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Original Article

Performance evaluation in young swimmers during 28 weeks of training

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Abstract:
The aim of this study was to verify the evolution of young swimmers' performance during 28 weeks of training. It was intended to analyze the performance in 25m and 50m front crawl and in the best stroke of each swimmer, critical velocity, general biomechanical variables (Stroke Length, Stroke Rate, Stroke Index), their anthropometric variables (weight, height, arm span, Body Mass Index, Leg Length and Upper Limb length) and sex maturation. The sample consisted of six swimmers (mean age 14.16 ± 1.32 years, 160.41 ± 14.01 cm of average height, average weight of 47.80 ± 13.68 kg, previous experience in swimming of 4.5 ± 2.1 years). Performance evaluations, biomechanical parameters and anthropometric measurements were performed every two weeks of training. The swimmers filiel in self-assessment questionnaire of sexual maturation, three times during 28 weeks of training. To check the normality of distribution it was performed the Shapiro-Wilk test (SPSS). To analyze the evolution over the 28 weeks of training of the different parameters it was performed a Paired-Sample T-Test, considering first week of teste as a baseline. The results showed significant differences at weeks 14 and 24 in the 25m and 50m front crawl, respectively. An increase was also found in performance of swimmers in the 25m and 50m in their best stroke technique, in critical velocity, in biomechanical and in anthropometric parameters during the 28 weeks of training. All these parameters can be used to monitor the training and performance over a season without the use of sophisticated equipment.
Keywords: Training Planning, Control Training, Swimming, Children

Introduction:

The practice of sport in certain activities begins at a very early stage in the life of a child (Borges, 2008). In particular, swimming is presented as one of the sport that is praticed at early ages as are artistic gymnastics and dance. This need arises from the attempt to get the best results in sports, so that valences are initiated and practice of specific physical conditions developed (Santos, 2001). These valences are specific to the practice that is iniciated. They need to be developed in a systematic manner so that the planning of the training program has coherence and that its objectives, methods and organization are defined according to the specific of sportsman and requirements of the activity. According to Marinho et al. (2009a), the efficiency of the training process appears to be profoundly determined by the possibility of collecting data about the capabilities and needs of each swimmer. It is necessary that the training be scheduled according to these data, their controlled development, and their effects noted by different methods for monitoring performance (Henke, 2009).

Reis and Alves (2006) and Leite et al. (2007) emphasize that the structure of the planning of training needs to be accompanied by assessments that determine whether the contents are applied to improve the performance of athletes. For Marinho et al. (2006) the efficiency of the training process can only be improved if there is an improvement of the methodology used to evaluate each to the component of sports performance. Thus, to guarantee that a training process is qualified and that consequently there will be an evolution, it is necessary to control several variables to understand the main purpose of the activity. Besides the requirements that swimming has as an activity and its training tries to answer, it is essential to consider the specificity of the sport, since only in this way may be a maximum return of the same.

Leite et al. (2007) states that the influence of different organizational methodologies makes the body respond according to the stimuli applied, when properly planned and considering the individuality of the sportsman. This specificity becomes more complex when the age groups of athletes are low, due to this period of adolescence (Abade, 2007). When the athletes pass through adolescence, the maturational processes that are responsible for structural and functional change occur, and this will not happen at the same time in all subjects. According to Valdivielso (2004), in order to conduct training in children and adolescents, it is essential to respect the principles of adaptation of the age and individuality, which implyies considering their biological possibilities (biological age and maturation), and thus the need to prepare the athlete for best long-term yields. As so, care in handling loads with the intensity and volume of training, is extremely important when planning the training of young swimmers (Neto et al. 2009). The structural and functional changes previously referred occur during adolescence and therefore modify the ability to perform tasks that are inherent in training and consequently the

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performance of the swimmer. The control of different training loads in young swimmers and how they relate to their performance has not been much studied by the scientific community (Stewart & Hopkins, 2000; Marinho et al. 2009a). As so the objective of this study is to analyze the performance of swimmers in distances of 25m, and 50m front crawl and in their best stroke technique, in critical velocity, in general biomechanical variables (stroke length and stroke rate, stroke index), in anthropometric variables (weight, height, arm span, Body Mass Index, Leg Length and Upper Limb length) and to characterize maturational young swimmers from different age groups over 28 weeks of training.

