Growth influences biomechanical profile of young talented swimmers after the summer break.

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DISSESTACAO DE MESTRADO EM CIÊNCIAS DO DESPORTO

ESPECIALIZAÇÃO EM AVALIAÇÃO E PRESCRIÇÃO NA ACTIVIDADE FÍSICA

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UNIVERSIDADE DE TRÁS-OS-MONTES E ALTO DOURO
VILA REAL 2013
Growth influences biomechanical profile of swimmers
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Acknowledgments

Nowadays the preparation of a master thesis is an important milestone for anyone who wants to achieve the success in both academic and professional point of views. As such, filed professionals should consequently embrace scientific information in order to improve their daily intervention. This work was initiated with that aim in mind, and was only possible to be concluded with an important help of several people that I need to highlight individually:

To my supervisor Mário Jorge Costa PhD, for all the support, encouragement and friendship during my academic accomplishments, for his determination while helping me concluding this thesis. Without him this work would have been impossible.

To my co-adviser Tiago Manuel Barbosa PhD, for initiation my way into swimming science by helping me during my graduation thesis and once again through this important journey of my life.

To my colleague Jorge Morais MSc for his important contribution during the data collection.

To my friend Daniel Marinho PhD due to his useful collaboration in giving his age group swimmers for the experimental work.

To Nuno Garrido PhD and António Silva PhD, for their support in making the necessary institutional contacts and orientation regarding the university rules and thesis process.

To all swimmers and coaches for their cooperation, interest and for having the necessary free time to participate in the present thesis.

To all my family for their unconditionally support, for admiring my work and for made me the person who I am nowadays.
List of Publications

The following parts of the present thesis have already been published:

The following parts of the present thesis have been submitted for publication:
Growth influences biomechanical profile of swimmers
Figures Index

Figure 1: Variation of anthropometric traits during the detraining period between the end of one season and the beginning of the following one. * Significant variations between pre-test and post-test (P<0.05).

Figure 2: Variations of biomechanics during the detraining period between the end of one season and the beginning of the following one. * Significant variations between pre-test and post-test (P<0.05).

Figure 3: Variation of performance during the detraining period between the end of one season and the beginning of the following one. * Significant variations between pre-test and post-test (P<0.05).
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Table 1: Pearson correlation coefficients between anthropometric, kinematic, efficiency and hydrodynamic variables and performance at the end of one season (pre-test) and the beginning of the following one (post-test).
Growth influences biomechanical profile of swimmers
Abstract

This study aimed to analyze the effect of growth on biomechanical profile of talented swimmers after the summer break. Twenty-five young swimmers (12.45 ± 0.94 years of age) undertook several anthropometric and biomechanical tests at the end of the 2011-2012 season (pre-test) and 10 weeks later at beginning of the 2012-2013 season (post-test). Height, arm span, hand surface area and foot surface area were collected as anthropometric features, while stroke frequency, stroke length, stroke index, propelling efficiency, active drag and active drag coefficient as biomechanical variables. The mean swimming velocity during an all-out 25 m front crawl effort was used as the performance outcome. After the 10 week break the swimmers were taller with an increased arm span, hand and foot areas. Increases in stroke length, stroke index, propelling efficiency and performance were also observed. Conversely, the stroke frequency, active drag and drag coefficient remained unchanged. When controlling the effect of growth no significant variation was determined on the biomechanical variables. The performance presented high associations with biomechanical and anthropometric parameters at pre-test and post-test, respectively. The results show that young talented swimmers still present biomechanical improvements after a 10 week break, which are mainly explained by their normal growth.

Keywords: young swimmers, kinematic, detraining, anthropometric.
Growth influences biomechanical profile of swimmers
Resumo

