tr>
<td>NOR</td>
<td>63.19</td>
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<tr>
<td>p&lt;</td>
<td>0.001</td>
<td>0.001</td>
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</tbody>
</table>

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

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

REFERENCES


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

Klauck J1, Daniel K2, Bayat M1

1Institute of Biomechanics and Orthopaedics, German Sport University Cologne, Germany
2Institute of Motor Control and Movement Technique, German Sport University Cologne, Germany.

INTRODUCTION

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

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

METHODS

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

RESULTS

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

REFERENCES

Sanders RH (2005). Strength, flexibility and timing the eggbeater kick. http://coachersinfo.com/category/water_polo/5/ (01.03.05)

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


University of Tartu, Tartu, Estonia
University of Bologna, Bologna, Italy.

INTRODUCTION

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

METHODS

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

RESULTS

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

DISCUSSION

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

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

Lima F1, Portela A1, Soares S1, Gonçalves P1, Machado L1, Lima A1, Barbosa T1, Keskinen KL1, Fernandes R1, Vilas-Boas JP1

1University of Porto, Faculty of Sport. Porto, Portugal
2Department of Sports Sciences, Polytechnic Institute of Bragança, Portugal
3Finnish Society for Research in Sport and Physical Education, Helsinki, Finland.

INTRODUCTION

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

METHODS

Four elite breaststroke swimmers (2 males of 17.0±0.0 yrs, 172.5±3.5 cm and 69.4±2.0 kg, and 2 females of 17.5±2.1 yrs, 167.0±7.1 cm and 64.2±4.2 kg) performed an incremental intermittent protocol (n x 200m) for maximal oxygen consumption assessment (Fernandes et al., 2003), during which biomechanical and bioenergetical parameters were measured. The test was videotaped in sagittal plane with two SVHS cameras, providing, after mixing and editing, a dual-media image of the swimmer. The APAS software (Ariel Dynamics Inc, USA) was used to calculate the variation coefficient (dv) of the v(t) function of the centre of mass (CM) for each 200m step. Oxygen consumption was measured through a portable gas analyser (K4 b2, Cosmed, Italy) connected to the swimmers by a respiratory snorkel and valve system. Capillary blood samples were collected from the ear lobe, before and after each set, to analyse blood lactate concentrations (YSI 1500L Sport, USA). Oxygen expenditure (Ě) and C (Ě.v2) were calculated for each 200m using net values of VO2 and blood [La-], converted with a 2.7 mlO2.kg-1.mmol-1 constant.

RESULTS

Intra-cyclic speed fluctuations (dv) decreased with mean swimming velocity (r=-0.63, p<0.01). Ė increased with v2 and, as it is possible to observe in Figure 1 for each swimmer, C decreased with increasing dv.

DISCUSSION

As it was expected, a cubic relationship between Ė and dv was found, once energy output is a function of mechanical power, and the latter is expected to be a function of v2. The relationship obtained between C and dv do not confirm previous literature (Vilas-Boas, 1996). This finding may be due to differences in methodological procedures, or more obviously due to the higher influence of v, than dv, in Ė.
REFERENCES

ACUTE EFFECTS OF THE USE OF A BIOFEEDBACK SYSTEM FOR THE TECHNICAL TRAINING IN BREASTSTROKE SWIMMING.
Lima, A1,2, Capitão F1, Morouco P1, Gonçalves P1, Fernandes R1, Barbosa T1, Correia M1, Tani G1, Vilas-Boas JP1
1University of Porto, Faculty of Sport, Porto, Portugal
2University of Ceará and University of Fortaleza, Fortaleza, Brazil

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

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

RESULTS & DISCUSSION
VC ranged from 0.40 to 0.43, without statistical significant differences between groups. The mean values of stroke length (SL) were between 1.41m and 1.65m, with less homogeneity between groups. The cycle duration (T) ranged between 1.5sec and 1.7sec. The mean velocity per cycle (V) was between 0.9m.s-1 and 1.0m.s-1, and the Stroke Index (SI=V*SL) varied between 1.4 and 1.8m².s-1. The higher positive acceleration values were observed, in all groups, during the propulsive leg action, and ranged between 4.8m.s-2 and 5.7m.s-2. Among the main conclusions of this research, it is possible to state that: (i) the use of the biofeedback devices (graphical and acoustic displays of the speedometer, and dual media video images) influenced the motor learning processes associated to the acute effect of the swimming technical training provided - this effect is as larger, as higher and frequent the quantity of information provided; (ii) the swimming technical training of one hour of duration, complemented or not by additional technological means, has as acute effect a depression of the subjects’ technical ability; (iii) the technical changes with training, at least during a one hour process, are not temporal, but spatial, or derived ones (velocity, and acceleration), and each group distinguished from the others, in each evaluation moment, from very detailed and changing technical variables.

EVOLUTION OF BUTTERFLY TECHNIQUE WHEN RESISTED SWIMMING WITH PARACHUTE, USING DIFFERENT RESISTANCES.
Llop F1, Tella V1, Colado J1, Diaz G1, Navarro F1
1Department of Physical Education of the University of Castilla La Mancha, Spain
2University of Valencia, Spain
3University Alicante, Spain.

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

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

RESULTS
The results obtained showed how the SF does not significantly differ with different spans, but there are significant differences between NS and 0cm (p=0.015), 15cm (p=0.001) and 30cm
The test was carried out with a group of 4 swimmers (national and international ranks).

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

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

DISCUSSION/CONCLUSIONS
We have been able to verify differences in some of the cinematic parameters analysed for all the different execution conditions.

We were able to infer that the use of the plate can be harmful in the most waving execution of the butterfly technique, because this is an exercise that does not take advantage of lower limbs action in the equilibrating oscillation of the body in the sagittal plan.

We can conclude that partial swimming with float and without float they have great alterations in the speed of displacement in relation to I swim it global. Deducing in this way that the immobilization of the upper limbs to the front has implications in the speed of displacement of the swimmer. In that it says respect to the movement structure did not exist significant modifications of the cycle in the different exercise conditions, in contrast in that it respects to the space structure where we find alterations between the partial swim ones and I swim global, as well as enters the two conditions of I partial swim.

REFERENCES


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

Maañón R, Sánchez J, Mon J, González S

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

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

<table>
<thead>
<tr>
<th>Turn</th>
<th>Butterfly</th>
<th>Breaststroke</th>
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<tbody>
<tr>
<td>Male</td>
<td>Female</td>
<td>Male</td>
</tr>
<tr>
<td>Age 14-15</td>
<td>12-13</td>
<td>16-17</td>
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<td>N 26</td>
<td>22</td>
<td>14</td>
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RESULTS
The highest number of errors found in butterfly stroke correspond to pulling with elbow dropped (42%), a common mistake even in skilled butterfly swimmers (Maglischo, 2003). In 74% of breaststroke swimmers viewed we detected hips too flexed, with similar data between female categories.

TURNING MISTAKES (%) Male Female
<table>
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<tr>
<th>Junior Pre-Junior</th>
<th>Junior Pre-Junior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulling with elbow dropped 50</td>
<td>55</td>
</tr>
<tr>
<td>Incomplete insweep underneath the body</td>
<td>27</td>
</tr>
<tr>
<td>No complete the downbeat of the second kick</td>
<td>31</td>
</tr>
<tr>
<td>Too flexed hips 83</td>
<td>71</td>
</tr>
<tr>
<td>Too separated elbows at arm recovery beginning</td>
<td>67</td>
</tr>
<tr>
<td>Shoulders or hips no horizontal</td>
<td>67</td>
</tr>
</tbody>
</table>

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

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

METHODS
A set of N velocity-[La-] data points, were split in two groups: points 1 to k for the first group and points k+1 to N for the second group, where k ranged from 2 to N-2. Two separate least squares fits were made: a linear fit to the first group; and an exponential fit to the second group. Other methodologies for AnT determination have been proposed to find more specific and individualized values for this parameter. This work presents in detail a mathematical model to obtain an individual value for the AnT in swimmers. This model has been used by Fernandes et al. (2005) to assess the individual AnT (IndAnT) for 32 swimmers.

RESULTS
Figure 1 shows an example of a fit by a line and an exponential. The value of IndAnT is obtained by the interception of both curves. The best set of fitting curves is chosen by visual inspection of the output plots and inspection of the values of the residue. Fernandes et al. (2005) found that the velocity- [La-] data points and the fitting line and exponential, as well as, the corresponding fitting parameters, point of interception of the curves and the value of the residue.

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

REFERENCES

RELATIONSHIP BETWEEN LEFT VENTRICULAR DIMENSIONS AND FUNCTION AND MAXIMAL OXYGEN UPTAKE IN YOUNG SWIMMERS.
Madeira R1,2, Trabulo M1, Alves P3, Gomes Pereira J1
1Universidade Lusofona de Humanidades e Tecnologias, Lisboa, Portugal
2Faculdade de Motricidade Humana, Universidade Técnica de Lisboa, Portugal
3British Hospital, Lisboa, Portugal.

INTRODUCTION
In the exercising human, maximal oxygen uptake (VO2max) can be potentially limited by each step of the oxygen pathway from the atmosphere to the mitochondria: (1) the pulmonary diffusing capacity, (2) the cardiovascular system, (3) the oxygen-carrying capacity of the blood, and (4) the muscle oxidative characteristics. Of particular importance is the cardiac system (function and/or size). The purpose of this study was to analyse the relationship between left ventricular (LV) dimensions and function and VO2max in young swimmers.

METHODS
Twelve young swimmers (15.88 ± 0.22 years old; 64.21 ± 6.81 Kg of body mass; 1.75 ± 0.58 m of height) took part in this study. Cardiac dimensions and function were determined by two dimensional M mode and Doppler echocardiography. Echocardiographic data were expressed in absolute units and then scaled allometrically for individual differences in anthropometric data. VO2max was determined using the modified Balke treadmill protocol. Body mass (BM), height (H), body surface area (BSA), body fat percentage (%BF) and fat free mass (FFM) were measured according to standard procedures. Pearson product–moment correlation coefficient was calculated to evaluate the relationships between LV dimensions and function and VO2max.

RESULTS
Absolute VO2max and VO2max/%BF correlated significantly with LV internal chamber dimension at end–diastole (LVIDd), left ventricular mass (LVM), LV internal chamber dimension at end–systole (LVIDs), LV volume at end–diastole, LV volume at end–systole, stroke volume (SV) and cardiac output (Q).
VO2max/BM correlated significantly with LVIDd, LV volume at end - diastole and SV, VO2max/BM 0.45 correlated significantly with LVIDd, LV volume at end – diastole, SV at baseline and Q, VO2max/FFM correlated significantly with LV volume at end – diastole and SV. Non significantly correlation was observed between absolute and relative VO2max and fractional shortening (FS), ejection fraction (EF) and ratio of early passive (E) to late atrial contraction (A) filling of LV (E/A ratio).

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

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

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1Campinas State University, São Paulo, Brazil
2Brazilian Confederation of Aquatic Sports, Rio de Janeiro, Brazil.

### INTRODUCTION

Dry-land strength training is an important factor for the improvement of the sprinters performance2. The increase in muscle volume is a morphological adaptation that contributes to significant increase in strength. Although this may decrease the speed of movement due to increase of the transversal section of the swimmer’s body, many coaches believe this increase might be compensated by the application of a greater force per stroke. Then, the goal of this study was to verify the relationship between the swimmer’s muscle volume and how to apply strength in special conditions.

### METHODS

The study sample is compound by 6 male swimmers specialized in 50 and 100m freestyle (23.53 ± 1.05 years) and 6 male swimmers in 200m free style (21.02 ± 4.03 years), and 5 female swimmers specialized in 50 e 100m free-style (22.75 ± 2.36 years) and 7 female swimmers specialized in 200m freestyle (20.33 ± 3.50 years), all of them part of the Brazilian national team pre-selected for the 2007 Pan American Games. The swimmers’ special strength has been measured by the tethered swimming, starting at 3 repetitions with 5 seconds each. The data obtained in the test were: maximum force (MF) and average force (AF). Muscle mass (MM) was estimated by the equation proposed by MARTIN et. al. (1990). To analyze the data, Pearson’s moment product correlation was utilized. The level of significance was p ≤ 0.05.

### RESULTS

#### Table 1. Correlation between MM, MF e AF.

<table>
<thead>
<tr>
<th></th>
<th>100m Male</th>
<th>200m Male</th>
<th>100m Female</th>
<th>200m Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>MM</td>
<td>0.57</td>
<td>0.09</td>
<td>0.32</td>
<td>0.82*</td>
</tr>
<tr>
<td>MF</td>
<td>0.45</td>
<td>0.45</td>
<td>-0.21</td>
<td>0.66</td>
</tr>
<tr>
<td>AF</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* significance (p≤ 0.05)

### DISCUSSION

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

### REFERENCES


### CHRONOMETRIC PARAMETERS ANALYSIS OF NATIONAL AND WORLD SWIMMING COMPETITION EVENTS.

Marques C1, Ribeiro-Martins M, Moreira A2, Silva A2

1Sport Sciences School of Rio Maior, Portugal
2University of Trás-os-Montes e Alto Douro, Portugal.

### INTRODUCTION

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

### METHODS

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

### RESULTS

Accordingly to the results pointed out, the start time represents 11% of the competition time. The pure swimming time was the component that fulfills the competition time: 70% (100m freestyle), 71% (100m Butterfly) and 67% (100m Breaststroke). The turning time, in 100m freestyle and 100m Butterfly represents 11% and 12%, and in Breaststroke represents 14% of the total competition time. The arrival time is about 5% of the total competition time. 100m Butterfly was the longest except for the 1st league swimmers. Different regression equations, depending on the swimmers level, were obtained for each one of the chronometric variables of swimming event analysis.
DISCUSSION
Distinguished swimming models were found in every group, for the 3 swimming techniques analyzed. The swimming competition components, starts, turns, and arrivals, correspond to 29% (100m freestyle) and 30% (100m butterfly) of the swimming events. The competition analysis should be an ordinary procedure that allows a construction of an individual swimming model. Their often utilization will give to the coach and the swimmer precise information about the weakest and the strongest point of each swimming competition.

REFERENCES

SWIMMING VELOCITY IMPROVED BY SPECIFIC RESISTANCE TRAINING IN AGE-GROUP SWIMMERS.
Mavridis G, Kabitsis C, Gourgoulis V, Toubekis A
Department of Physical Education and Sport Sciences, Democritus University of Thrace, Komotini, Greece.