Materials and Methods

Participants:

The study sample consisted of six swimmers (three female and three male) of the Swimming Club of Portalegre. All swimmers and their corresponding parents were informed of the purpose and methods of the study. Table 1 shows age, height, weight and previous average experience of the swimmers in the sample held at the 1st anthropometric measurements (November 12, 2010).

Table I: Mean values (± standard deviation) of age, height, weight and previous experience at the 1st anthropometric measurements.

	Age (years)	Height (cm)	Weight (Kg)	Previous Experience(years)
Mean ± Standard D	14,16±1,32	160,41±14,01	47,80±13,68	4,5±2,1

Measures:

Weight (kg) was determined by the balance of brand Future FB-9005. The height (cm) was obtained by the distance between the ground and the vertex, and the individual was in an upright position. The Body Mass Index (BMI) (kg/cm^2) was obtained by dividing the weight by the square of height. The scale (cm) was determined by the distance between the end of the middle fingers of both hands with both arms extended. The length of the upper limbs (LUL) (cm) was obtained by the distance between the acromion and dactylion. The length of the lower limb (LLL) (cm) was obtained by performing the measurement between the upper iliac crest and the plantar surfaces of the heel.

To evaluate the mean velocity (M.V.), stroke index (S.I.), stroke length (S.L.) and stroke frequency (S.F.), swimmers were viedeotaped using a Canon PowerShot A450 model camera, during the 50m front crawl and in the best stroke tests. The S.F. (cycles / second) was calculated by the count of three stroke cycles from 15 meters away from the pool, dividing by the time interval (s) it took to perform the three stroke cycles. S.F. was considered as the time between the entry of a hand in the water until the new entry of the same hand in the water. The S.L. (m / cycle) was obtained by dividing the M.V. and the corresponding S.F. The M.V. (meters / second) was obtained by dividing the distance of the race (meters) by swim time (seconds). The S.I. ($meters^2$/cycle/second) was calculated by multiplying the S.L. by M.V.

The critical velocity (meters / second) was determined by the slope of the linear regression line between the 50m and 400m distances and their respective times (Fernandes, 2011).

The maturity assessment of the swimmers was performed according to the method of Tanner (Tanner, 1962), in which a survey of self-assessment of sexual maturation was conducted.

Procedures:

The evaluations were conducted over 28 weeks of training between November 2010 and April 2011. During this period the swimmers had a total of 348.15 kilometers of training volume and 123 training sessions. Figure 1 represents the volume of training, in meters, over 28 weeks of training.

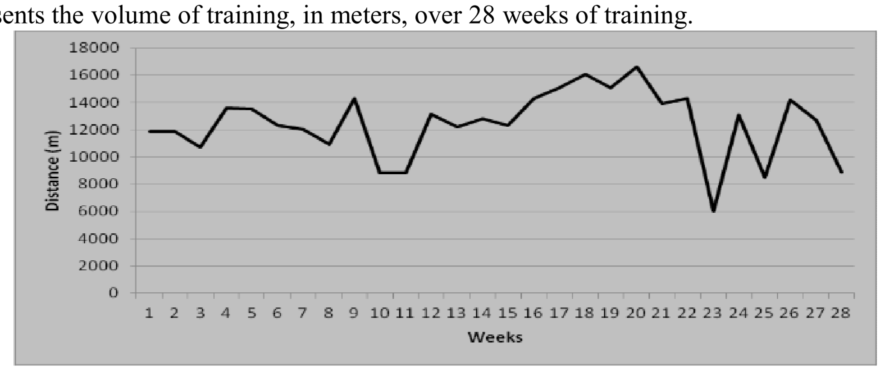

Figure I: Training volume, in meters, over 28 weeks of training

The type of training conducted over 28 weeks was divided into three distinct phases. The first occurred between week 1 and week 14 and focused predominantly on the development of aerobic endurance. In the second cycle, which lasted between week 15 and week 22, there was an increasing importance of speed work, despite the fact that aerobic component had been well developed. The last phase, which occurred between week 23 and week 28, requested primarily aerobic endurance.