O presente estudo teve como objetivo analisar o efeito do crescimento na biomecânica/técnica de jovens nadadores após as férias de verão. Vinte e cinco nadadores portugueses (12.45 ± 0.94 anos de idade), foram sujeitos a vários testes antropométricos e biomecânicos no final da época 2011-2012 (pré-teste) e 10 semanas mais tarde no início da época 2012-2013 (pós-teste). Foram obtidos a estatura, a envergadura, a área palmar e a área plantar como indicadores antropométricos, e a distância de ciclo, a frequência gestual, o índice de nado, a eficiência propulsiva, o arrasto ativo e o coeficiente de arrasto como variáveis biomecânicas. A velocidade média obtida num esforço máximo de 25 m crol foi tida como o indicador de performance. Após as 10 semanas os nadadores apresentaram-se mais altos, com uma maior envergadura e áreas palmar e plantar. Foram ainda determinadas melhorias significativas na distância de ciclo, índice de nado, eficiência propulsiva e performance. Contrariamente a frequência gestual, o arrasto ativo e o coeficiente de arrasto ativo permaneceram inalterados. Quando controlando o efeito do crescimento nenhuma das variáveis biomecânicas apresentou variações significativas. A performance apresentou associações significativas com as variáveis biomecânicas e antropométricas no pré-teste e no pós-teste, respetivamente. Os resultados demonstram que, apesar de 10 semanas de destreino, os nadadores desta faixa etária conseguem mesmo assim evidenciar melhorias na técnica/biomecânica que são explicadas pelo processo de crescimento e desenvolvimento.

Palavras-chave: nadadores jovens, cinemática, destreino, antropometria
Introduction

In recent years, the expertise, identification and development of talented performers have gained substantial attention. Research on the topic suggested a multidisciplinary approach, identifying the range of interacting constraints that impinge on performance potential of individual athletes (Philipps et al., 2010). As such, the interaction between training and growth is a major concern while assessing the individual pathway to expertise.

Young talented swimmers usually have several weeks of school break during summer where they take several months off from swim training until the beginning of the following season. According to training principles, the prolonged insufficient/absence of training stimulus (e.g., detraining) can lead to a partial or complete loss of the acquired adaptations in a previous training period (Mujika and Padilla, 2000a).

The evidence-based knowledge about this topic is scarce. A long-term detraining period adversely affects muscle biochemistry (Costil et al., 1985a), endurance fitness (Ormsbee and Arcierom, 2012) and promotes fat gain (Alméras et al., 1997) in adult swimmers. However, detraining effects might differ in terms of adversity according to detraining duration, modalities, population and age (Mujika and Padilla, 2000b). In the case of young talented swimmers, a reduced body of evidence exists about this abrupt cessation of intense physical training from one season to another. Sambanis (2006) reported decreases in pulmonary function and performance of young male swimmers after 50 days of detraining. Conversely, Garrido et al. (2010) determined unchanged muscle strength and hydrodynamic characteristics, but improved performance among young swimmers after 6 weeks of strength detraining. Despite the earlier evidence, the knowledge of the physical detraining on performance should comprise a multidisciplinary approach, mostly at younger ages. Changes in physical traits
determine biomechanical profile thus affection energy demand and performance (Barbosa et al., 2010a).

Talented swimmers, as any other children, experience physical changes as part of their normal biological development. Body mass, height, and therefore, limb length/area are some of the anthropometric features that change with normal growth (Malina and Bouchard, 1991). It is well documented that differences in the physical characteristics of young athletes might reflect the selection at a relatively young age for the size demands of a specific sport (Baxter-Jones et al., 1995). Bi-variate research reported that arm span was the anthropometric feature with highest association ($R^2 = 0.45$) to the 400-m performance in young male subjects (Jürimäe et al., 2007); hand and foot areas have been found to be positively correlated with young swimmers’ 100-m performance (Helmuth, 1980). Furthermore, multivariate analysis also reported a good performance prediction based on anthropometrics (height and arm spam), notably for the boys (Saavedra et al., 2010).

At earlier ages, physical development (i.e., growth and maturation) may also lead to changes in the stroke mechanics and efficiency (Komar et al., 2012). In the past years, some links between biomechanical profile and performance also have been established. Between two major championships, the improvement in the swimming speed of age group swimmers depended mainly on stroke length increases and stroke rate decreases, resulting in part from the anthropometric growth (e.g. height, arm span, and length of foot and hands) (Tella et al., 2002). A higher stroke efficiency expressed by stroke index (Jürimäe et al., 2007) and propelling efficiency (Kiliki and Thorland, 1994; Barbosa et al., 2010b) were also found to be good predictors of performance in young swimmers. A large number of coaches still reduce as much as possible, the summer vacation period to avoid substantial losses in the ability of their swimmers.
Thus, understanding the interaction between growth and technical ability is a major concern at younger ages.