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

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

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

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

REFERENCES
Table 1. Comparison of results between sexes (Mean and SD for each stroke). In bold the higher [La] peak found in each sex.

<table>
<thead>
<tr>
<th></th>
<th>Male (Mean)</th>
<th>Female (Mean)</th>
<th>Male (SD)</th>
<th>Female (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fb</td>
<td>17.2±2.14</td>
<td>24.7±2.36</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Brst</td>
<td>17.2±2.14</td>
<td>24.7±2.36</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Brst</td>
<td>17.2±2.14</td>
<td>24.7±2.36</td>
<td>**</td>
<td>**</td>
</tr>
</tbody>
</table>

DISCUSSION

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

REFERENCES


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

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INTRODUCTION

In literature there are many studies about aquatic motor sequences in young children that interested different aspects of aquatic psychomotor development. [1,2,3]

The aim of this study was to investigate if the spontaneous swim movements following a methodological approach based on “keep doing” and on “free exploration” of the children can evolve into effective actions.

METHODS

This study involved 30 children divided into 3 groups composed of 5 males and 5 females each, respectively aged 4-12 months (group A), 12-24 months (group B) and 24-36 months (group C).

Age and anthropometric data (weight and height) were taken for each subject. Moreover a personal report about the presence of some specific swim movements (submersion, inclined body position, simultaneous and alternating actions of arms and legs) was drawn up.

The data survey was executed before and after a 10-lesson program that has been carried out following a methodological approach based on “keep doing” and on “free exploration” of the children.

RESULTS

A comparison of the pre-post status within group and a comparison among the three groups for each characteristic observed, were conducted with a Mann-Whitney non-parametric Test, for p<0.05.

No significant differences (p>0.05) were found in the comparison between the pre and post experience analysis within group. On the contrary significant differences (p<0.05) were found both in the comparison 4-12 versus 24-36 months of age and in comparison 12-24 versus 24-36 months of age.

DISCUSSION

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

REFERENCES


KINEMATICS PARAMETERS OF CRAWL STROKE SPRINGING THROUGH A TRAINING SEASON.

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¹Physical Education and Sport Center, Londrina State University, Brazil
²School of Physical Education, Federal University of Rio Grande do Sul, Porto Alegre, Brazil.

INTRODUCTION

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

METHODS

Nine swimmers (7 males and 2 females; mean age = 14.78 ± 1.48 years) participated in this study. The protocol consisted
on the evaluation of SR, SL, SV and SI in a 25 m maximal effort test, every ten weeks, before (M1), during (M2), and after (M3) five months of training. Measurements were obtained from manual counting of cycles and time from 10 to 25 m of the trials. Anthropometric data were collected. Intensity and distance swan during the training season were controlled. ANOVA repeated measures, Bonferroni post-hoc tests and Intra-Class Correlation Coefficients (ICC) were applied to the data, adopting a 0.05 significant level.

RESULTS

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

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

<table>
<thead>
<tr>
<th>Variables</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (cm)</td>
<td>168.8 ± 0.13</td>
<td>169.3 ± 0.13</td>
<td>170.0 ± 0.12</td>
</tr>
<tr>
<td>Upper limb span (cm)</td>
<td>172.1 ± 0.13</td>
<td>173.3 ± 0.13</td>
<td>174.3 ± 0.13</td>
</tr>
<tr>
<td>Total body mass (Kg)</td>
<td>91.9 ± 14.2</td>
<td>91.7 ± 13.3</td>
<td>91.5 ± 13.3</td>
</tr>
<tr>
<td>SR (Hz)</td>
<td>0.85 ± 0.08</td>
<td>0.72 ± 0.18</td>
<td>0.78 ± 0.11</td>
</tr>
<tr>
<td>SL (m)</td>
<td>1.79 ± 0.17</td>
<td>1.57 ± 0.14</td>
<td>1.59 ± 0.15</td>
</tr>
<tr>
<td>SV (m².s⁻¹)</td>
<td>1.52 ± 0.13</td>
<td>1.57 ± 0.14</td>
<td>1.59 ± 0.15</td>
</tr>
<tr>
<td>SI (m².s⁻²)</td>
<td>2.71 ± 0.45</td>
<td>2.73 ± 0.46</td>
<td>2.83 ± 0.36</td>
</tr>
</tbody>
</table>

Kinematics data showed stability along the training season: SR: (ICC = 0.808; IC 95% [0.421; 0.953]; p < 0.001); SL: (ICC = 0.815; IC 95% [0.421; 0.955]; p = 0.002); SV: (ICC = 0.977; IC 95% [0.827; 0.994]; p < 0.001); and SI: (ICC = 0.939; IC 95% [0.809; 0.989]; p < 0.001). There were improvements (p < 0.05) on anthropometric data throughout the training season.

DISCUSSION

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

REFERENCES


OXYGEN UPTAKE AT THE LACTATE THRESHOLD IN SWIMMING.


University of Porto, Faculty of Sport, Porto, Portugal.

INTRODUCTION

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

tions ([La⁻]), has been considered a topic of great interest in swimming literature. However, due to the difficulties related to the assessment of maximal oxygen uptake (VO₂max) in normal swimming conditions, the LT intensity has normally been interpreted using the corresponding swimming velocity, instead of the respective percentage of VO₂max. The purpose of this study is to identify, in terms of %VO₂max, the intensity of swimming associated with a non linear increase of [La⁻].

METHODS

Twenty nine trained swimmers were studied: 15 male (21.4±3.0 yr, 177.3±7.0 cm, 68.3±7.1 kg and a VO₂max of 70.9±10.2ml.kg⁻¹.min⁻¹) and 14 female (18.7±2.4 yr, 164.9±2.3 cm, 55.1±3.9 kg and a VO₂max of 59.8±8.02ml.kg⁻¹.min⁻¹). Each subject performed an intermittent incremental test for freestyle VO₂max assessment, with increments of 0.05 m.s⁻¹ each 200m stage and 30s intervals, until exhaustion (Fernandes et al., 2003). Velocity was controlled using a visual pacer with flashing lights on the bottom of the pool. In water starts and open turns were used. [La⁻] were assessed at rest, during the 30s intervals, immediately after each 200m stage, and at minutes 3 and 5 of the recovery period (YSI1500LSport auto-analyser). VO₂ was measured through direct oximetry (Sensormedics 2900). LT was assessed individually through a [La⁻]/VO₂ curve modelling method (least square method) and was assumed to be the intersection point, at the maximal fit situation, of a combined pair of regressions (linear and exponential) (Machado et al., 2006).

RESULTS

In mean terms, the non linear increase in [La⁻] with swimming intensity occurred at values of 2.99±0.8 mmol.l⁻¹, which corresponded to 73.54±8.0%VO₂max.

DISCUSSION

The present study showed that the non linear increase of [La⁻] corresponding to LT in a specific swimming situation occurred at 73.54±8.0%VO₂max. This result also seems to confirm that the best single [La⁻] value to predict LT, when testing trained swimmers, should be lower than the usual value of 4 mmol.l⁻¹.

REFERENCES


OXYGEN UPTAKE AND VENTILATORY THRESHOLD IN SWIMMING.


University of Porto, Faculty of Sport, Porto, Portugal.

INTRODUCTION

Due to the difficulties associated with the evaluation of ventila-
tory parameters in normal swimming conditions, the assessment of the ventilatory threshold (VT), to our knowledge, has not been tried yet. However, the determination of this parameter is essential in order to achieve a more precise knowledge of the aerobic capacity of swimmers. The purpose of the present study was to identify the swimming intensity associated to the VT, expressed as a percentage of the maximal oxygen consumption (%VO₂max).

METHODS
Twenty-nine trained swimmers were studied: 15 male (21.4±3.0 yy, 177.3±7.0 cm, 68.3±7.1 kg and a VO₂max of 70.9±10.2 ml·kg⁻¹·min⁻¹) and 14 female (18.7±2.4 yy, 164.9±2.3 cm, 55.1±3.9 kg and a VO₂max of 59.8±8.0 ml·kg⁻¹·min⁻¹). Each subject performed an intermittent incremental test for freestyle VO₂max assessment, with increments of 0.05 m.s⁻¹ each 200 m stage and 30 s intervals, until exhaustion (Fernandes et al., 2003). Velocity was controlled using a visual pacer. VO₂ and Ventilation (Ve) were measured through direct oximetry (Sensormedics 2900 oximeter). VT was assessed by Ve/VO₂ curve modelling method (least square method) – Machado et al. (2006) – and VT was assumed to be the intersection point, at the maximal fit situation, of a combined pair of regressions (linear and exponential). Mean (SD) computations for descriptive analysis were obtained for all variables.

RESULTS
The non linear increase of Ve seems to occur at 88.1±31.3 l·min⁻¹, corresponding to 84.3±8.7%VO₂max.

DISCUSSION
The non linear increase of the Ve corresponding to the VT in normal swimming conditions seems to happen at 84.3±8.7%VO₂max. The obtained result seems to be in agreement with other studies conducted in cycle-ergometers (cf. Dekerle et al., 2003). In this sense, this result seems to confirm that, nonetheless the specificity of the aquatic environment, the VT occurs at a similar absolute intensity as in running and in cycling.

REFERENCES

REFERENCE

A THREE-YEAR FOLLOW-UP STUDY OF AGE GROUP SWIMMERS: ANTHROPOMETRIC, FLEXIBILITY AND CMJ FORCE RECORDINGS.
Morales E, Arellano R
Faculty of Physical Activity and Sport Science, University of Granada, Spain.
null velocity.


cylinders (for Re of 10^5, 10^6 and 10^7) decreased with the increase in Re number as dimensionless analysis) are available: experimental research and numerical simulation. Due to the experimental research limitations the use of the numerical simulation has become an important role in the biomechanical research area. All the studies of computational fluid dynamics (CFD) developed in swimming used the turbulent model k-ε to the resolution of the Navier Stokes equations (NS). However, no studies were performed to confirm if this model (k-ε) is the most appropriated for CFD in swimming. Therefore, the aim of this study was twofold: i) to evaluate the CFD code capacity to solve simple problems of the turbulent flow around a cylinder, by the comparison of values from different turbulence models with experimental values for similar Reynolds number (Re); ii) to evaluate, for the most appropriated turbulent model, the thickness of the adjusted mesh in order to apply it to similar Re values as it is in swimming.

METHODS
For this purpose various turbulent models were applied (k-ε; k-ω; Spalart-Allmaras; Reynolds Stress) with different mesh spacing of 0.10–10.0 [m/s] in order to obtain the same Re numbers usually observed (Re from 10^5 to 10^7) in human swimming. The model was considered as a fix element with null velocity.

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

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

VALIDATION OF A CABLE SPEEDOMETER FOR BUTTERFLY EVALUATION.

Moroção P1,2, Lima A2, Semblano P3, Fernandes D3, Gonçalves P4, Sousa F4, Fernandes R5, Barbosa T5, Correia MV2, Vilas-Boas JP5

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

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

RESULTS
The individual Pearson correlation coefficients were highly significant (p<0.01) and their mean values were: (i) between Vhip and
DISCUSSION

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

REFERENCES


EMG ANALYSIS OF THE MUSCLES PECTORALIS MAJOR AND DELTOID POSTERIOR.


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

INTRODUCTION

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

METHODS

Four woman aged between 20 and 25 years participated in this study. Electromyographic activities of the posterior Deltoid and the Pectoralis major muscles were analysed during horizontal flexion and extension movements of the shoulder. Participants performed 8 repetitions in four cadences: at 40, 60 and 80 bpm, paced by a metronom. These repetitions were also performed at maximum velocity. The electromyographic sign was filtered and the RMS values of the third, fourth and fifth repetition were analysed. An ANOVA statistics analysis for EMG was performed to verify the velocity (cadence) effect (p<0.05).

RESULTS

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

DISCUSSION

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

REFERENCES


ELECTROMYOGRAPHIC DIFFERENCES OF ABDOMINAL EXERCISE IN WATER AND ON LAND.


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

METHODS

Twenty woman aged between 21 and 29 years participated. The electric activity of the Obliquus externus abdominis (OE), Rectus femoris (RF) and of the Rectus abdominis (RA) were measured with surface electrodes. The exercise of trunk flexion up to a seated position, performed on land was used as standard exercise and the root mean square (RMS) of the ascending phase of this exercise were being used for normalization the signal that was collected during another variations of speed and environment. Trunk flexions in water were performed in a horizontal position with the support of a floating device for the upper members. The exercise was performed in a standard rhythm and also in maximum speed. For each muscle ANOVA was used for the factors phase, speed and environment (p<0.05) was performed.

RESULTS

Statistically differences were found in the mean value of the percentual of EMG activation when the two phases, two environments and two speeds were analysed separately for all muscles, in the interaction of the factors environment/phase the muscles RF, upper and lower RA and OE, in the interaction of the factors environment/speed to the muscles upper and lower RA and OE and in the interaction of the factors phase/speed for all muscles analysed. When the exercise was performed in maximum speed and in the ascending fase of the exercise in the water the observed EMG activity was stronger than the muscle activity for the exercise performed in standard speed. This was observed in water and on land. The EMG activity of the RF when performing the exercise in maximum speed in water was lesser than on land.
DISCUSSION
The trunk flexion in maximum speed in the water can be considered an exercise of strong abdominal activity and low activity of the hip flexors. The characteristics of the external forces that act upon the body during the abdominal exercises in water provide a very special situation of reduced hydrostatic weight (1), resistance to the movement, relative support and a tendency of rotation to attain a stable balance and increase resistance to the movement.

REFERENCES

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

Novais D1, Carmo C1, Gonçalves P1, Sousa F1, Lima A1, Barbosa T2, Santos P1, Machado L1, Keskinen KL3, Fernandes R1, Vilas-Boas JP1

1University of Porto, Faculty of Sport, Porto, Portugal
2Department of Sports Sciences, Polytechnic Institute of Bragança, Portugal

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

METHODS
Four elite freestyle swimmers (2 males of 18.5±0.7 vy, 176.0±11.3 cm and 71.6±12.7 kg, and 2 females of 16.5±0.7 vy, 171.0±1.4 cm and 60.7±3.5 kg) performed an incremental intermittent protocol (n x 200m) for maximal oxygen consumption assessment (Fernandes et al., 2003), during which biomechanical and bioenergetical parameters were measured. The swims were videotaped in the sagittal plane with two SVHS cameras, providing, after mixing and editing, a dual-media image of the swimmer. The APAS software (Ariel Dynamics Inc, USA) was used to calculate the variation coefficient (dv) of the v(t) function of the centre of mass (CM) for each 200m step. Oxygen consumption was measured through a portable gas analyser (K4 b2, Cosmed, Italy) connected to the swimmers by a respiratory snorkel and valve system. Capillary blood samples were collected from the ear lobe, before and after each set, to analyse blood lactate concentrations (YSI 1500L Sport, USA). The energy expenditure ( ) and C ( .v-1) were calculated for each 200m using net values of VO2 and blood [La-], converted with a 2.7 mlO2.kg-1.mmol-1 constant.