Performance tests were conducted in each two weeks of training, for distances of 25m and 50m front crawl and the best stroke technique of each swimmer, where the swimmer had to swim at maximum speed. In total, these tests were performed 12 times over 28 weeks, starting on November 12, 2010 and finished on April 29, 2011. The definition of the best stroke technique of each swimmer was determined by the coach of the Swimming Club of Portalegre, and the main component choosen was the times achieved by swimmers in the different strokes available. The anthropometric and biomechanical evaluation was performed every two weeks of training, and determining the critical speed was held once a month over 12 weeks. The self-assessment of sexual maturation survey was performed three times during 28 weeks of training. They were held on November 12, 2010 (Week 4), February 18, 2011 (Week 18) and April 29, 2011 (Week 28).

Statical analysis

To check the normality of distribution a Shapiro-Wilk test was performed (SPSS). In order to analyze the evolution over the 28 weeks of training anthropometric factors (weight, height, arm span, BMI, LUL, LLL), biomechanical factors (SL, SF,MV, SI) and performance in 25 meters and 50 meters front crawl and in the best stroke of the swimmers a Paired-Sample T-Test was conducted. Comparisons were made between week 1 and the remaining weeks of training, and the significance level for rejecting the null hypothesis in all statistical tests was set at $p \leq 0.05$.

Results:

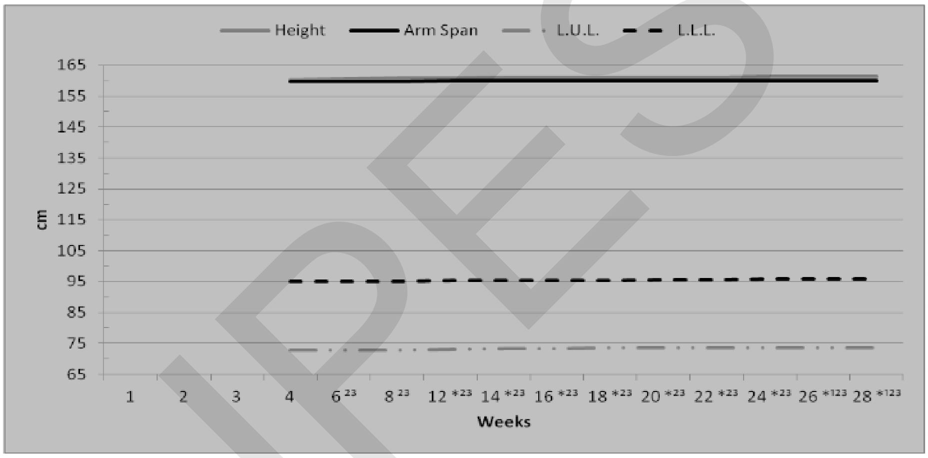

Figure II: Mean of Height (*), Arm Span ([1]), L.U.L. ([2]) and L.L.L. ([3]) over 28 weeks of training. ($*^{123}$ $P < 0.05$)

Figure 2 notes the evolution of mean height, arm span, L.U.L. and L.L.L. of the swimmers over the 28 weeks of training. As expected it turns out that there is a gradual increase in average height, arm span, L.U.L and L.L.L. More specifically, the height differs significantly from week 12 through week 28, while the arm span when comparing the first measurement with the last measurement performed, recorded an average increase of 0.41 cm and significant differences occurred in only weeks 26 and 28. Regarding L.U.L. and L.L.L. it appears that differences occurred throughout the week 28 of training with an increase in the average difference of 0.75 cm and 0.83 cm, respectively, when compared the first measurement with the last measurement performed.