The aim of this research was to analyze the effects of growth on young swimmers’ biomechanical profile after a 10 week summer break. Despite the absence of swim training, an improvement during that period in the biomechanical ability because of the anthropometric growth was hypothesized.
Methods

Participants
Twenty-five talented swimmers (12.45 ± 0.94 years old; 49.74 ± 8.64 kg of body mass; 3.18 ± 0.52 years of training experience, and; Tanner stages 1-2 by self-evaluation) were recruited to participate in this study. They were swimmers with regular presence in regional and national level competitions, including national champions and national record holders for their age-group. Coaches, parents and/or guardians gave their consent for the children to participate in this study. All procedures were in accordance to the Helsinki Declaration regarding human research. The university institutional review board approved the study design.

Study design
A longitudinal research design with repeated measures of several anthropometric and biomechanical outcomes in two different moments was carried out. Field tests were conducted for two days at the end of the 2011-2012 season (pre-test) and 10 weeks later at the beginning of the 2012-2013 season (post-test). Anthropometric and kinematic tests were conducted in the morning. Hydrodynamic tests were carried out in the afternoon of the same day. Twenty-four hours later, performance measures were collected based on a 25-m maximal trial. The swimmers experienced the summer break between both time point measurements. No specific swim training was conducted during such time. Although subjects were instructed to avoid any type of vigorous/controlled water program during the summer, uncontrolled leisure activities were eventually performed as part of their normal summer vacations.
Anthropometric data collection

Swimmers were only wearing a textile swimsuit and a cap during all anthropometric tests. Height, arm span, hand surface area and foot surface area were considered as anthropometric features. The height (in cm) was obtained with the swimmer in anthropometric position, by measuring the distance from the vertex to the floor with a digital stadiometer (SECA, 242, Hamburg, Germany). For the arm span measurement (in cm) the subjects stayed in an upright orthostatic position with arms and fingers fully extended in lateral abduction at a 90° angle with the trunk. The arm span was considered the distance between the third fingertip of each hand and measured with a flexible anthropometric tape (RossCraft, Canada). The test/re-test evaluation (i.e., intraclass correlation coefficient (ICC) for arm span was quite high (ICC = 0.98). Both surface areas were computed using digital photogrammetry. The swimmers put their dominant hand and foot, respectively, on the scan surface of a copy machine (Xerox 4110, Norwalk, Connecticut, USA), near a 2D calibration frame (Morais et al., 2012). Thereafter, the perimeter of the hand surface area and foot surface area was digitized in the Xerox machine, and files were converted to *.pdf format. The areas (in cm²) were computed using a specific software (Universal Desktop Ruler, v3.3.3268, AVPSoft, USA) as reported elsewhere (Morais et al., 2012). The test/retest evaluation was quite high for the hand (ICC = 0.99) and foot (ICC = 0.97) areas.

Biomechanical data collection

Each swimmer performed three 25-m front crawl swim with underwater start. Trials were separated with at least 30 minutes to ensure full recovery of the swimmers. Stroke frequency and stroke length were determined as kinematic variables. For further analysis, the average value of the three trials was computed during the middle of the 25-m. To avoid the starting effect, mean swimming velocity was assessed between the 11th and 24th m from the starting wall to the head by passing a marker and calculated through a 15 m distance, shown as follows:
where $v$ is the mean swimming velocity (in m.s$^{-1}$), $d$ is the distance covered (in m) and $t$ is the time spent to cover that distance (in s). Stroke frequency (in cycles.min$^{-1}$) was measured with a chrono-frequency counter during three consecutive strokes by two expert evaluators (ICC = 0.97). The stroke frequency values were then converted to International System units (Hz). Stroke length was calculated as follows (Craig and Pendergast, 1979):

$$SL = \frac{v}{SF}$$

(2)

where $SL$ is the stroke length (in m), $v$ is the mean swimming velocity (in m.s$^{-1}$), and $SF$ is the stroke frequency (in Hz).

Efficiency variables (i.e., representing overall swimmer’s technical ability) were calculated from kinematics data. Stroke index was computed as follows (Costill et al., 1985):

$$SI = v \cdot SL$$

(3)

where $SI$ represents stroke index (in m$^2$.c$^{-1}$.s$^{-1}$), $SL$ represents stroke length (in m) and $v$ is the mean swimming velocity (in m.s$^{-1}$). The propelling efficiency was computed as follows (Zamparo et al., 2005):

$$\eta_p = \left( \frac{v \cdot 0.9}{2\pi \cdot SF \cdot l} \right)^{\frac{2}{\pi}}$$

(4)
where $\eta_p$ is propelling efficiency (in %), $v$ is the swimming velocity (in m·s$^{-1}$), SF is the stroke frequency (in Hz) and $l$ is the distance between the shoulder and tip of the 3rd finger during the in-sweep length (in m).