RESULTS
Intra-cyclic speed fluctuations and v increased with v (r=0.63 and r=0.85, p≤0.01, respectively). C rose with the increasing of dv (cf. Fig. 1, for pooled data).

DISCUSSION
A linear relationship was found between tot and v. The relationship obtained between C and dv is in accordance with literature. In the present study it was found that, for the entire sample, C seems to be mainly influenced by dv and, at an individual level, v seems to be the C main determining factor. These two variables appear to determine 70% of the variance in C.

REFERENCES

EFFECT OF THE TEACHING POINTS ON TURN MOTION OF BREASTSTROKE FOR BEGINNER’S SWIMMER.

Ohba M1, Takahashi M1, Shimoyama Y1, Nomura T3
1Niigata University, Niigata, Japan
2Niigata University of Health and Welfare, Niigata, Japan
3University of Tsukuba, Ibaraki, Japan.

INTRODUCTION
Breaststroke turns require a simultaneous two-hand touch at the wall, followed by the turning of the body and pushing off into the next swim. Beginning-swimmers have difficulty making breaststroke turns in a smooth motion because of that complexity. Therefore, specific skills are required in order to make the turn motion efficiently. The purpose of the present study was to evaluate the effect of the teaching points on the turn motion of breaststroke for beginning-swimmers.

METHODS
Eight non-skilled college swimmers participated in this study. They were taught the turn motion at three times for 15 minutes. Trials of the turn were conducted in order to analyze the turn motion before and after the teaching. Each test was recorded using two digital video cameras for motion analysis, and another camera for measuring a turning time (T-turn; the
INTRODUCTION
The objective of this research was to search for a particular type of repeated behaviour patterns in swimming movement cycles. The search used a new data analysis approach based on a process known as T-Pattern detection of the temporal and sequential structure of a data set (Magnusson, 1996). The temporal patterns can be related to performance specific actions (e.g. comparison intra-cycle movement patterns similar to the one described by Coleman at al. (1998). Theme can be used for the analysis by using the relevant types of swimming data files created with Themecoder or other qualitative codification set.

METHODS
Breaststroke cycles of a national champion swimmer have been recorded underwater. Thirty cycles of execution style were coded and analyzed with Theme, using a categorical system analyze known as “field format” (Weick, 1968; Anguera, 1979), composed by seven criteria representing the relevant stroke phases. Each one of those criteria includes the relevant inter-segmentar relationships observed, such as critical leg position related to body, head and arms (intra cycle components). This coding produced 162 events composed by 28 event types. The event type includes information about each segment relation of each criterion.

RESULTS
Through the use of the theme program we could find highly regular patterns of swimming technique. Several levels of pattern complexity output allow us to analyse relations between cycles.

RESULTS & DISCUSSION
T-turn (Pre; 1.71sec, Post; 1.84sec) and T-hand (Pre; 0.65sec, Post; 0.86sec) were significantly longer (P < 0.05) in comparison to before teaching. It seemed that another time except for T-touch (Pre; 1.06sec, Post; 0.89sec) was shorter. All subjects felt that the present teaching points were effective in improving the turn motion in spite of a short teaching program. There were many positive comments such as “I learned to be able to have no trouble turning the body” and “I was able to kick a wall firmly”. It was suggested that the teaching program leaded the swimmers to acquire the good tips on turn motion and do turning of the body certainly.

REFERENCES

REFERENCES

Onodera S1, Nishimura K2, Ono K2, Seki K2, Nishioka D3, Okamoto T3, Oyanagi E3, Senoh N2, Kawano H1, Ogita F4, Toussaint H5

INTRODUCTION
It also allowed the detachment of some procedures to integrate in future analyses, having as an orientation the sequence the quality of the movement, required to gestures of advance breaststrokes variants.

REFERENCES

CHANGES IN CROSS SECTIONAL AREA OF INFERIOR VENA CAVA DURING ARM CRANKING EXERCISES IN WATER.

Onodera S1, Nishimura K2, Ono K2, Seki K2, Nishioka D3, Okamoto T3, Oyanagi E3, Senoh N2, Kawano H1, Ogita F4, Toussaint H5

INTRODUCTION
It is well known bradycardia and increases in strike volume occur induced by hydrostatic pressure during water immersion.
We clarified that the response of venous return was about twenty seconds using the change of size of in the cross section- al area of inferior vena cava during exercises in water. Therefore the purpose of the present study was to investigate the cross sectional area of inferior vena cava changes during exercises in water.

METHODS

Six subjects were voluntarily participated in this study (age of 23 ± 3 years, height of 173 ± 15 cm, body weight of 173 ± 5). We have informed consent for subjects according to the HELSINKI Ethical Principle. The study was set into four experimental conditions of 20%VO2max, 40%VO2max, 60%VO2max and control. They participated in an arm cranking exercise program. The exercise program was performed for 15-min. Water temperature was 30 degrees C. Water depth was examined venous return. Heart rate was measured by electrocardiography. The cross sectional area of inferior vena cava was measured by using B-mode echocardiography. Data were analyzed by ANOVA and the level was set at P<0.05.

RESULTS

This study indicated that the cross sectional area of inferior vena cava is decreased during the exercise program, and there is a significant relationship between the cross sectional area and intensity of the exercise program (P≤ 0.05). The results of recovery after the exercise program also indicated that there is a significant difference between the cross sectional area and intensity of the exercise program (P≤ 0.05).

DISCUSSION

We suspect the venous return has two factors controlling the velocity and volume. The findings of the study indicated keeping volume down during the low intensity exercise program and more importantly indicated the treatment by velocity during the high intensity exercise program.

REFERENCE


THE EFFECT OF THE BREATHING ACTION ON VELOCITY IN FRONT CRAWL SPRINTING.

Pedersen T, Kjendlie P-L

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INTRODUCTION

During a 50m freestyle race, swimmers attempt to breathe as little as possible, or not at all. For 100m freestyle races, the need for oxygen is greater; still many swimmers tend to reduce their breathing. The purpose of this study was to examine how breathing actions influence velocity during a 25m front crawl sprint using two different breathing patterns, and no breathing.

METHODS

Ten competitive, national level, adult swimmers (age 25 ± 3 years (mean ± SD), 8 males and 2 females) volunteered for this study. They all swam three 25m freestyle sprints with different breathing patterns (randomised order), starting every 4 minutes; 25m with no breathing, 25m with one breath after 15m of swimming (approximately one breath every third stroke cycle), and 25m with one breath every stroke cycle. All breathing was to the swimmers preferred side. Velocity measurements were carried out using a computerized swimming speedometer (1), connected to the swimmer using a thin non elastic line. Data from mid-pool free swimming (10-20m) was extracted and used in all analyses.

RESULTS

There was no significant difference in mean velocity (v) between 10m of mid pool sprinting when the swimmers took one breath compared to no breath. There was a significant (p<0.05) reduction in velocity when breathing every stroke cycle, compared to both no breath and one breath trials, see table 1.

DISCUSSION

The results indicate that swimmers at this performance level may breathe once every 3rd stroke cycle without loosing velocity due to breathing actions in front crawl sprint. If swimmers breathe every stroke cycle they may lose up to 0.1 sec per 10m of mid pool swimming. In 100m races, swimmers tend to breathe every stroke cycle at the end of a race. Coaches should stress breath control both in training and competitions and teach effective breathing technique to avoid velocity reductions due to breathing actions. To give more accurate advice about which breathing patterns to use in 100m races, both individual differences in technique and different physiological and metabolic variables must be taken into consideration.

<table>
<thead>
<tr>
<th>Table 1: Mean velocity from the three trials.</th>
</tr>
</thead>
<tbody>
<tr>
<td>No breath</td>
</tr>
<tr>
<td>v10-20 (m/s-1)</td>
</tr>
<tr>
<td>Mean (±SD)</td>
</tr>
</tbody>
</table>

# significant different from both no and one breath trials (p<0.05)

REFERENCES


BIOMECHANICAL ANALYSIS ON CRAWL STROKE TURNS.

Pereira S, Araújo L, Freitas E, Gatti R, Roeslers H

Santa Catarina State University, Laboratory of Research in Aquatic Biomechanics, Florianópolis, Santa Catarina, Brazil.

INTRODUCTION

The time of the turns can contribute up to 20% of the total race time (3). The main objective of this study was to investigate the contribution of the dynamic and kinematic variables to the performance in crawl stroke turn.

METHOD

The turns of 38 swimmers were analyzed using an underwater
force platform and two video cameras that supplied, respectively, dynamic and kinematic data. Each swimmer performed 8 turns. Descriptive statistics were used to characterize the data. Angle of knee flexion (AK), maximum normalized force peak (FPn) and contact time (CT) were measured as variables in the multiple linear regression to determine the effect of these variables on total turn time (TT). Pearson’s correlation was used to analyze the relationships between the variables. The data was separated in four groups, it was classified by turn times and to verify the difference between the variables, One-Way Analyses of Variance (ANOVA) and Scheffe’s post-hoc were used.

RESULTS
Through investigation of the contribution of the variables AK, PMn and CT to the variable TT it was possible to identify that PMn explains the greatest percentage of variance in turn performance (17.70%). The relation between AK and PMn indicated that larger values of AK (smaller flexions) tend to provide larger values of PMn (r = 0.38). In the relation between AK and CT it was verified that larger values of AK tend to provide smaller values of CT (r = -0.38). The relation between PMn and CT indicated smaller values of CT tend to provide larger values of PMn (r = -0.23).

DISCUSSION
Starting from the results analysis, it can be suggested that angles of knee flexion between 110 and 120 degrees tend to provide larger force peaks, smaller contact times and smaller turn times, reaching the best performance of the crawl stroke turn execution.

REFERENCES

‘EPIDEMIOLOGICAL’ ANALYSIS OF THE FREESTYLE TURNING TECHNIQUES USED IN TOP LEVEL SWIMMING.

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1University of Porto, Faculty of Sport, Porto, Portugal
2State University of Santa Catarina, Florianópolis, Brazil.

INTRODUCTION
The aim of this study was to conduct an inventory of the freestyle turning techniques, and an analysis of the evolution of the use of different variants, in top level swimming during the last 10 years.

METHODS
Official images of FINA from the Olympics Games and World Championships, since 1996 up to 2003 were analyzed. All the visible freestyle turns were considered being discarded those carried through the same athlete in the only event. The turns had been analyzed and classified in accordance to the used technique variant, between men and women, the gotten ranks, and the countries they represented.

RESULTS
256 turns were analyzed. The dorsal rolling technique was the most used by 171 swimmers (66.81%). The touch in the wall is dorsal for 35.16% of the total swimmers, and lateral for 31.65%. However, the most important aspect seems to be the technique variants for the impulse out of the wall. Independently of the rolling position, 84.77% of the swimmers adjust their body position for the ventral position during the impulse. Just 15% of the swimmers do not perform trunk rotation during the impulse, leaving to adjust the body position during the underwater glide (13%), or touching the wall in a favorable position to displacement (2%). The USA swimmers perform their turns with dorsal rolling (16%) and the Australian swimmers, mostly perform the turns with lateral rolling (11%). The other countries present predominance of the dorsal rolling technique (31%). The impulse is characterized by a movement of trunk rotation in 41% of the turns.

DISCUSSION
One can observe the predominance of a rotational movement of the trunk along the longitudinal axis during the impulse phase of the wall, most likely for the adjustment of the body position for the beginning of the stroke. However, this action does not seem to be a biomechanically optimized action, once it tends to a “dispersion” of the applied force, exactly in the instant where force seem to be one of the main aspects to take into account for the performance of the turn action (Araújo et al, 2005). More biomechanical studies of the turn movement are necessary in freestyle comparing the efficiency of the techniques used by the best swimmers of the world.

REFERENCES

BIOMECHANICAL ANALYSIS OF THE UNDERWATER PHASE IN SWIMMING STARTS.

Pereira S, Ruschel C, Araújo L

Laboratory of Research in Aquatic Biomechanics, Santa Catarina State University, Florianópolis, Santa Catarina, Brazil.

INTRODUCTION
Authors who investigate the characteristics of the swimming starts recognize the importance of the underwater phase to the start performance, suggesting the necessity of making measurements and descriptions of the variables behavior during the execution of this phase. The main objective of this study was analyse, through cinemetry, the underwater phase of the swimming start.
METHODS
The sample was composed by 4 swimmers of national and state levels. The data were collected in the swimming pool of Doze de Agosto Club and analyzed in the Laboratory of Research in Aquatic Biomechanics of CEFID/UDESC. Three VHS video cameras (30Hz) and a sign synchronizer equipment were used. Each swimmer performed 6 starts for the crawl stroke. One analyzed the following variables: maximum depth achieved (DP), time, distance and average velocity of the underwater phase (UPT, UPD and UPV respectively) and total start time in 15 meters (T15m). The relation between the variables was carried out through Pearson’s Correlation.

RESULTS
It was observed significant correlation between PMA and T15m, which indicates that higher values of maximum depth correspond to higher values of T15m. The maximum depth also presented significant correlation with UPT, UPD and UPV; higher values of PMA corresponded to higher values of distance and time and, at the same time, to smaller values of average velocity during the underwater phase. It was observed a negative correlation coefficient between UPV and T15m, which indicates that higher values of average velocity during the underwater phase correspond to slower starts.

DISCUSSION
The achieved depth after the entrance in the water had influenced significantly the underwater phase. About the average velocity during this phase, it seems to be the variable which most affects the total start time in 15 meters. Both variables are important factors to be observed by athletes and coaches, that should look forward to perform great values that provide the efficient execution of swimming starts. It suggests that the swimming start analyses should contemplate, beyond the block and the flight phases, the underwater phase that is an essential phase to be considered for the determination of performance parameters of the start in swimming.