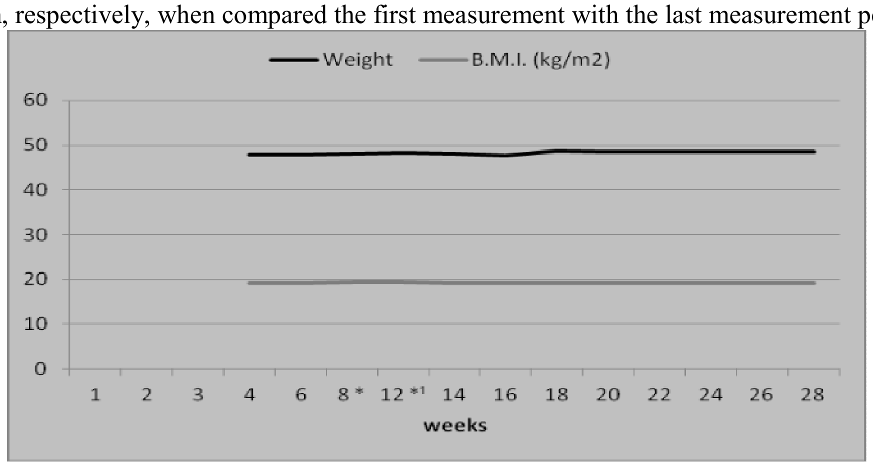

Figure III: Average of weight (*) and B.M.I.([1]) for all swimmers over 28 weeks of training. (^{1} * $p < 0.05$)

Figure 3 reflects the progress of average weight and BMI of all swimmers over the 28 weeks. It is possible to observe that over time there were no major changes of those, with only significant differences at weeks 8 and 12 for the average weight and at week 12 in mean of the BMI for all swimmers.

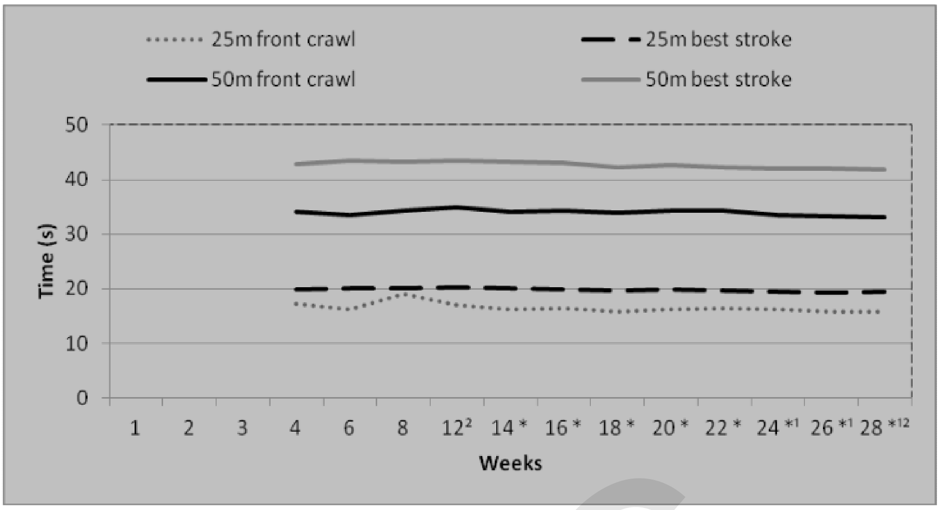

Figure IV: Average of performance of all swimmers in the 25m front crawl (*), 25m in best stroke, 50m front crawl (¹) and 50 in best stroke (²) over 28 weeks of training. (¹ ² * $p < 0.05$)

Considering the average level of performance in the 25 meters and 50 meters front crawl and in the best stroke technique of all swimmers, when comparing the first performance measurement (week 4) with the last performance measurement (week 28), it was found that there was an improvement. More specifically, the performance improvement in 25 meters front crawl happens from week 14 where the average time made by the swimmers was always lower than the times achieved during 4 weeks before. It was also notorious that although there are no significant variations, the best average in the 25 meters in the best stroke was obtained in the last week of training. Regarding to the average performance of all swimmers in the 50 meter front crawl, it appears that it differs significantly from week 24, while for the average performance of the 50 meters in the best stroke of the swimmers, the same happens in weeks 24 and 28.