Active drag and active drag coefficient were computed as hydrodynamic variables using the velocity perturbation method (Kolmogorov and Duplishcheva, 1992). Each swimmer performed two maximal 25-m trials of front crawl swim with push-off start. The first trial was performed without carrying the perturbation device and the second one with the device (Marinho et al., 2010). Trials were performed with no other swimmer in the lane or nearby lanes to reduce drafting or pacing effects. Active drag was calculated from the difference between the swimming velocities with and without towing the perturbation buoy (Marinho et al., 2010). The drag of the perturbation buoy was computed from the manufacturer’s calibration of the buoy-drag characteristics and its velocity (Kolmogorov and Duplishcheva, 1992). Swimming velocity was assessed between the 11$^{th}$ and 24$^{th}$ m from the starting wall from the head passing a marker. The time spent to cover this distance was measured with a stopwatch (Golfinho Sports MC 815, Aveiro, Portugal) by two highly-expert evaluators. Both evaluators walked with the swimmer ensuring that their line of sight would be in perfect condition when the swimmer passed the specific point of measurement. The ICC for both evaluators was very high (ICC = 0.96). Active drag was computed as follows (Kolmogorov and Duplishcheva, 1992):

\[
D_a = \frac{D_b}{v^2} \cdot \frac{v^3 - v_b^3}{v^3}
\]

(5)

where $D_a$ is the swimmer’s active drag at maximal velocity (in N), $D_b$ is the resistance of the perturbation buoy (in N), and $v_b$ and $v$ are the swimming velocities with and without
the perturbation device (in m.s\(^{-1}\)), respectively. Active drag coefficient was computed as follows (Kolmogorov and Duplishcheva, 1992):

\[
C_{da} = \frac{2D_a}{\rho S v^2}
\]

(6)

where \(D_a\) is the swimmer’s active drag (in N), \(\rho\) is the water density (assumed to be 1000 kg.m\(^{-3}\)), \(v\) is the swimmer’s velocity (in m.s\(^{-1}\)), and \(S\) is the swimmers’ projected frontal surface area (in cm\(^2\)), photographed with a digital camera (DSC-T7, Sony, Tokyo, Japan) in the transverse plane from above simulating the hydrodynamic position (Caspersen et al., 2010) and computed with a specific previously mentioned software (Morais et al., 2012).

Performance data collection
A competitive swimmer tries to travel a given distance as fast as possible. Based on this assumption, mean swimming velocity has been considered the best predictor of performance (Barbosa et al., 2010a). Performance was assessed through an all-out 25-m front crawl effort from the starting block. The velocity representing the swimming performance was computed according to equation 1 but was not considered for the remaining kinematic assessments.

Statistical analysis
Kolmogorov-Smirnov and the Levene tests were used to assess normality and homocedasticity assumptions, respectively. Box plots with quartile data from all variables were calculated for each period.

Repeated-measures ANOVA (i.e., within-subjects comparison), according to the testing occasion (pre-test vs post-test), were conducted for all dependent variables. ANCOVA was also computed, controlling the effect of the growth rate (i.e., height difference
between post-test and pre-test) in each biomechanical variable. All assumptions to perform the ANOVAs and ANCOVAs were considered (i.e., independence, normality, and homoscedasticity). The level of statistical significance was set at $P \leq 0.05$.

Effect sizes were computed based on Eta-squared ($\eta^2$) procedure, and the following values were interpreted according to Ferguson (2009): without effect if $0 < \eta^2 \leq 0.04$, minimum if $0.04 < \eta^2 \leq 0.25$, moderate if $0.25 < \eta^2 \leq 0.64$ and, strong if $\eta^2 > 0.64$. Data were reported to have a “meaningful variation” if significant ($P \leq 0.05$) with a medium/moderate or large/strong effect size ($\eta^2 > 0.25$) and a “significant variation” if significant ($P \leq 0.05$) with a small effect size ($\eta^2 \leq 0.25$) (Winter, 2008). Pearson correlation coefficients were calculated to assess associations between performance and remaining variables in each testing occasion ($P \leq 0.05$).