REFERENCES

DIAGNOSTIC, TRAINING AND REALISATION OF STRENGTH CONDITION OF SWIMMERS WITH USE OF FEEDBACK DIAGNOSTIC SIMULATOR “ART”.

Petriaev A, Kleshnev I
Saint-Petersburg Research Institute of Physical Culture, Saint-Petersburg, Russia.

INTRODUCTION
The purpose of this article was to present results of research project in diagnostic, training and realisation of strength condition of swimmers with use of visual immediate feedback diagnostic swimming simulator “ART”.

METHODS
In the study was used the computerized swimming simulator “ART” which has force-velocity characteristics with high correlation to in-water swimming (1). Different work-loads gave opportunity to change force-velocity ratio. An athlete performed simulated arm-pulling lying at swimming bench (modified training program) and it was able to receive immediate feedback on dynamical structure of the drive phase, stroke rate and power using PC display. Around 400 athletes from new to elite took part in the research.

RESULTS AND DISCUSSION
In the study in group of boys the characteristics of strokes power increase in the age of 12-14 years more than on 40%. However, the qualitative parameter (ratio power to athlete body weight) changes much less and in the group of 14-years boys, it is equal 87% from national team medium meanings. Correlation of young swimmers sport results were connected with the absolute parameters of power in force and speed work-loads in tests with maximal intensity (p<0.001) and two years later their sport results were connected with qualitative parameters (ratio of stroke power to body weight) in speed mode in analogous tests (p<0.001). In analyse of stroke dynamical structure it was determined that the stroke structure was being changed with increasing of work intensity. This fact showed that long use of swimming exercises with low intensity can form stroke dynamical structure that does not correspond to the structure on competition velocity. Use of training program of stroke dynamical structure correction using visual immediate feedback had high efficacy of such work in the increasing of sport result. Using speed mode in the same interval training the stroke rate is increased (7%) with low increase of stroke power (2,5%), but using power mode the stroke power is improved (13%) with low increase of rate (1,5%) (p<0.05). It means that we can use different modes of load depended on training aims, for correction of stroke rate and stroke lengths.

CONCLUSION
Used exerciser “ART” with visual immediate feedback in the training of swimmers allows to value qualitative and quantitative dynamical characteristics of stroke, to do trainings to increase stroke specific power, to correct stroke dynamical structure, that have difficulties in real swimming. To increase the swimmers’ strengths potential into the swim power it is important to use training modes, in which the stroke velocity will correspond or exceed the record velocities of athletes.

REFERENCES
THE INFLUENCE OF COMPETITIVENESS LEVEL ON MATCH EXERCISE INTENSITY IN ELITE WATER POLO PLAYERS.

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1Department of Aquatics
2Department of Sports Medicine & Biology of Exercise, University of Athens, Greece.

INTRODUCTION
This study was designed to investigate the physiological responses that elicited in different competitive level players during water polo games. Specifically, the hypothesis that the players of Greek National Team (NTP) perform with higher intensity than the players of the 1st Greek National League (NLP) was tested.

METHODS
Thirty players, who had equally split to NTP and NLP, participated in this study. Initially, their physiological profile, which was related with their performance, was evaluated. Subsequently, heart rate (HR) was continuously monitored and blood lactate (La) was measured at the end of each period during 10 water polo games.

RESULTS
Maximum oxygen uptake, lactate threshold point as well as HR values corresponding to the threshold are presented in Table 1. In addition, Table 1 shows HR and La values attained during the water polo games and their respective significant differences. No differences were found with respect to the percentage of time spent with exercise intensity above and below the threshold between NTP and NLP. However, as Figure 1 indicates, regardless of relative terms (%), NTP swam with significantly higher velocity than NLP throughout the game.

Table 1: Physiological traits of subjects during performance tests and water polo games

<table>
<thead>
<tr>
<th>Test Type</th>
<th>NTP</th>
<th>NLP</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>VO2max (ml/kg/min)</td>
<td>70.23±6.97</td>
<td>57.14±9.26</td>
<td>0.001</td>
</tr>
<tr>
<td>LTH (mmol/l)</td>
<td>3.47±0.76</td>
<td>4.60±0.80</td>
<td>0.002</td>
</tr>
<tr>
<td>HRTH (beats/min)</td>
<td>147.5±9.6</td>
<td>163.1±9.6</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Figure 1: Mean swimming velocity of water polo players in 10 games.

DISCUSSION
Exercise intensity exhibited during the games was not affected by the level of competitiveness when values were considered relative to lactate threshold; however, NTP had higher swimming velocity than NLP. It is concluded that the players of Greek national team performed at higher absolute exercise intensity than the players of the 1st Greek national League.

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

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1University of Porto, Faculty of Sport, Porto, Portugal
2Department of Sports Sciences, Polytechnic Institute of Bragança, Portugal
3Finnish Society for Research in Sport and Physical Education, Helsinki, Finland.

INTRODUCTION
The purpose of this study was to examine the relationship between energy cost (C) and intra-cyclic speed fluctuations (dv), in backstroke.

METHODS
Five male elite backstroke swimmers (18.6±1.5 yr, 179.2±2.3 cm and 70.2±8.5 kg) performed an incremental intermittent protocol (n x 200m) for maximal oxygen consumption assessment (cf. Fernandes et al., 2003), during which biomechanical and bioenergetical parameters were measured. The test was videotaped in sagittal plane with two SVHS cameras, providing, after mixing and editing, a dual-media image of the swimmer. The APAS software (Ariel Dynamics Inc, USA) was used to calculate the variation coefficient (dv) of the v(t) function of the centre of mass (CM) for each 200m step. Oxygen consumption was measured through a portable gas analyser (K4 b2, Cosmed, Italy) connected to the swimmers by a respiratory snorkel and valve system. Capillary blood samples were collected from the ear lobe, before and after each set, to analyse blood lactate concentrations (YSI 1500L Sport, USA). The energy expenditure (E) and C (E-v-1) were calculated for each 200m using net values of VO2 and blood [La-], converted with a 2.7 mlO2.kg-1.mmol-1 constant.

RESULTS
The E vs v presented a linear relationship for the pooled data of the sample (r=0.67, p=0.001) and for 2 subjects (0.98±rs 0.99, p≤0.01), and a cubic relationship for the others (0.92±rs 0.99, p≤0.05). For the pooled data, C increased linearly with dv (r=0.39, p≤0.05), despite individual relationships showed particular results (Fig. 1).

Figure 1: Individual relationships between C and dv.
INTRODUCTION
Effective turns play a critical role in the outcome of swimming competition. In short-course events, turns comprise up to one-third of the total race time. At elite competitive levels, mid-pool swimming velocity is the primary determinant of race performance. However, turns have the potential to determine a winner among swimmers with the same mid-pool swimming velocities. The purpose of this study was to examine the effect of three variables on the velocity of the push-off during the freestyle flip-turn. These variables are: (a) The distance from the wall a swimmer’s hips should be at foot contact (Tuck Index); (b) The depth of the foot plant on the wall during push-off; and (c) The wall-contact time.

METHODS
Twelve male and eleven female members of a University (Division I) swimming team participated in the study. Their ages ranged from 19 to 25 years. Each subject was required to perform a series of trials, each trial consisting of a 50-yard freestyle swim over a 25 yard (22.5 m) course which included one turn. Subjects were instructed to perform the flip turn at race pace, swimming at maximum speed for 5 meters before and after the turn. Each turn was videotaped from underwater using a single digital camera. The camera was placed at a depth of half a meter, and located 2 meters from the end of the pool and 7 meters lateral to the turning surface. A four-point calibration rod was used as a scaling factor for the kinematic analysis. 2D analyses in the sagittal plane were made using motion analysis software (Vicon/Peak, Denver, Colorado). A Pearson correlation coefficient matrix was constructed to identify the relationship between variables. Simultaneous regression analysis was conducted using the push-off velocity as a dependent variable to determine the overall predictive characteristics of the variables.

RESULTS & DISCUSSION
The mean push-off velocity was 2.47 ms⁻¹. The minimum velocity was 1.3 ms⁻¹ and the maximum push-off velocity was 3.29 ms⁻¹. Tuck index is the ratio measurement used to indicate how close a swimmer is to the wall. A higher tuck index indicates straighter legs. In the present study, the mean tuck index of all turns was 0.37 ± 0.14, indicating that the hips were a mean distance from the wall that was approximately 57% of the length of the swimmer’s legs. The study found a significant, negative correlation between push-off velocity and tuck index, indicating that the more tucked position (lower tuck index) predicted higher push-off velocity. No significant correlations existed between push-off velocity and foot-plant. Wall Contact Time (WCT) was divided into two segments, a “preparatory” segment and an “active” segment. The mean percentage of the wall contact spent in the “active” push-off phase was 74.31%. Although previous studies have shown positive correlations indicated that longer active segments resulted in faster final push-off velocities, no significant relationship was found between “active” WCT and push-off velocities.

COMPARISON BETWEEN DIFFERENT METHODS FOR THE ASSESSMENT OF THE VO₂ SLOW COMPONENT OF FREESTYLE ELITE SWIMMERS.

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¹University of Porto, Faculty of Sport, Porto, Portugal
²Finnish Society for Research in Sport and Physical Education, Helsinki, Finland

INTRODUCTION
The purpose of this study was to compare different methods for the assessment of the Oxygen Slow Component (SC) in elite swimmers in a time limit test at the minimum velocity that elicits maximal oxygen consumption (TLim-VO₂max).

METHODS
Five females (16.9 ± 1.5 yr, 59.0 ± 3.1 kg and 165.8 ± 3.2 cm) and two males (18.5 ± 0.6 yr, 74.6 ± 8.5 kg and 176.0 ± 11.3 cm) elite front crawl swimmers swam until exhaustion at their previously determined VO₂max to assess TLim-VO₂max (Fernandes et al., 2003). VO₂ was measured by a portable gas analyser (K4 b¹, Cosmed, Italy) connected to the swimmers by a respiratory snorkel. To describe the SC kinetics was used a mathematical model with three exponential functions (cf. Machado et al., 2006). This model was compared with different methods of rigid time intervals defined as the difference between the end VO₂ and the one at the 2nd min of exercise (ΔVO₂[2nd min]) or at the 3rd min of exercise (ΔVO₂[3rd min]), with different averages around the 2nd and 3rd min, and the end of the exercise (20 s, 30 s or 40 s).

RESULTS
with performance and many physical, biomechanical and psychological variables were used to demonstrate the importance of same of these characteristics to performance. The main goal of this study was to find the most important characteristics to swimming performance at young ages working with different approaches namely Data Mining algorithms, and multi regression analysis.

**METHODS**

The sample is constituted of 420 swimmers of national Portuguese level (boys - 13 to 16 years old and girls - 12 to 14 years old). During 5 years data were collected at national and regional evaluation meetings. Anthropometric, experience of training, and same physical tests namely maximal isometric strength, power, flexibility and hydrostatic and hydrodynamic characteristics were measured. In order to compare swimmers according to their performance level we use LEN point scores tables.

Data were analyzed using different algorithms: Decision Tree, K-Means (5-clusters) and Kohonen[2]. We also used the multi regression analyses with those variables that show significant correlation with performance.

**RESULTS & DISCUSSION**

With multi regression analysis using only anthropometric variables we found a model that explain performance (LEN Points score) 35,2% for males and 25,4% for females. When we include on the model other variables related to work capacity and training experience the explanation reaches 68,3% for males and 63,5% for female.

Using different algorithms we found similar results with the anthropometric variables assuming particular importance for performance.

**REFERENCES**


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**Determinant Factors Related to Performance in Young Swimmers.**

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2Centro de Informática e Sistemas da Universidade de Coimbra, Portugal
3Faculdade de Motricidade Humana de Lisboa, Universidade Técnica de Lisboa, Portugal.

**INTRODUCTION**

Talent identification is one of the most pursued issues of swimming research aiming to find at very young ages, the most important markers of mastering performance. Usually sport technicians and coaches, are aware of particular traces not supported on training experience that enhance best performances on future. Often they look to the morphologic and anthropometric characteristics of the adult champions of particular style or event [1]. Coaches want their swimmers to come close to these traces. In swimming, technique is everything. To reach technical excellence experience is necessary. So, looking for these traces. In swimming, technique is everything. To reach performance (LEN Points score) 35,2% for males and 25,4 for females. When we include on the model other variables related to work capacity and training experience the explanation reaches 68,3% for males and 63,5 for female.

Different algorithms we found similar results with the anthropometric variables assuming particular importance for performance.

**REFERENCES**


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**Stoke Performance During Butterfly and Breast-Stoke Swim at the Lowest Speed Corresponding to Maximal Oxygen Consumption.**

Ramos L1, Marinho D1, Soares D1, Mota J1, Figueiredo J1, Moroço P1, Barbosa V1, Keskinen KL1, Fernandes R1, Vilas-Boas JP1

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2Finnish Society for Research Sport Sciences and Physical Education, Helsinki, Finland.

**INTRODUCTION**

Time Limit (Tlim) is a concept that has been used to diagnose effects of swimming training and performance. It is the time duration a swimmer can perform at lowest speed corresponding to maximal oxygen uptake (Tlim- \( \dot{V}O_{2} \text{max} \)). While the technical performance during this specific test has not been previously explored in butterfly and breast strokes, the aim of the present study was to analyze stroke rate (SR) and stroke length (SL) in relation to the Tlim- \( \dot{V}O_{2} \text{max} \).
INFLUENCE OF TIMING DELAY ON MONOFIN INTRACYCLE SWIMMING VELOCITY.

Rejman M

University School of Physical Education, Wroclaw, Poland.

INTRODUCTION

The aim of this study is an analysis of temporal delay in the structure of the body and monofin segments during swimming. On the theoretical basis of the mechanics of propulsion [1,2,3], it has been accepted that delays in the structure of biokinemat-

METHODS

Ten elite swimmers (7 males, 19.58 ± 2.9 y, 176.0 ± 5.0 cm, 70.5 ± 6.2 kg; 3 females, 17.6 ± 1.5 y, 166.3 ± 5.1 cm, 60.9 ± 6.5 kg) performed, in their best simultaneous technique, an intermittent increment test consisting of a set of 200-m swims. VO₂max was assessed from the swimming velocity versus oxygen consumption relationship. After 48 hours rest, continuous swimming at a speed corresponding to VO₂max was performed until exhaustion to determine TLim-vVO₂max (Fernandes et al., 2003). SR and SL were analyzed from underwater video recordings for each 25-m lap throughout the test.