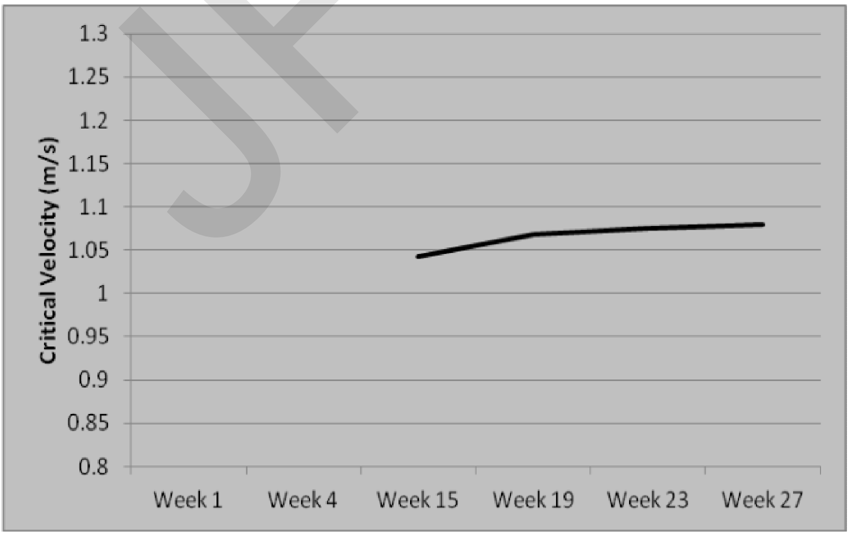

Figure V: Critical Velocity average of all swimmers over 28 weeks of training**.**

Considering the graph shown above (Figure 5), there is an improvement of the average critical velocity of the swimmers during the last 12 weeks training, noting that there was a gradual increase of this variable and the highest value occurs in the last week of testing, although no significant differences were found in different stages of evaluation.

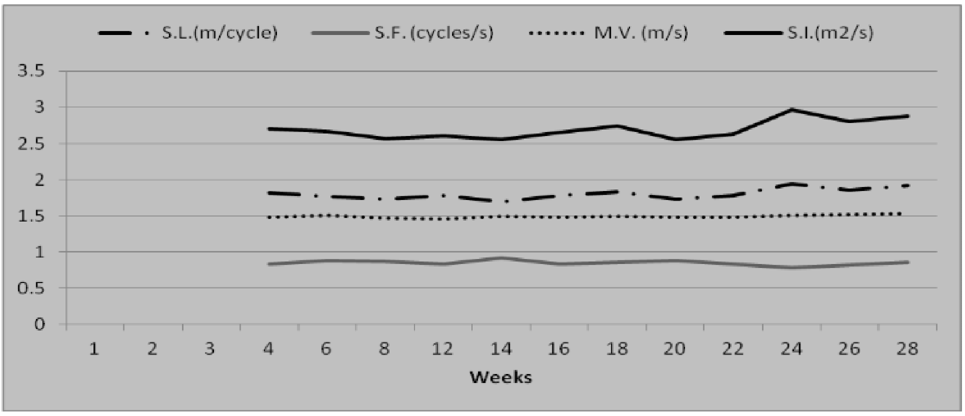

Figure VI: Average of S.L., S.F., M.V. and S.I. in the 50 meter front crawl of all swimmers over 28 weeks of training.