**Results**

Figure 1 presents the box plot with quartile data of the anthropometric traits during the detraining period. ANOVA presented significant increases in height [$F_{(1,24)} = 22.299; p < 0.001; \eta^2 = 0.04$] and arm span [$F_{(1,24)} = 23.687; p < 0.001; \eta^2 = 0.07$], whereas hand surface area [$F_{(1,24)} = 18.428; p < 0.001; \eta^2 = 0.92$] and foot surface area [$F_{(1,24)} = 24.315; p < 0.001; \eta^2 = 0.66$] demonstrated meaningful increases.
Growth influences biomechanical profile of swimmers

Figure 1. Variation of anthropometric traits during the detraining period between the end of one season and the beginning of the following one. * Significant variations between pre-test and post-test (P<0.05).

Figures 2 and 3 present the box plot with quartile data of the biomechanical and performance variables, respectively. Meaningful increases were determined for stroke length \(F_{(1,24)} = 21.139; p < 0.001; \eta^2 = 1.00\), stroke index \(F_{(1,24)} = 21.816; p < 0.001; \eta^2 = 1.00\) and propelling efficiency \(F_{(1,24)} = 20.907; p < 0.001; \eta^2 = 1.00\). Stroke frequency \(F_{(1,24)} = 2.056; p = 0.17; \eta^2 = 1.00\), active drag \(F_{(1,24)} = 1.468; p = 0.24; \eta^2 = 0.95\) and active drag coefficient \(F_{(1,24)} = 2.465; p = 0.13; \eta^2 = 1.00\) remained unchanged. A meaningful variation was also determined for performance \(F_{(1,24)} = 19.265; p < 0.001; \eta^2 = 1.00\) from pre-test to post-test.
Figure 2. Variations of biomechanics during the detraining period between the end of one season and the beginning of the following one. * Significant variations between pre-test and post-test (P<0.05).

Figure 3. Variation of performance during the detraining period between the end of one season and the beginning of the following one. * Significant variations between pre-test and post-test (P<0.05).
Whenever the growth rate was used as covariate, (i.e., ANCOVA), all biomechanical variables presented a non-significant variation [stroke length, $F_{(1,24)} = 0.669, p = 0.42$; stroke frequency, $F_{(1,24)} = 0.124, p = 0.73$; stroke index, $F_{(1,24)} = 0.857, p = 0.37$; propelling efficiency, $F_{(1,24)} = 0.593, p = 0.45$; performance, $F_{(1,24)} = 0.473, p = 0.50$; active drag, $F_{(1,24)} = 0.022, p = 0.88$; active drag coefficient, $F_{(1,24)} = 0.178; p = 0.68$].

Table 1 presents the associations between anthropometric, kinematic, efficiency and hydrodynamic variables and performance. High and significant associations were determined between technical skills (stroke length, stroke index and propelling efficiency) and performance at pre-test. Conversely, high and significant associations were most notable between the anthropometric features and performance at post-test. At post-test, both stroke length and stroke index presented a moderate and high relationship with performance, respectively.

Table 1. Pearson correlation coefficients between anthropometric, kinematic, efficiency and hydrodynamic variables and performance at the end of one season (pre-test) and the beginning of the following one (post-test).

<table>
<thead>
<tr>
<th></th>
<th>performance @ pre-test</th>
<th>performance @ post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anthropometrics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>height</td>
<td>0.28 ($P = 0.17$)</td>
<td>0.72 ($P &lt; 0.01$)</td>
</tr>
<tr>
<td>arm span</td>
<td>0.27 ($P = 0.22$)</td>
<td>0.69 ($P &lt; 0.01$)</td>
</tr>
<tr>
<td>hand surface area</td>
<td>0.31 ($P = 0.14$)</td>
<td>0.72 ($P &lt; 0.01$)</td>
</tr>
<tr>
<td>foot surface area</td>
<td>0.15 ($P = 0.50$)</td>
<td>0.59 ($P &lt; 0.01$)</td>
</tr>
<tr>
<td><strong>Kinematics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>stroke length</td>
<td>0.89 ($P &lt; 0.01$)</td>
<td>0.52 ($P &lt; 0.01$)</td>
</tr>
<tr>
<td>stroke frequency</td>
<td>0.27 ($P = 0.20$)</td>
<td>0.26 ($P = 0.21$)</td>
</tr>
<tr>
<td><strong>Efficiency</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>stroke index</td>
<td>0.97 ($P &lt; 0.01$)</td>
<td>0.85 ($P &lt; 0.01$)</td>
</tr>
<tr>
<td>propelling efficiency</td>
<td>0.82 ($P &lt; 0.01$)</td>
<td>0.13 ($P = 0.55$)</td>
</tr>
<tr>
<td><strong>Hydrodynamics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>active drag</td>
<td>0.40 ($P = 0.06$)</td>
<td>0.52 ($P = 0.08$)</td>
</tr>
<tr>
<td>active drag coefficient</td>
<td>0.39 ($P = 0.06$)</td>
<td>-0.07 ($P = 0.55$)</td>
</tr>
</tbody>
</table>
Discussion