RESULTS

The two strokes differed so that the TLim-vVO₂max was higher in breaststroke (331.4 ± 82.7 versus 277.6 ± 85.6 s) with lower speed (1.10 ± 0.1 versus 1.29 ± 0.0 m·s⁻¹), SR (30.00 ± 2.7 versus 36.5 ± 1.2 cycles·min⁻¹) and SI (2.48 ± 0.4 versus 2.76 ± 0.1 m²·s⁻¹) but with longer SL (2.23 ± 0.2 versus 2.14 ± 0.1 m·cycle⁻¹). All differences were statistically non-significant. When the two samples were pooled together (6 breaststroke, 4 butterfly) an inverse relationship between TLim-vVO₂max and SR (r=-0.54, p≤0.05) was observed.

DISCUSSION

The results of other studies concerning the relations between TLim-vVO₂max and stroke parameters in front crawl pointed out inverse relationships between TLim-vVO₂max and SR (Fernandes et al., 2005), and TLim-vVO₂max and vVO₂max (Fernandes et al., 2003). For butterfly and breaststroke it was not found any relationship between the above-referred parameters, which can be justified by the low number of swimmers studied for each technique. When both strokes were considered together, n rose, and the relationships became similar to the ones previously obtained for front crawl.

REFERENCES


INTRODUCTION
Determining the level of preparedness, as a significant factor in training, represents the feedback information about the current condition of an athlete. It plays an important role since it provides the information about the changes of the athlete’s conditions caused by the training load and other factors with the objective to regulate the impact the training process on the athlete. To monitor the level of both endurance and pace a set of swimming tests has been compiled. Some of the tests used by the Slovak Swimming Federation have been taken into consideration.

METHODS
From March to April 2005 a testing of 62 ‘performance’ swimmers aged 13/14 and 56 ‘performance’ swimmers aged 15/16 took place, using the 3000m test. The testing had been deliberately arranged so that it came at the end of the special summer yearly makrocycle training program 2004/05. In June 2005 of the same macrocycle an altered version of 4x50m test have been used; recordings and timings were conducted in the groups of 35 swimmers of 13-14 years, and 36 swimmers aged 15-16 respectively.

RESULTS
The blood lactate level was being probed after completing each particular test with time allowance of 3 and 10 minutes. Based on the results the applied 3000m test for both men and women in particular age-groups it is possible to assume that it provides a relatively exact anaerobic threshold pace of a swimmer. The 4x50m test, based on the results achieved, thus seems an appropriate to evaluate the level and changes in anaerobic capacity.

DISCUSSION
Based on the results gained by the blood lactate level it is possible to state that the 3000m test is useful when evaluating both the level and changes in aerobic capacity. The threshold pace (arrived at during 3000m test of maximal effort) can be used to determine the training load intensity when repeating each particular test with time allowance of 3 and 10 minutes. Nevertheless, all the methods and tests have both strong and weak spots. Nevertheless, all the information provide coaches with the data that can help them when determining the efficiency of the training process.

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DIAGNOSING PERFORMANCE BY APPLYING SWIMMING TESTS.
Ružbarský P, Turek M
University of Prešov, Faculty of Sport, Slovak Republik.

INFLUENCE OF EXCESS WEIGHT ON IMPROVEMENT IN PHYSICAL CONDITION THROUGH AN AQUAEROBICS PROGRAM.
Saavedra J, Cruz E, Torres S, Caro B
AFIDES Workgroup, University of Extremadura, Spain.

INTRODUCTION
The purposes of the present study were: (i) to establish the differences in physical condition based on the existence or not of excess weight and (ii) to discover whether the application of an aquaerobics program improves the different components of physical condition.

METHODS
The sample was made up of 20 women (43.1±9.7 years), and was subclassified according to the existence (BMI≥25) or not (BMI<25) of excess weight into a group of overweight women (OW, n=9) and a group without excess weight (OW, n=11). All the subjects carried out a program of low-impact aquaerobics twice a week for 8 months. In addition, they carried out pre- and post-tests, which consisted of the following: height, weight, body mass index, waist-hip ratio (WHR), modified sit and reach, two-hand dynamometry, modified curl-ups, one-leg balance with closed eyes and UKK 2-km walking test. The basic descriptions (mean and standard deviation) were determined; the differences between the pre- and post-tests were calculated using a Student t-test for related samples, and the differences between both groups were found by means of a one-factor ANOVA (Table 1).

RESULTS
Table 1. Basic descriptions (M, SD) and differences between pre- and post-tests (Student t-test for related samples) and ANOVA of one factor between WOW-WOW.

DISCUSSION
With regard to improvement in physical condition, surprisingly none of the studied factors improved significantly, although it seems that in the OW group, there exists a no significant tendency towards improvement. However, the OW group was able to reduce its weight and BMI. It should also be pointed out that group WOW is in better physical condition than group OW (1).

REFERENCES
IMPROVEMENT IN QUALITY OF LIFE OF HEALTHY ADULT WOMEN THROUGH THE APPLICATION OF AN AQUAEROBIC PROGRAM.
Saavedra J, Cruz E, Caro B, Torres S
AFIDES Workgroup, University of Extremadura, Spain.

INTRODUCTION
The purpose of the present study was to discover whether the application of a program of low-impact aquaerobics influences the quality of life of the participants.

METHODS
The sample was made up of 20 women (43.1±9.7 years old), who participated in a program of low-impact aquaerobics twice a week for 8 months. At the same time, they completed the SF-36 questionnaire (3), which consists of eight dimensions (physical function, physical role, corporal pain, general health, vitality, social function, emotional role, and mental health), the day before and the day after the activity. The normality of each of the variables was calculated by means of the Kolmogorov-Smirnov test; the basic descriptions (mean and standard deviation) were determined; and the differences between the pre- and post-tests were calculated by means of a Student t-test for related samples (Table 1).

RESULTS
Table 1. Basic descriptions (M, SD) and differences between pre- and post-tests (Student t-test for related samples).

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Pre-test</th>
<th>Post-test</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Physical function</td>
<td>85.50</td>
<td>15.88</td>
<td>98.50</td>
</tr>
<tr>
<td>Physical role</td>
<td>81.25</td>
<td>33.31</td>
<td>93.75</td>
</tr>
<tr>
<td>Corporal pain</td>
<td>69.25</td>
<td>21.99</td>
<td>91.45</td>
</tr>
<tr>
<td>General health</td>
<td>72.51</td>
<td>20.95</td>
<td>75.40</td>
</tr>
<tr>
<td>Vitality</td>
<td>61.87</td>
<td>17.03</td>
<td>79.75</td>
</tr>
<tr>
<td>Social function</td>
<td>83.12</td>
<td>22.31</td>
<td>93.75</td>
</tr>
<tr>
<td>Emotional role</td>
<td>80.26</td>
<td>34.78</td>
<td>96.66</td>
</tr>
<tr>
<td>Mental health</td>
<td>70.74</td>
<td>16.34</td>
<td>81.00</td>
</tr>
</tbody>
</table>

**p<0.05; ***p<0.001

DISCUSSION
All the dimensions from questionnaire SF-36 showed values greater than the 75th percentile of the normative reference values (1), except for “general health”. A significant improvement in all the dimensions for quality of life was observed, except for the dimensions “general health” and “physical role”. These improvements agree with other studies (2).

REFERENCES

ALTERNATIVE STYLES TURN TECHNIQUE QUALITATIVE EVALUATION TO INTERNATIONAL SPANISH JUNIOR AND PRE-JUNIOR SWIMMERS: AN ANALYSIS OF ERROR FREQUENCY.
INTRODUCTION

Data analysis is an important task in any kind of science, and the biomechanics domain is no exception. Dealing with complex data is a hard task, especially when using statistical tools, due to the huge number of situations to analyze, and available variable combinations. An alternative to statistical tools is the use of new analysis tools, which can explore the space of possible analysis situations, and variable combinations. The field of Data Mining [1] has developed several algorithms that enable a new way to analyze data, searching for patterns in data repositories. These algorithms are able to work with complex data. One scientific domain in which the analysis of data constitutes a challenge is the swimming competition domain. Not only the number of variables is huge, but also the nonlinearity of relations between variables is huge, making the search for patterns in data a hard task, even for the most experienced researchers.

This paper presents a data analysis tool that uses a Data Mining approach, enabling a more efficient search for patterns in data. We also present a study using this tool in the domain of pre-junior swimming athletes. The main goal of this study was to build a model for each swimming style, related to swimming performance (scoring LEN points).

METHODS

We developed a tool called AIDNat, which uses Data Mining algorithms to search for patterns in data. The tool is generic and is able to work with any kind of domain. The tool is simple to use and is thought to be used by non-expert users, guiding the analysis with a wizard. This wizard aids the user defining the data analysis to be executed in several steps: choosing the data file to analyze, pre-processing the data (for example, eliminating data rows in which there are missing values), selecting the input and target variables, and selecting the data mining algorithm to be used. In the end, the system generates a report with the analysis generated from the data, which describes the patterns found in the selected data file.

AIDNat was used for analyzing data of pre-junior swimming athletes. We have done three iterations in the analysis of data, each one exploring and focusing specific aspects of the swimming domain. The study involved about 90 variables and 420 individuals.

RESULTS & DISCUSSION

After three data analysis iterations, the tool presented several detailed models, one for each study goal. These models describe the most important characteristics for a swimmer, and they have accuracies from 40% to 60%, depending on the used algorithm. We have also identified the most important variables for each model. For example, the main characteristics for determining the adequate style for a swimmer are anthropometric, namely: upper limb length, sitting height, height, mass, lower limb length.

REFERENCES


MOVEMENT ANALYSIS IN CAD-PATIENTS.

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2Department of Rehabilitation Science, K.U. Leuven, Belgium.

INTRODUCTION

The relevance of physical activity in Patients with Coronary Artery Disease (CAD) is undisputable. The aim of rehabilitation is to develop an optimal sport specific program depending on the current conditions of individuals. Nevertheless such programs primarily almost always focus on physiological adaptations although it is well known that changes in the movement may influence these adaptations. Therefore the goal of this study was to assess the movement parameters of CAD patients under different load conditions during swimming.

METHODS

2-dimensional movement analysis (SIMI-Motion) was done in a flume “load-step-test” in breaststroke of 27 male CAD-patients. The movement analysis was based on the breaststroke phase model by Jähnig et al.1. All in all 57 movement-parameters were analysed for each patient recorded. To describe the complex movement, time-discrete and time-continuous characteristics, timing of the swim-movement (Phase Structure Quotient-PSQ by Blaser et al.2) and a factor analysis were done.

RESULTS

Based on the time-discrete findings 9 parameters (e.g. duration of propulsion-pause between main phase of arms and legs and angle of attack of hip–shoulder-water surface) were found to be relevant to describe the swim-movement of the CAD-patients examined. From the time-continuous point of view individual patterns were observed of arm and leg movements. The calculated PSQ described some problems of these patients to react to increased load conditions. As a result of factor analysis 4 factors of relevance (time-structure, velocity-regime, posture of upper part of the body, angle of attack of thigh) provide indications to organise swim rehabilitation programs with a special view on movement-coordination.

DISCUSSION

The movement patterns of CAD-patients react in diverse ways to increased loads. Based on these findings the importance of movement analysis in swimming of CAD-patients was underlined in order to guarantee an adapted sport-specific rehabilitation program as an additional way to control the load-stress situation and to develop movement skills.
INTRODUCTION
In the front crawl, Chollet et al. (1) defined the Index of Coordination (IdC) as the lag time between propulsive phases from one arm to the other. The calculation of IdC was based on the duration of 4 swimming phases. The duration of the propulsive phase was the sum of the durations of the pull and push phases, whereas the duration of the non-propulsive phase was the sum of the catch and recovery durations. But the key points that delimit these swim phases were determined visually on the basis of video analysis. This study determines the effect of using an intracyclic velocity signal on IdC calculation.

METHODS
Nine subjects of national and international level performed 8 swim trials at different speeds. Four mini-dv videos were mixed with the intracyclic velocity signal (Speedometer Fahnenmann Inc, Germany). The duration of the propulsive phase was first analyzed only on the basis of the video data (visual) and then with the help of the speedometer to assess the end of the propulsive phase. The third analysis used only the speedometer. The mean values of IdC and the standard deviations obtained with these 3 methods were compared with ANOVAs.

RESULTS
Table 1 presents the mean values of IdC obtained with the different methods.

<table>
<thead>
<tr>
<th>Method</th>
<th>IdC (%)</th>
<th>SD of</th>
<th>IdC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual</td>
<td>-9.5±5.9</td>
<td>4.1±1.6 NS</td>
<td>-21.5±5.3 a, c</td>
</tr>
<tr>
<td>Mixed</td>
<td>-15.2±6.7 b, c</td>
<td>5.3±1.7 NS</td>
<td>4.2±1.6 NS</td>
</tr>
<tr>
<td>Speedometer</td>
<td>-21.5±5.3 a, c</td>
<td>5.3±1.7 NS</td>
<td>4.2±1.6 NS</td>
</tr>
</tbody>
</table>

a : significant difference with mixed method
b : Significant difference with speedometer method
c : significant difference with visual method
NS: non-significant difference p<0.05

DISCUSSION
The type of method had a significant effect on the calculation of IdC. The more visual the method, the higher the values of IdC were. One explanation is that the visual method considers the push phase to be propulsive until the arm exits the water, whereas data from Monteil et al. (2) showed a drastic decrease in propulsive force before the hand exits. The visual method may thus overestimate the duration of propulsive phases. Our data in fact indicate that the visual determination of propulsive phases, as proposed by Chollet et al. (1), can overestimate duration by 5.2 to 12%. On the other hand, Table 1 indicates that the variation in IdC (Sd of IdC) with changes in self-selected speed was statistically non-significant, whatever the method of calculation. It seems thus that the visual method appear adequate for practical applications like training but for pure research into coordination, the intracyclic velocity signal provides more precise data and should be used.

REFERENCES

THE STABILITY OF IDC DURING MAXIMAL AND SUB-MAXIMAL SWIM TRIALS QUESTIONED.
Schnitzler C1,2, Ernwein V, Seifert L1, Chollet D1
1C.E.T.A.P.S. UPRES EA 3432, Faculty of Sports Sciences, Rouen, France
2Faculty of Sports Sciences, Strasbourg, France.