Concerning the biomechanical parameters measured over 28 weeks of training and shown in Figure 6, it appears that there is an increase of S.L., S.F., M.V. and S.I. In particular and despite that over 28 weeks of the evolution S.L. and S.I. are slightly irregular, the highest values occurred at weeks 24, 26 and 28. One can also noted that the highest values of S.F. occurred in the first half of the assessments, existing from week 14 slight decreases in the same variable. When comparing the first evaluation with the last measurement, it can be verified that there is an increase in the average of M.V. in all swimmers and week 28 presented the highest value of the velocity.

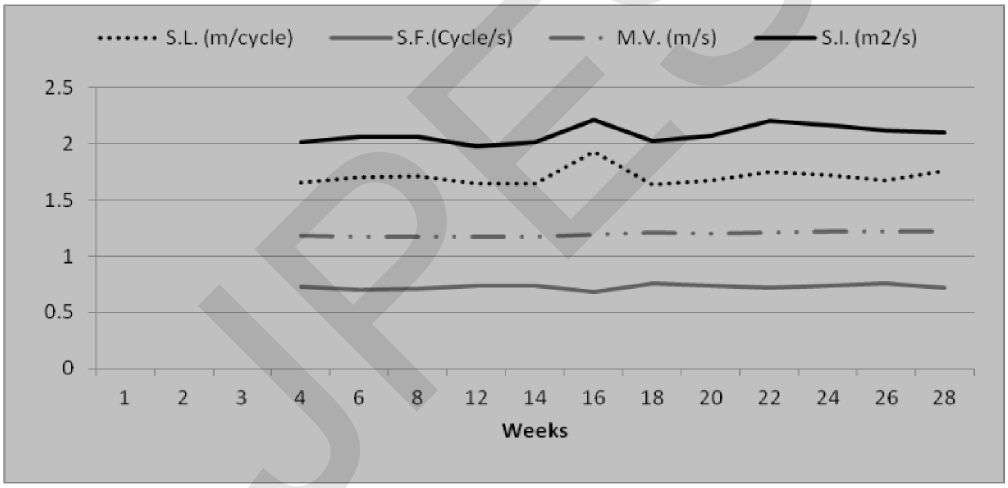

Figure VII: Average of S.L., S.F., M.V. and S.I. in 50 meters in the best stroke of all swimmers over 28 weeks of training

Looking at Figure 7, which represents the evolution of biomechanical parameters in 50 meters in the best stroke over the 28 weeks of training, it appears that there is an increase of S.L., M.V., S.I. and a decrease in the S.F. Taking into acount the average of S.L. for all swimmers and comparing the four weeks measurments (1.65 m / cycle) at week 28 (1.75 m / cycle), apparently there is an increase of the mean of S.L. of all swimmers in the in the best stroke, approximately 10 cm. Comparing also the first assessment (0.73 cycle / s) and last (0.72 cycle / s), it was found that there was a slight decrease of the S.F. mean in the best stroke over the 28 weeks, observing a lower S.F. mean in week 16. Regarding the evolution of M.V. and S.I it turns out that there is a gradual increase from week 12 through week 28, for the M.V., while SI, despite reaching maximum values at week 16 and week 22, presents a slight decrease after week 22 until week 28. Besides this event and, as mentioned above, when comparing week 4 to week 28, there is a slight increase in the S.I.

Table II: Biological maturation of the female gender over 28 weeks of training

Female	*T1*	*T2*	*T3*
Swimmer1	*M3 – ** P4	*M3 –** P4	*M3 –** P4
Swimmer2	*M3 –** P4	*M3 –** P4	*M3 –** P4
Swimmer3	*M3 –** P4	*M3 –** P4	*M3 –** P4

M - Breast Development / ** P - Development of Pubic Hairiness

Table III: Biological maturation of the male gender over 28 weeks of training

Male	*T1*	*T2*	*T3*
Swimmer4	*D5- **P5	*D5- **P5	*D5- **P5
Swimmer5	*D5- **P5	*D5- **P5	*D5- **P5
Swimmer6	*D5- **P5	*D5- **P5	*D5- **P5

* D - Development Genital / P ** - Development of Pubic hairiness

Tables 2 and 3 show the stages of sexual maturation of each swimmer. As shown by Table 2, all female swimmers are at stage 3 and stage 4 of breast development and in pubic hair growth. Over the 28 weeks of training there were three self-assessment questionnaires although there was no change regarding the stadium they were. The same is true for the male swimmers, where all swimmers are in stage 5 of genital development and of pubic hair growth. As the girls there were no changes of stadiums throughout the 28 weeks of training (Table 3).