The aim of this research was to analyze the effects of growth on talented swimmers’ biomechanical profile after the summer break. There was an improvement in the biomechanical ability after the 10 week break, which is mainly explained by the physical development (i.e., growth).

The participants of our sample were both young boys and girls. We pooled together both boys and girls because gender gap is not an issue at this age group, at least when it comes to pre-adolescence. In a sample of 202 pre-adolescent subjects that were examined on a battery of anatomical and physiological tests, no significant interaction between age, sex, and sporting involvement was found, which indicated sex differences to be independent of age and training group (Blanksby et al., 1986). A solid body of knowledge also exists about the absence of a gender gap in pre-pubertal swimmers (e.g., Ratel and Poujade 2009; Seifert et al., 2010; Zuniga et al., 2011). Gender gap will be most notable near puberty when growth spurt, hormonal profile and strength development start to play a determinant role (Malina and Bouchard, 1991).

After the 10 week break from swim training, the swimmers were taller, with a higher arm span and surface areas (hands and feet). Data are consistent with literature, at least when comparing the values of physical characteristics with young swimmers engaged on regular swim training (Latt et al., 2009a; Latt et al., 2009b; Morais et al., 2012). The interest in the stimulus that the presence of training at an early age has on a child's growth, was the focus of several researchers in the past, but limited information was reported about detraining in young talented swimmers. Anthropometric growth is not influenced by physical activity or sports participation (Malina, 1994; Baxter-Jones et al., 1995) but by a pre-determined biological process involving complex structural/anatomical changes that children experience throughout formative years (Malina and Bouchard, 1991).
In our sample, growth spurt was more evident for limb areas than for height and arm span. Development of anthropometric proportions may be viewed as a set of different rates of growth. Anthropometric growth starts from the outside of the body, leading to an earlier expansion of the hands and feet when comparing to longest bones (Ulijaszek et al., 1998). As the latter height spurt is only reachable at the age of 14 years (Blanksby et al., 1986), the remaining anthropometric traits (e.g., hands and feet dimensions) experience an accelerated growth at previous ages. Probably this might have happened during the 10 weeks, because the subjects were far away from the typical height spurt.

Despite the prolonged absence of regular technical drills during the detraining period, the kinematic aspects of the stroke still improved. Whereas the stroke length increased, the stroke frequency remained unchanged after the break. It is known that increases in velocity can be reached using different combinations between stroke frequency and stroke length in adults (Craig and Pendergast, 1979; Barbosa et al., 2008) and young swimmers (Barbosa et al., 2010b). At earlier ages, increases in stroke frequency by maintaining stroke length are limited, mainly because of the muscle properties of the swimmers. The abrupt increase in muscle strength through growth usually starts 12 to 15 months after the appearance of the height peak (Bloomfield et al., 1990). At least one study reported unaltered strength levels of young swimmers after a 6 weeks detraining period (Garrido et al., 2010). It is clear that the swimmers from the present sample have not reached their height peak yet. Thus, increases in stroke frequency while maintaining stroke length were not possible. Instead, the improvement in velocity was based in stroke length increases, which can be explained by an increased arm span. An increased upper limbs’ length allowed reaching higher distances during each stroke cycle (stroke length), maintaining the number of strokes (stroke frequency) performed at a given event.
The swimming efficiency improved as well. Meaningful increases in the stroke index and propelling efficiency are explained because both variables are rough estimations based on the kinematic and anthropometric outcomes. Increases in stroke length due to limb dimensions led to a markedly increase in performance and consequently in the stroke index. The stroke frequency maintenance and the upper limb growth promoted an improvement in propelling efficiency. Thus, it is expected that anthropometric growth has an exclusive effect in efficiency during the detraining phase, because the physical traits determine the biomechanical variables (Barbosa et al., 2010a).