INTRODUCTION
The Index of Coordination (IdC) represents the lag time between propulsive phases from one arm to the other, based on 4 swimming phases in front crawl: catch, pull, push and recovery (Chollet et al., 2000). The change in IdC was evaluated during 8 self-paced simulation of race paces swum on a 25-m distance. The reliability of this indicator obtained on this basis can be questioned, especially as race distance increases. We thus investigated how IdC changes with distance during a 400-m trial and, second, we determined whether the magnitude of effort to be performed has an influence on the mean IdC value.

METHODS
Twenty-two subjects of 3 levels of expertise [8 expert, 93.0±3.1% of world record (WR); 6 mid-level, 78.5±4.2% WR; 8 recreational, 69±1.5% WR] performed a maximal 400 m freestyle swim trial. The expert population then performed 100-m, 200-m and 300-m trials at the speed of the previous 400-m. Four video cameras placed in both underwater and aerial planes allowed the calculation of IdC every 50-m.

RESULTS
Table 1 presents the changes in IdC with swimming distance during a maximal 400-m trial.
Table 1. Change in IdC (%) with swimming distance as a function of expertise.

<table>
<thead>
<tr>
<th>Distance (m)</th>
<th>Expert (%)</th>
<th>Medium (%)</th>
<th>Recreational (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>-13.5</td>
<td>-10.5</td>
<td>-11.5</td>
</tr>
<tr>
<td>100</td>
<td>-14.7</td>
<td>-12.9</td>
<td>-10.7</td>
</tr>
<tr>
<td>150</td>
<td>-14.4</td>
<td>-12.6</td>
<td>-10.3</td>
</tr>
<tr>
<td>200</td>
<td>-15.1</td>
<td>-12.8</td>
<td>-10.3</td>
</tr>
<tr>
<td>250</td>
<td>-15.2</td>
<td>-13.1</td>
<td>-10.3</td>
</tr>
<tr>
<td>300</td>
<td>-13.7</td>
<td>-12.2</td>
<td>-10.3</td>
</tr>
<tr>
<td>350</td>
<td>-13.9</td>
<td>-12</td>
<td>-10.3</td>
</tr>
<tr>
<td>400</td>
<td>-12.2</td>
<td>-11</td>
<td>-10.5</td>
</tr>
</tbody>
</table>

*p<0.05 NS: non-significant (p>0.05).

Table 2 presents the mean values of IdC obtained after swim trials of different distances.

Table 2. Mean values of IdC during sub-maximal swim trials.

<table>
<thead>
<tr>
<th>Distance of the swim trial (m)</th>
<th>IdC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>-14.2±1.7</td>
</tr>
<tr>
<td>200</td>
<td>-13.8±2.2</td>
</tr>
<tr>
<td>300</td>
<td>-14.1±1.7</td>
</tr>
<tr>
<td>400</td>
<td>-14.2±1.8</td>
</tr>
</tbody>
</table>

*p<0.05 NS: non-significant.

DISCUSSION

The first part of the experiment showed that IdC did not change during a maximal 400-m swim trial for any level of expertise. The second part showed that mean IdC values were not modified even when the swim distance was reduced. The evaluation of IdC on the basis of short-distance swim trials, as proposed by Chollet et al. (2000), appears to be reliable and reproducible.

REFERENCES


USE OF INDEX OF COORDINATION TO ASSESS OPTIMAL ADAPTATION: A CASE STUDY.

Schnitzler C1,2, Ernwein V1, Seifert L1, Chollet D1

1C.E.T.A.P.S. UPRES EA 3432, Faculty of Sports Sciences, Rouen, France
2Faculty of Sports Sciences, Strasbourg, France.

INTRODUCTION

In the front crawl, Chollet et al. (1) defined the Index of Coordination (IdC) as the lag time between propulsive phases from one arm to the other. A higher value of IdC with an increase in self-selected speed was considered to be an optimal adaptation to environmental constraints since it indicates that the continuity of propulsion is maintained (1). However, a large inter-individual effect was noted in the IdC values within the same expertise level. In another study, Ria et al. (2) showed that lower velocity fluctuation (VVI) was linked to better performance in swimming. This study examines how the combination of IdC and VVI could help to determine the optimal adaptation in competitive swimming.

METHODS

Two highly-trained female swimmers were compared: “international” (95.3% of world record on 100-m, WR) vs. “national” (87.9% of WR), according to the protocol from Chollet (1). IdC was determined from 4 mini-dv cameras, and the underwater lateral view was synchronized with the intracyclic velocity signal (speedometer Fahnemann, Inc). The IdC and VVI of these subjects were compared with parametric statistics (ANOVA).

RESULTS

The “international” swimmer had lower VVI (p<0.05) (except on V3000) and higher IdC (p<0.05) than the “national” swimmer at all self-selected speeds.

DISCUSSION

The results tend to confirm that the best swimmers are characterized by greater continuity in propulsive actions and thus higher IdC, which lowers VVI. The analysis of both IdC and VVI values at self-selected speeds can be used to evaluate how adequate a swimmer’s adaptation is and thus may serve as a basis for optimizing performance at an individual level.

REFERENCES

lessons of 40 minutes each with the same analytical didactic progression with or without instructional flotation devices. At the end of each lesson, all subjects were tested by an 18 meters of length stroke, filmed and timed. Both a qualitative (by MERS-F scale) and a quantitative (arm-stroke cycles, breathings, stroke rate, stroke length, efficiency index) analysis have been carried out by the Student’s t test (p<0.05).

RESULTS
In the qualitative stroke analysis, the group using buoyancy achieved better results only in the arm-stroke evaluation at the end of the second (p<0.05) and the third (p<0.01) lesson. The quantitative stroke analysis pointed out a significant difference in the arm-stroke average number per breathing (p<0.05), lower in the group non-using flotation devices.

DISCUSSION
From the analysis of the results, it appears that after a 10 lesson program the learning of front crawl in beginners isn’t significantly affected by use or non-use of instructional flotation devices. The significant difference in arm-stroke average number per breathing (no guidelines were given about arm-stroke and breathing action to follow in the tests) could depend on fact that subjects taught by kickboard used a short arm-stroke, whereas subjects taught without flotation devices kept a slow and stretch arm-stroke.

REFERENCES

LONGITUDINAL EVALUATION OF BREASTSTROKE SPATIAL-TEMPORAL AND COORDINATIVE PARAMETERS: PREPARING OF THE 100-M BREASTSTROKE BRONZE MEDALLIST OF THE ATHENA 2004 OLYMPIC GAMES.

Seifert L, Chollet D, Papparodopoulos C, Guerniou Y, Binet G
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INTRODUCTION
Arm to leg coordination has recently well analysed to point out his impact on velocity, as regards skill level, gender and race paces (1, 2, 3). In this way, our study shows how a model of arm to leg coordination was used to prepare an elite swimmer for the Athena 2004 Olympic Games in the 100-m breast-stroke. His coordination was periodically evaluated as regards velocity (V), stroke rate (SR) and stroke length (SL) and the detailed information provided by this model served to guide the subsequent training decisions.

METHODS
Seven evaluations (E1 to E7) were made over a two-year period and assumed a parallel with the competitive performances during this period. At each evaluation, the swimmer performed 25-m at his 100-m race pace where V, SR, SL and the coordination (temporal gaps between the stroke phases of the arm and leg: T1 assessed glide, T2, T3 and T4 assessed the superposition of arm to leg recoveries) were calculated over three stroke cycles identified from underwater cameras with lateral and frontal views (50Hz). The differences between the evaluations were assessed by one-way ANOVAs and a post hoc Tukey test with p set at 0.05.

RESULTS
V decreased at E3 and E4 because of a shorter SL and an increase in SR. The glide (T1) was decreased at E2, E3 and E4 in comparison with E1, E5, E6, E7, while T2 and T3 showed a negative increase (at E3, E4 and E5 in comparison with E1, E2, E6, E7).

DISCUSSION
The evaluations at E1 and E2 were made during the period in which the swimmer was setting his personal world record. Then at E3 and E4, his coordination showed a degradation, with contradictory superposed movements (T2: leg recovery before the end of arm propulsion; T3: beginning of leg propulsion before the end of arm recovery), that resulted in a reduced glide (T1) and increased SR. Finally, following the change of spatial-temporal and coordinative parameters enabled to detect any degradation in technique.

REFERENCES

COMPARISON OF SUBJECTIVE AND OBJECTIVE METHODS OF DETERMINATION OF STROKE PHASES TO ANALYSE ARM COORDINATION IN FRONT-CRAWL.

Seifert L1, Schnitzius C1, Aujouannet Y1, Carter M1, Rouard A1 Chollet, D1
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2.L.M.A.S., Faculty of Sports Sciences, University of Savoie, France.

INTRODUCTION
Arm coordination in front crawl was most of time quantified by an index of coordination (IdC), based on the time lag between the end of the push phase of the first arm and the beginning of the pull phase of the second arm (1). The stroke phases in the sagittal plane were subjectively defined from hand
The velocity at blood lactate accumulation of 4 mmol/L

INTRODUCTION

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Shimoyama Y

COMPETITIVE SWIMMERS.

THE FACTORS AFFECTING VELOCITY AT OBLA IN WELL-TRAINED

Sport Med, 21(7): 54-59

coordination for the crawl: description and usefulness. Int J

REFERENCES


and thus allowed to minimise the time process.

nation did not automatically required the digitising method

from the digitsing process. Consequently, the phases determi-

uate the stroke phases in regard to the similar results obtained

hand positons from the expert was sufficiently accurate to eval-

use this method. Conversely, the visual determination of the

experience and underlined the necessary training process to

non-reliability of the subjective method for operators without

instead of downward and backward. These results showed the

Smaller standard deviations of IdC for the novice operators related to

The overestimation of the pull phase duration and the large

results obtained from the expert operators and the digitising

The IdC values assessed by the novice operators were higher

than those of the expert operators, due to an overestimation of

stroke phases and of IdC were observed between the

operators compared to novice operators. No significant differ-

ences of stroke phases and of IdC were observed between the

results obtained from the expert operators and the digitising

RESULTS

The IdC values assessed by the novice operators were higher

than those of the expert operators, due to an overestimation of

the pull phase duration and to a smaller catch phase duration.

Small standard deviations of IdC were observed for expert

operators compared to novice operators. No significant differ-

ences of stroke phases and of IdC were observed between the

results obtained from the expert operators and the digitising

process.

DICUSSION

The overestimation of the pull phase duration and the large

standard deviations of IdC for the novice operators related to

their confusion to determine the beginning of this phase. For

them, the phase started when the hand went downward

instead of downward and backward. These results showed the

non-reliability of the subjective method for operators without

experience and underlined the necessary training process to

use this method. Conversely, the visual determination of the

hand positons from the expert was sufficiently accurate to eval-

uate the stroke phases in regard to the similar results obtained

from the digitsing process. Consequently, the phases determi-

nation did not automatically required the digitising method

and thus allowed to minimise the time process.

REFERENCES


coordination for the crawl: description and usefulness. Int J

Sport Med, 21(7): 54-59

THE FACTORS AFFECTING VELOCITY AT OBLA IN WELL-TRAINED

COMPETITIVE SWIMMERS.

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2University of Tsukuba, Ibaraki, Japan

INTRODUCTION

The velocity at blood lactate accumulation of 4 mmol/L

(V@OBLA) measured by the lactate curve test have been wide-

ly conducted for evaluating the effects of endurance training.

V@OBLA might increase when stroke would become more

efficient as well as when aerobic capacity would improve by

endurance training. The purpose of present study was to inves-

tigate the factors affecting the change in V@OBLA by

endurance training in well-trained competitive swimmers.

METHODS

Twelve well-trained male college swimmers participated in this

study. The tests were conducted at three times (pre-, mid- and

post-test). The subjects carried out the endurance training for

6 week among those tests. The tests consisted of a continuous

progressive swimming (CON) for measuring VO2max and an

intermittent progressive swimming (INT) for V@OBLA using

the swimming flume. INT were nine stage swims which con-

sisted of 3 minutes swimming and 5 minutes rest. The veloci-

ties of the nine swims were identical among pre-, mid- and

post-test. Stroke length (SL) and stroke rate (SR) at each veloc-

ity during INT were measured from video image. From these

results, SL@OBLA and SR@OBLA were calculated.

RESULTS

VO2max at mid- and post-test were significantly higher (p <

0.05) than that at pre-test, but there was no significant differ-

cence between mid- and post-test. V@OBLA at mid- and post-

test were significantly higher (p < 0.05) than that at pre-test,

but there was no significant difference between mid- and post-

test. SR@OBLA was significantly higher (p < 0.05) at mid-test

than that at pre-test. There were no differences in SR@OBLA

between pre- and post-test, and between mid- and post-test.

There were no significant differences in SL@OBLA between

the three tests.

DISCUSSION

The result of VO2max suggested that aerobic capacity improved

by endurance training from pre- to mid-test. However, from the

results of SL@OBLA, it was likely that stroke efficiency would

not improve by endurance training. Therefore the improvement

of V@OBLA in the present study seemed to be almost caused by

aerobic capacity indicated on VO2max.

ASSISTED VELOCITY SWIMMING TRAINING IN TWO AND SIX BEATS

AGE GROUP FRONT CRAWL SWIMMERS.

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Porto Alegre, Brasil

INTRODUCTION

Swimming velocity (SV) is the product of stroke length (SL)

and stroke rate (SR) (2). Assisted velocity training (AVT) can

increase SR and, as a consequence, enhancing SV (1). The aim

of this study was to verify and to compare the effects of an

AVT program on SR and time to perform 25 m in front crawl

stroke in two and six beats age group front crawl swimmers.

METHODS

Ten swimmers (both sex; age = 13 to 15 years old; height =
RESULTS

Table 1 summarizes SR and time to perform 25 m (T25) results, before and after the AVT program.

Table 1: Mean ± sd of SR and T25, before and after the AVT program, * indicates difference (p < 0.05).