Discussion:

The aim of tis study was to analyse the performance evolution during 28 weeks of training. It was found that there were improvements in the 25m and 50m front crawl and in the best stroke technique.

When comparing the study of Neto et al. (2009), where the training was mainly on improving the swimmers endurance over 23 weeks, there was also an increase in performance of the swimmers in the 25 meters. However, significant differences in performance occurred weeks later when compared with these swimmers, although this study of Neto et al. (2009) took place in the competitive period. According to Maglisho (1999), aerobic resistance training is necessary because a good aerobic capacity will allow swimmers to train more intensively over short distances and it will increase the amount of muscle glycogen while allowing performance of more and incresed series of sprints without reaching exhaustion.

This may be one reason for the significant differences referred earlier. Comparing current results to the study of Marinho et al. (2009a), which aimed to monitor the performance of sprint over 9 weeks of training, there was an increased of performance of the swimmers for short distances. However, in this study, significant differences occurred slightly earlier, at the end of seven weeks of training. Yet in a study of Mavridis, Kabitsis, Gourgoulis and Toubekis (2006), which applied a specific speed training for 12 weeks, there was an increase in performance over short distances (50m, 100m and 200m) at the end of that period of time. As in the first two studies mentioned above, there were still significant differences in the performances of the swimmers occuring after a decrease in the volume of weekly training.

Considering the assessment of critical velocity held over 12 weeks of training, similar results were obtained in a study of Marinho et al. (2009b) and Machado et al. (2011), where at the end of 12 weeks of training there were significant differences in the values of critical velocity. In a study of Reis and Alves (2006), where the objective was to determine the relationship between different methods of assessing aerobic capacity and aerobic training-induced changes, improvements were also noted in the critical velocity of the swimmers at the end of 9 weeks of aerobic training. Another study of Neto et al. (2009), which aimed to investigate the differences of the critical velocity over 23 weeks of training, only obtained significant differences at the end of 20 weeks of training. In this case, the significant differences in the critical velocity of the swimmers did not happen during the aerobic endurance training, and succeeded only after the completion of it and when there was a reduction in training volume. In comparison to the same study, it appears that significant differences occur only after 12 weeks of measurements. These results can be justified as between weeks 15 and 22 training focused mainly on speed sets, with only 23 weeks from the same privileged aerobic resistance training. As so, it can be said that the last 4 weeks of endurance training promoted positive changes in aerobic capacity of the swimmers.

Facing biomechanical evaluation conducted over 28 weeks of training, it can be asserted that it converges with different studies. There is an increase of almost all parameters in the 25 meters and 50 meters front crawl and in the best stroke of the swimmers. More specifically, by comparing the average S.L. of all swimmers with the performance achieved for the same in 50 meters front crawl during the 28 weeks of training, it appears that the weeks in which the swimmers achieved their best performances in the 50 meters front crawl coincided with the highest values of average SL. This event is consistent with the hypothesis that SL is the main factor that should be improved to enhance performance (Craig & Pendergast, 1979, De Groot & Van Ingen Schenau, 1988). Contradictory results were obtained by Minghelli & Castro (2006), where the aim of the study was to investigate how predominantly aerobic training influenced the biomechanical parameters (SL, SF, SI and MV) in carrying out the front crawl sprints over five months. In the same study there was an increase in speed due to increased SL at the end of five months of training. However, and as Minghelli & Castro (2006) stated, it was found that when the training was mainly focused on endurance the SL decreases and there was an increase only during and after training focuses primarily on speed. Also of importance, body mass, height and arm span were correlated with SL in tests of maximum velocity (Franken, Carpes, Diefenthaeler & Casto, 2008), which means that it cannot be the main factor which alone explains SL increases, as over the 28 weeks there was an increase in anthropometric variables and the technical efficiency (SI) of swimmers, two of the variables that influence the SL (Barbosa et al., 2009; Franken et al., 2008) and were measured in this study.