Both active drag and active drag coefficient remained unchanged from pre-test to post-test. A similar finding was reported for young swimmers after a seasons' break of 6 weeks (Garrido et al., 2010). Apparently hydrodynamic characteristics are not so sensitive to detraining than other biomechanical outcomes in this age group. Hydrodynamic characteristics depend on the technical aspects and physical growth. Probably, a detraining period longer than 10 weeks might lead to changes in the technical ability and, therefore, in the hydrodynamics. As such, an increased growth period in several anthropometric traits that were not considered for analysis (e.g., chest perimeter or trunk transverse area) may also induce hydrodynamic changes. Even 8 weeks of swim training through a general training phase were not sufficient to statistically change active drag in young swimmers (Marinho et al., 2010). Conversely, one week of hydrodynamics training mainly with specific visual and kinesthetic feedbacks, was sufficient to decrease active drag coefficient in pubescent swimmers (Havriluk, 2006). Thus, changes in hydrodynamics of young swimmers also through shorter training phases might be strongly related to a rigorous design with proper feedback (at least according to subjects’ competitive level) and less with growth.
Despite detraining, the swimmers were able to swim faster at the beginning of the new season. The few existing studies about this topic demonstrate contradictory findings. The 25 and 50-m front crawl performances of young swimmers still improved after 6 weeks of strength detraining (Garrido et al., 2010). Nevertheless, 50 days without swim training led to small decreases in the 100-m front-crawl performance of young male subjects (Sambanis, 2006). This inconsistency in the literature may rely on the distances selected to measure the performance. Detraining effects might be more pronounced in longer than in shorter distances because several energetic pathways have different partial contributions to total energy expenditure in each race distance. Probably, higher losses are more evident in the aerobic system than in the anaerobic one, and may help in explaining such phenomenon. However, further research should be conducted to expand the knowledge about this thematic in young swimmers.

When controlling the effect of the growth rate, no significant variations were found for the selected variables. Earlier interventions reported that anthropometric traits had an impact in performance and in several stroking parameters during periods of training in swimmers from similar age and competitive level (Pelayo et al., 1997; Tella et al., 2002; Latt et al., 2009a; Latt et al., 2009b). Thus, covariation results confirm that physical growth was the major factor that led to an improvement in biomechanical profile of talented swimmers through the 10 weeks of detraining.

Correlation coefficients were computed to determine the variables with higher associations with performance at both testing occasions. Whereas the biomechanical characteristics were the ones with higher associations with performance at pre-test, the anthropometric traits were the ones defining performance 10 weeks later. At these ages, a large part of the swimming sessions comprise technical drills to improve biomechanics. Because the maturation of the nervous central system enables the task acquisition related to specific sport (Fogassi et al., 2005), a notable evolution in the
swimming skills should be observed through the season and consolidated at the end. At this point, faster swimmers are expected to be the ones with a more “refined” technical ability. Conversely, at the beginning of the new season, the growth factor plays a major role. As water is not the natural environment for human locomotion, perhaps the absence of swimming drills during summer vacations may lead to a reduction in neural adaptations acquired in a previous training period, and the loss of “water sensibility” as it is called by practitioners. To our knowledge, technical literature fails to have empirical data regarding this issue in young swimmers. However evidences exists that physical loss after detraining periods could be attributed to neural alterations (Gondin et al., 2006). Thus, the faster swimmers at the beginning of the new season are expected to be the ones with higher anthropometric dimensions and, consequently, higher technical ability.

The main limitations of this research are as follows: (i) the absence of rigorous control of the summer activities engaged by the swimmers; (ii) the need to expand the multidisciplinary analysis including other performance’s determinant variables (e.g. speed fluctuation, index of coordination, and aerobic and anaerobic capacity) and; (iii) the lack of genetic assessment to discriminate high from slow responders to the training and detraining.
Conclusions

It can be concluded that young talented swimmers still can improve their swimming biomechanics despite the absence of swim training after a 10 week summer break. Those improvements are mainly explained by the anthropometric growth. Thus, coaches can give to their young athletes a fairly long training break (i.e. 10 weeks) to recover and motivate for the next season, without worrying about biomechanical changes during the summer vacations.
References


Growth influences biomechanical profile of swimmers