<table>
<thead>
<tr>
<th>Groups</th>
<th>n SR (Hz) before</th>
<th>SR (Hz) after</th>
<th>T25 (s) before</th>
<th>T25 (s) after</th>
</tr>
</thead>
<tbody>
<tr>
<td>TB</td>
<td>5 1.00 ± 0.11*</td>
<td>1.07 ± 0.10*</td>
<td>14.1 ± 1.5</td>
<td>14.0 ± 1.4</td>
</tr>
<tr>
<td>SB</td>
<td>5 0.92 ± 0.07</td>
<td>0.97 ± 0.06</td>
<td>14.1 ± 0.8</td>
<td>14.07 ± 0.3</td>
</tr>
</tbody>
</table>

DISCUSSION

The only significant difference found was in SR for the TB group, which has enhanced after the AVT program. However, this increased in SR values has not affected the time to perform the 25 m. Perhaps this result is related to a concomitant decreasing in SL (1), variable that has not been assessed in this study. Thus, AVT, in age group, should be performed under a rigid technique and stroke length control.

REFERENCES


ENERGY EXPENDITURE AND FOOD INTAKE OF COMPETITIVE SWIMMERS DURING TRAINING.

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Faculty of Physical Education and Sport Sciences, Aquatics Department, University of Athens, Greece.

INTRODUCTION

Poor daily dietary habits can influence the performance of swimmers during training. Repetitive sessions of high intensity training can deplete glycogen stores and important vitamins, minerals and other nutrients. The great emphasis placed on nutritional supplements underestimates the importance of nutrition. The purpose of this study was to evaluate whether dietary intakes of elite swimmers can match the energy and nutrient requirements of training.

METHODS

Sixteen, elite teenage swimmers participated in this study. Food intake and energy expenditure were calculated through the completion of three-day weighed dietary records and activity records. Food intake was analyzed by computer analysis (Food Processor II, ESHA Research) for its caloric content, carbohydrate, fat, protein, dietary fiber, and saturated fat. Energy expenditure estimations were based on the Food and Agricultural Organization equations and exercise metabolic rate was calculated through the reported training records (on types, duration and intensity of training). Data were statistically analyzed by a Pearson’s r correlation coefficient test.

RESULTS

Swimmers mean age was 18±1.4 years. Their three day training distance averaged 7568 meters per day. The mean dietary intake was significantly lower than the energy cost of swimming and protein intake was almost double the energy cost of swimming. Carbohydrate content and fat didn’t demonstrate any significant differences (table 1).

Table 1: Dietary Intake and Energy Cost during a 3-day training period.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Calories(Kcal)</th>
<th>Protein (g)</th>
<th>Carbohydrate (g)</th>
<th>Fat (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dietary Intake</td>
<td>2182.23±964.14</td>
<td>103.28±41.59</td>
<td>262.38±125.08</td>
<td>88.65±49.67</td>
</tr>
<tr>
<td>Energy Cost</td>
<td>3146.38±494.10</td>
<td>52.96±11.18</td>
<td>456.19±71.57</td>
<td>104.89±16.25</td>
</tr>
</tbody>
</table>

*pDenotes that means are significantly different (p<0.05) from the Energy Cost values.

DISCUSSION

If energy intake is high and a varied diet is consumed, supplementation of the diet with vitamins and minerals is not necessary, unless a specific deficiency is identified (1). Caloric deficiency which was noted in this study can eventually lead to carbohydrate deficiency, whereas the excess of protein intake may unnecessarily tax the system. Swimmers, are usually not well informed on balanced nutritional practices that would give them an edge during training and eventually during competition. Swimmers, need to be educated on nutritional practices and the importance of meeting the energy demands (calories) of swimming. Even if nutrient requirements are met the amount of food daily consumed may be more important on its effect on performance in terms of energy supply.

REFERENCES

INTRODUCTION
The purpose of this study was to evaluate the impact of two different velocities on arm pull and recovery characteristics as well as to evaluate the force exerted by the arms. So far, the stroke characteristics that have been extensively studied are the stroke rate and the stroke length with no major emphasis on pull and recovery times. And despite the fact that force exerted is directly related to speed there is limited research.

METHODS
Twelve, non-competitive swimmers participated in this study. Arm pull characteristics and forces were measured by a hydrodynamic measuring device incorporated in a portable laptop (Aquanex by swimming technology research, Inc., Florida, Tallahassee). Prior to entering the water, cables with sensors were secured with elastic bands from the back of the swimmers’ waist to their fingers. The swimmers performed two consecutive 25 meter trials a slow (SS) and a fast (FS) at their fastest perceived velocity with a 2 minute rest in between the trials.

RESULTS
As expected the average force (N) and the swimming velocity (yds/sec) were greater in the FS. The stroke rate (strokes per second) was greater in the FS, while the stoke length (yards per stroke) was smaller. The average pull time and the recovery times of the FS were shorter than the SS. However, the decrease in pull time of the FS was of a magnitude of 15.4% while the decrease of the recovery phase was much greater (45.7%) than when compared to the SS while the decrease of the recovery time was a magnitude of 45.7% when compared to the SS freestyle.

Table 1. Arm Pull and Recovery times and Average force at two velocities.

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>SLOW SWIM</th>
<th>FAST SWIM</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swimming Velocity (yds/sec)</td>
<td>0.48±0.05</td>
<td>0.60±0.07</td>
<td>P&lt;0.0001</td>
</tr>
<tr>
<td>Average Pull Time (sec)</td>
<td>0.91±0.17</td>
<td>0.77±0.12</td>
<td>P&lt;0.05</td>
</tr>
<tr>
<td>Free Recovery Time (sec)</td>
<td>1.03±0.28</td>
<td>0.56±0.13</td>
<td>P&lt;0.0001</td>
</tr>
<tr>
<td>Average Pull Force (N)</td>
<td>18.05±8.1</td>
<td>28.96±13.3</td>
<td>P&lt;0.01</td>
</tr>
</tbody>
</table>

DISCUSSION
Great emphasis has been placed on the effects of stroke rate and stroke length on velocity and generally stroke rate increases while stroke length decreases with increasing velocity (1). However, no attention has been drawn to the contribution of speed of pulling and recovery on velocity. The important finding of this study was that in the freestyle swim the increment of speed of the recovery phase was much greater (45.7%) than the increment of speed of the pulling phase (15.4%) during the fast swim in freestyle. It appears that the non-propulsive phase is a key factor for better performance as evidenced in other strokes as well (2).

REFERENCES
ent swimming FCS seems to allow a more effective discrimination of the swimmer’s specific ability, what demonstrates the relevance of using more accurate tests for assessing the athlete’s motor capacity for its classification into competitive categories.

**STROKE LENGTH, FREQUENCY AND VELOCITY AMONG UNIVERSITY PHYSICAL EDUCATION STUDENTS AND ITS USE AS A PEDAGOGICAL TOOL.**

Stallman R, Kjendlie P-L

*The Norwegian School of Sport Science, Oslo, Norway.*

**INTRODUCTION**

Much is known about the relationship between stroke length, stroke frequency and velocity among competitive swimmers \(^1\), Little, however, is known about this phenomenon among non-competitive young adults. What can and should we expect from non-competitive swimmers? Can the concept of stroke length be used as a pedagogical tool in a teaching situation?

**METHODS**

Two hundred and forty (240) university physical education students, 120 males and 120 females, swam a 50m crawl maximal time trial, with the start in the water. The time and the number of strokes were recorded for each 25m. Stroke length and frequency were calculated. This was done at the start and end of a period of 36 lessons (18wks). The concept of stroke length was then introduced. The elementary back stroke was introduced initially, to demonstrate the concept. As skill improved, other strokes were introduced, with constant reference to stroke length. At concrete efforts were made, for example, to increase purchase on the water by improving the high elbow position, or to reduce resistance by improving the streamlining of the body, the subjects were encouraged to regularly monitor progress by counting strokes and to relate this to their tactile experience. Practicing in pairs was commonly used also to allow visual feedback in relation to the partner’s technique.

**RESULTS**

The mean stroke length (crawl) for men at T1 was 2.2 m. For women, it was 1.8. Stroke frequency for men was 38.3 and for women 35.5 strokes·min\(^{-1}\). Mean velocities were 1.3 and 1.1 m·s\(^{-1}\) for men and women respectively. Stroke length, given the women 35.5 strokes·min\(^{-1}\). Mean velocities were 1.3 and 1.1 m·s\(^{-1}\) for men and women respectively. Stroke frequency for men was 38.3 and for women, it was 1.8. Stroke frequency for men was 38.3 and for women, it was 1.8. Stroke frequency for men was 38.3 and for women, it was 1.8. Stroke frequency for men was 38.3 and for women, it was 1.8.

**DISCUSSION**

Coaches are generally well versed in the importance of stroke length and its consequences. They routinely control this parameter and intuitively see changes which might indicate improvement or even temporary negative influences (over training, sickness, etc). The instructor has a larger number of students and meets them less often. The kind of close monitoring, which can provide individual feedback. Further, a start has been made at establishing norms for these parameters among non-competitive swimmers.

**REFERENCES**


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**A RELIABILITY STUDY OF A LACTATE Profile TEST FOR RUNNING IN THE WATER WITH “WET VEST”**

Stallman R, Naess G, Kjendlie P-L

*The Norwegian School of Sport Sciences, Oslo, Norway.*

**INTRODUCTION**

A blood lactate (La) profile test for step wise work loads can be used to assess changes in physical capacity and to a certain extent, monitor training \(^1\). This can be applied to any activity. The purpose of this study was to test the reliability of a given protocol for the La profile, while running in the water with the “Wet Vest”, by test retest design.

**METHODS**

The test protocol was performed on two occasions with at least one day in between. Fifteen subjects, mean age, 24yrs. participated. The test protocol was an adaptation of the standard test used in our laboratory for treadmill running and consisted of 6-7 step wise progressive work loads guided by HR. The heart rate values used were 120, 130, 140, 150, 160 and if necessary, 170 and 180 bpm. Each effort was 5min with a 1 min pause between efforts. HR was continuously monitored by a test assistant on the pool side using a HR monitor (Polar). The “run” was performed on a 15m course at the deep end of a 25m pool. The assistant provided continuous feedback to help the subject maintain the specified work load. Blood samples were drawn during each pause for La analysis. Mean HR was recorded and compared to the stipulated HR for each effort. Test & retest were compared using Pearson PM correlation and Students t-test for paired differences was applied.

**RESULTS**

Mean deviation of HR and the corresponding SD for each workload was within 2bpm±5 of the stipulated HR for all considered subjects. The Mean SD for HR values within each 5 min effort was 1.6 bpm. The curves generated by the recorded La values for test and retest were compared. The HR differences at 2, 3 and 4 mmol L\(_a\) between tests over all subjects and all La levels were 3.88, 3.86 and 3.54 bpm respectively. The mean coefficient of variation was 1.456.

**DISCUSSION**

The ability to meet the designated work load while running in the water was demonstrated by the low variation in HR over all subjects at all loads. The ability to hold a given level of intensity (by HR) within each 5min effort was demonstrated by the
low variation over all subjects and all work loads.

CONCLUSIONS
The La profile test protocol examined was found to be reliable for running in the water and can be recommended for use in assessing physical capacity and for monitoring training.

REFERENCES

The values obtained for peak VO2 and HR, corroborate previous findings; values for running in the water tend to be appr. 10-20% lower than that obtained on land. Peak La values on the other hand were higher than on land, as also seen in previous findings [1]. The test-retest comparison showed exceptionally high reliability. The test protocol examined can be recommended as reliable and can be used in attempts to measure Peak VO2 while running in the water with the wet vest.

REFERENCES
forces are produced. The highest correlation between P2H and P4H showed on smaller pelvis/leg action involvement in water throws. The player that threw the ball with the highest velocity was able to increase ball velocities from P1 to P4 most proportionately with both the normal and heavy ball. On individual basis, players playing in different positions (driver, center forward, goal-keeper) had different velocity increase due to changed kinetic chain. Accordingly, individual differences were observed in normal/heavy ball index as well which may point to conditional or technical specificities. It is concluded that main characteristics of the water throw was related to reduced pelvis/leg fixation and high adaptation to specific water conditions.

REFERENCES

The results show that: 1) there is statistically significant differences in all three anxiety factors (cognitive, somatic, self confidence) concerning experience and game. This proves that for swimmers (individual game) and water polo players (team game), self confidence increases with more contest experience that is to say with more years in contest participation.

REFERENCES

DISCUSSION
The results demonstrate that there is statistical significant difference in all three anxiety factors (cognitive, somatic, self confidence) concerning experience and game. This proves that for swimmers (individual game) and water polo players (team game), self confidence increases with more contest experience that is to say with more years in contest participation.
BMI. The $V_{crit100}$ is explained at the level of 57.79% ($\text{AdjR}^2 = 0.5679$), and it was defined in a significant way statistically ($F = 5.10$, $p = 0.024$) by the following predictors, i.e. index of the body shape, the shape of trunk, LBM and the percentage of fat. For women, the $V_{crit50}$ is explained at the level of 57.09% ($\text{AdjR}^2 = 0.5709$), and it was defined in a significant way statistically ($F = 8.31$, $p = 0.009$) by the following predictors: arm-length index and LBM. The $V_{crit100}$ is explained at the level of 47.29% ($\text{AdjR}^2 = 0.4729$), and was defined in a significant way statistically ($F = 5.93$, $p = 0.023$) by the same predictors, that is arm-length index and LBM.

DISCUSSION
The results have shown the existence of important differences between indices of $V_{crit50}$ and $V_{crit100}$ and AnthMorph characteristics between genders. As regards men, at the critical speed faster were those who have a rectangular shape of trunk and higher LBM. With regard to women, at the critical speed faster were those who have a longer arm length in relation to body height and higher LBM. The results lead to the conclusion that the above mentioned AnthMorph characteristics can be used as the one of selection criteria for the sprint swimmers.

REFERENCES

THE DIURNAL EFFECTS OF A TETHERED SWIMMING POWER TEST.
Thorsvald K, Kjendlie P-L
Norwegian School of Sport Sciences, Oslo, Norway.

INTRODUCTION
Research has shown that diurnal differences in maximal swimming performance exists (100m time trial)[1]. None have to our knowledge yet tested the diurnal effect for shorter trials. The aim of this study was to investigate the diurnal effect of a tethered swimming power test.

METHOD
15 national level competitive swimmers (13- 25 years old) were tested both in the morning and in the afternoon on the same day. The test protocol consisted of 3 tethered trials where the maximal force was registered and the highest measurement was used as the test score. Force was measured using a load cell with peak-hold display (AEP Italy). The swimmers were connected to the load cell using a rubber tube to smoothen the force during the stroke – resulting in a possibility to measure the peak force during a stroke. Maximum work time was approximately 10 seconds. The spring stiffness of the system was 20 N/m. All the morning tests took place between 6:00am-9:00am, and the afternoon tests took place between 4:00mp-7:00pm the same day. Standardized warm up procedures were conducted and subjects were accustomed to the testing procedure.

RESULTS
The mean (SD) morning and afternoon tethered swimming force was 151.5 (29.1) and 152.8 (28.5) respectively. No statistical difference was found between the two test situations ($p=0.30$, paired t-test). The correlation coefficient between morning and afternoon testing was $r=0.99$. Average absolute coefficient of variation was 2.7% (1.7%).

Fig. 1: Tethered swimming force of morning (y-axis) and afternoon (x-axis).

DISCUSSION
The results indicate that for a maximal tethered swimming force test the time of day for testing may be of less importance. The variation was almost identical to test-retest on the same time of day. This is under the assumption that 3 trials are used in the testing protocol, the subjects are accustomed to the testing procedures by prior familiarization and that no exhaustive training was done prior to testing. However some variations may occur for different individuals and the largest difference between morning and afternoon test for the included subjects was 5.7%.

CONCLUSION
Tethered swimming force testing may be done without diurnal effects affecting performance, assuming that proper warm up is conducted, and 3 trials is used for protocol.

REFERENCES

DIFFERENT LEVELS OF HYDRATION FOLLOWING A TRAINING SESSION ON SWIMMING PERFORMANCE.
Toubekis A, Christoforou N, Laparidis K, Tahtalis T, Tokmakidis S
Department of Physical Education and Sport Sciences, Democritus University of Thrace, Komotini, Greece.

INTRODUCTION
During swimming training sessions an amount of fluids could be lost (1). This may affect swimming performance as has been observed in cycling (2) and proper hydration is advisable. The purpose of the study is to examine the effect of two different levels of hydration after a training session on performance eight hours later in a following afternoon session.
METHODS
Eight swimmers (mean±SD, age:21.4±1.2 years, height:179±6 cm, body weight:74.8±4.3 kg, VO2max:3.9 l/min) performed a morning swimming training session of 4800m (intensity range: 95-105% of critical velocity). Eight hours later, an afternoon testing session consisting of 4x200m at intensity 95% of the critical velocity (4x200submax) and 200m maximum effort (200max) was performed. In two separate trials a week apart, swimmers consumed a fluid volume (isostar® 6%) of either 150% (F150) or 50% (F50) of the morning post-training body weight loss. Blood lactate was determined at the end of each training set and blood glucose was measured before and after each training session. Heart rate was recorded continuously during both sessions. Diet was recorded two days before the testing days and prescribed with equal carbohydrate content (solid and fluid) during the eight hours of recovery.

RESULTS
Blood lactate and glucose as well as heart rate were similar during the morning session in both trials (p>0.05). Body weight was reduced by 0.9±0.2% and 0.8±0.3% after the morning session in F150 and F50 trials respectively (between trials, p>0.05). At the beginning of the afternoon session, body weight had recovered in the F150 but remained low in the F50 trial (p<0.05). Heart rate showed a tendency to increase at the end of the 4x200submax (p=0.08) and was higher in the afternoon testing compared to the morning session in the F50 trial (p<0.05). Performance of the 200max was not different between trials (p>0.05).

DISCUSSION
The volume of fluid consumed after a swimming training session should exceed 150% of the total body weight loss. Dehydration of about 1% may not be severe enough to impair performance during a maximum 200m swimming effort. This level of dehydration may, however, alter cardiac responses during a prolonged submaximal swimming.

REFERENCES

MENTAL REPRESENTATION OF SWIMMING STROKES.

Ungerechts B, Schack T
University of Bielefeld, Bielefeld, Germany.

INTRODUCTION
Biomechanics in aquatic space is an important tool to better understand how corporal actions determines locomotion of the body based on flow physics. An understanding how actions are represented mentally might also be of value, e.g. when communicating about swimming strokes (the interaction between limbs and surrounding water). The purpose of this paper is a first attempt to apply a new experimental method: Structural Dimensional Analysis-Motoric (SDA-M) (1) to self-propulsion in water.

METHODS
SDA-M contains four steps: basically people are asked to judge the functional relation between adjacent BACs (Basic Action Concepts) according to their present knowledge. BACs can be viewed as the mental counterparts of functionally relevant elementary components of complex movements, recognisable perceptual features. They can be described verbally as well as pictorially. Finally, the hierarchical structure is measured according to cluster-analysis approach presenting the results in a dendogram.

RESULTS
The following figures represents the hierarchic cluster analysis for two swimmers.

DISCUSSION
The individual mental representation of swimming action can be shown experimentally by uncovering the distances between selected basic action concepts which are closely related to functional items as shown by Ungerechts (2). The knowledge of this very individual aspect of locomotion will assist to communicate much more effectively aspects of stroking beyond to create flow, transfer momentum and raise efficiency.

REFERENCES

IS THERE A DIFFERENCE? – THE GENDER ISSUE IN PSYCHO-SOCIAL CHARACTERISTICS OF SWIMMING CHAMPIONS.

Vikander N1, Stallman R2

1North Trøndelag University College, Levanger, Norway

2Schorndorf/GER: Hofmann.
Gender distinctions in the preparation of athletes have received increasing attention and commensurate with the recognition of gender issues generally in post-modern society. The present study investigates this dimension in the psycho-social arena at the high performance level in swimming.

METHODS

The investigation analyzed the responses to the Rushall Psychological Inventories for Competitive Swimmers (PICS) of 18 Norwegian elite swimmers (9 women and 9 men) who had won individual titles at Senior National Championships and had represented Norway in international competition. The Rushall methodology from the development of the Champion Characteristics Checklist (based on elite athlete responses to a series of specific sport inventories) was utilized whereby items answered in a like manner by 75% or more of the champion swimmer sample were judged as indicative of commonality. These resulting items were then assessed for clustering tendencies.

RESULTS

Of the 242 PICS items in the four inventories, those meeting the inclusion criterion were distributed in 7 theme clusters: General Features, Relationship with Coach, Relationship with Swimmers, Training, Pre-Competition, Competition, and Motivational Features. Items were listed as specific to women, specific to men, and common to both.

DISCUSSION

Coaching and swimmer developmental implications are discussed in terms of the gender differences and commonalities. The primary function of this map of variegated characteristics is to enhance the appreciation of the nuances in the psycho-social dimension of the aquatic arena, as based on the modeling characteristics of champions. As a research tool for swimmer and coach development, it lends itself well to longitudinal application.

REFERENCES


DETERMINATION AND APPLICATION OF INTERVAL SWIM CRITICAL VELOCITY AND CRITICAL REST TIME IN THE 50M INTERVAL SWIM TRAINING.

Wakayoshi K1, Takano C1, Ogita F2

INTRODUCTION

Critical velocity (Vcri) determined by the relationship between the swimming distance and the swimming time, has been defined as the maximal speed which could theoretically be maintained without exhaustion during swimming. Moreover, the interval swim critical velocity (Vcri-IS) defined as the maximal average speed to be able to swim repeatedly without exhaustion in the 50m interval swim training at one swimming velocity higher than anaerobic threshold could be determined and the critical rest time (tcri), which could theoretically be repeated the interval swims without exhaustion could be estimated by using Vcri-IS (Wakayoshi & Ogita, 2003). Therefore, the purpose of this study was to determine Vcri-IS and tcri for interval swim training at four velocities higher than anaerobic threshold and to apply those data to an index for setting the combination of velocity and rest time for the interval training.

METHODS

The subjects were 11 well-trained college male swimmers. Experiments were carried out in the 50m pool. The maximal swim test (Tmax) and 50m interval swim test (Tint) were performed. In Tmax, the subjects swim 50m and 2000m at maximal effort, and the mean velocity of each swim was determined (V50, V2000). The velocity in Tint were set at four paces of V30%, V40%, V50% and V60% for each subject, which were calculated by the following equation, Vcri-IS as an example, Vcri-IS = 0.3(V50-V2000) + V2000. If the subject could not complete interval swim 30 times in each Tint, the rest time was increased by 2-10 s in the next trial, until the subjects could complete Tint. Finally, the subjects performed four to six sets of Tint at each velocity. The total time (tT) of Tint including interval swims and rest periods and the total swim distance (Dint) of Tint were determined. Ccri-IS at each velocity (Vcri-IS, Vcri, V50%, V40%, and V30%) could be determined by the relationship between Dint and tT. Vcri-IS multiplied by the cycle time that added swimming time (ts) to tcri makes the interval swim fatigue threshold (ISFT) could be defined from the results of Vcri-IS and tcri, and ISFT could be applied as a helpful index to prescribe the interval training program.

RESULTS

The relations between Dint and tT were expressed in the general form, Dint=a+b*tT in all subjects. Vcri-IS and tcri at V50%, V40%, V30% and V20% were determined. Ccri-IS at each velocity (Vcri-IS, Vcri, V50%, V40%, and V30%) could be determined by the relationship between Dint and tT. Vcri-IS multiplied by the cycle time that added swimming time (ts) to tcri makes the interval swim fatigue threshold (ISFT) could be defined from the results of Vcri-IS and tcri, and ISFT could be applied as a helpful index to prescribe the interval training program.

DISCUSSION

It was thought that the combinations of velocity and rest period which imply interval swim fatigue threshold (ISFT) could be defined from the results of Vcri-IS and tcri, and ISFT could be applied as a helpful index to prescribe the interval training program.

REFERENCES

SWIMMERS POSTURE: SCREENING NORTHEAST BRAZILIANS.

Wanderley F

Laboratory of Physical Fitness, Health and Performance of Physical Education Department, Alagoas’ Federal University, Brazil.

INTRODUCTION

It is estimated that 70% to 80% of individuals had suffered of low back pain in their lives. At EUA, low back pain is the first functional limitation cause. One of the most frequent recommendations to treat this problem, and to increment posture, is to swim. Although, many studies (1, 2, 3) have demonstrated that cyclic and repetitive activities, such as competitive swimming, may induce posture changes in the most solicited joints.

METHODS

The aim of this study was to identify the most frequent postural changes in competitive swimmers, analyzing the scapular waist, the spine, the knees, and the hips. Thirty two male swimmers from Northeast of Brazil, who participated in a Northeast Swimming Cup in December 2004, had their posture assessed. The participants were included in the age categories infantile, juvenile and senior (M = 17.9 years; mv = 13 years; Mv= 32 years). With the purpose of characterize swimmers, some anthropometric data was collected: weight (M = 65.2 kg; mv = 39.0kg; Mv= 85.0kg), height (M = 1.74m; mv= 1.48m; Mv= 1.87m) and body fat (M = 14.3%; mv= 10.4%; Mv= 24.3%). The posture was measured through an adaptation of the Portland State University Posture Analysis Form. The swimmers were photographed in orthostatic position in anterior, posterior and sagital plan and anterior back inclination. Their pictures were compared with the Portland State University Posture Analysis Form. Descriptive statistics was used for data analysis.

RESULTS & DISCUSSION

The results revealed that the most frequent postural changes were: (i) scapular waist- un leveled shoulders (90.6%) and protruse shoulders (31.2%); (ii) spine - scoliosis (59.3%), hyperkibhosis (75.0%) and hiperlordosis (37.5%); (iii) knees - genovaro (37.5%), genovalgum (21.9%) and genorecurvatum (15.6%) and (iii) hips - un leveled hips (31.2%) these findings are in agreement with other studies (1).

It were formulated three recommendations: (i) it should be diversified the train methodologies.

REFERENCES


ABILITY OF COMPETITIVE SWIMMERS TO MODIFY START DEPTH IS NOT DEPENDENT UPON EXPERIENCE.

White J, Stager J, Parry T, Willmott A, Cornett A

Counsilman Center for the Science of Swimming, Indiana University, Bloomington IN, USA.

INTRODUCTION

There is a distinct paucity of research relating to safety concerns in competitive swimming starts. Blitvich, McElroy, Blanksby, Clothier, and Pearson [1] found that competitive swimmers complete significantly shallower starts in a 1.2m depth pool than a 2m depth pool. The purpose of this study was to expand upon this and compare the ability of inexperienced and experienced competitive swimmers to modify on request the maximum head depth achieved during a competitive swimming start.

METHODS

Twelve experienced (age = 20.2 ± 1.2 years, height = 1.79 ± 0.08 m, mass = 76.3 ± 10.3 kg) and 13 inexperienced (age = 14.8 ± 1.1, height = 1.68 ±0.06 m, mass = 57.1 ± 6.2 kg) swimmers were filmed underwater during completion of two competitive starts from a 0.75 m block with a 10 degree angle into 3.66 m of water. Experienced swimmers were collegiate swimmers. Inexperienced swimmers were high school swimmers in the first month of their first season of competitive swimming. Swimmers completed one start and subsequent freestyle sprint without instruction. Prior to the second start the swimmers were asked to make the start as shallow as possible while still completing the sprint. For each start, the maximum depth of the center of the head was determined using 2D DLT analysis.

RESULTS

A two-way mixed design ANOVA for maximum depth of the center of the head yielded no interaction between instruction and experience, but significant main effects for both instruction (F2,212 = 28.0; p<0.001) and experience (F2,212 = 29.7; p<0.01). The experienced swimmers attained a significantly deeper maximum head depth than the inexperienced swimmers (0.91 ± 0.05 m vs. 0.55 ± 0.05m respectively). As there was no significant interaction between experience and instruction, the experienced and inexperienced groups were combined in an analysis of the ability to modify depth. When instructed to dive shallower, the maximum head depth decreased significantly (p<0.01) from 0.83 ± 0.04 m to 0.64 ± 0.03 m. Similar results were seen for the absolute velocity of the head at maximum depth, with experienced athletes moving significantly
faster than inexperienced (3.06 ± 0.10 m/s vs. 1.98 ± 0.10 m/s) and the shallower start having a significantly faster head velocity at maximum depth than the deeper start (2.69 ± 0.08 m/s vs. 2.36 ± 0.09 m/s).

DISCUSSION
The ability of inexperienced swimmers to modify start depth implies that in a post-pubescent population spinal cord injuries during competitive swimming starts are not necessarily due to an inability to control the depth of the start. Future study will focus on the ability of a pre-pubescent population to control competitive swimming start depth.

REFERENCES