Evaluating the evolution of the SF in the 50 meter front crawl and in the best stroke, there was a slight increase of the same trend for the 50 meter front crawl and a slight decrease for the 50 meters in the best stroke. According to Yanai (2003), after a training period there is an increase in performance because the swimmers reach higher swimming speeds with larger SL and consequently lowers SF. For Caputo, Lucas, Greco & Denadai (2000), an increase in propulsive efficiency or a decrease in drag, after a training period, may be related to a decrease in the SF and an increase in the SL to the same swimming speed. According to Yanai (2003), increasing the SF to achieve higher speeds results in a decrease of the body roll and an increase of fluctuations of the trunk. These combined changes result in a reduction of shoulder rotation preventing swimmers having benefits associated to the large rolling action of the upper trunk. Thus, the same author indicates that swimmers should adopt the lowest possible SF for a given speed, because a low SF requires a lower amount of forces applied to the non-propulsive directions to maintain the same range of body roll. As can be seen, there was an increase in MV and also in the SL, which meant that there was also an increase in the SI. Since SI can be considered a measure of technical efficiency of the swimmer (Latt, Jurimae & Haljaste, 2009; Barbosa et al., 2010), all swimmers increased their swimming technique in the 50 meters front and in the best stroke.

Considering that the girls reach peak height velocity at age 12 and boys at 14 years of age (Beunen & Malina 1996), and that the average age of this study is only 14.6 years, it was expected to verify significant differences in height over the weeks. As expected, all anthropometric parameters (height, LUL, LLL, arm span) showed significant differences and consequently increased over 28 weeks of training. It is noteworthy that the sizes of these parameters influence the performance of the swimmers. More specifically and according to a study of Pacheco, Grossl, Mann and Kleinpaul (2009), it was demonstrated a correlation between height and arm span with the times performed in the 50 meters front crawl.

The better was the performance of the swimmers the largest arm span and height values were observed. Thus and observing the results on arm span and height together with the performances of the swimmers, it appears that in the weeks where there are significant differences in height and arm span, the average performance of the swimmers also presents significant differences. With this and although concrete evidence is not presented, one can conjecture that the results are consistent with the study of Pacheco et al. (2009), where there is a correlation between height and arm span with the times performed in the 50 meters front crawl. Baxter-Jones and Mafulli (2002), Beunen and Malina (1996), and Damsgaard, Bencke, Matthiesen, Petersen and Muller (2001), indicate they need to perform more studies in this direction, since there is no association between regular training and growth, thus suggesting that exercise does not influence the development of these parameters.

Concerning the values observed in weight and BMI parameters, similar results were obtained by Leite et al. (2007), where the objective was to evaluate the body composition of swimmers at the end of 23 weeks of training. For the women there were no significant differences while the men showed significant differences only in the last three weeks of training for the BMI, as for the weight there was an increase in body mass of swimmers. A similar study conducted by Olkoski, Katzer, Mello, Matheus & Corazza (2010), where the aim was also to evaluate the body composition of swimmers at the end of 20 weeks of training, there was also an increase in the body mass of swimmers. According to Baxter-Jones, Thompson & Malina (2002), the weight can be influenced by regular training, thus resulting in a change in body composition of adolescents. More specifically, the training is associated with a decrease in fat mass in both sexes and occasionally an increase in lean mass in boys.

According to Baxter-Jones et al. (2002), the biological evaluation in studies that consider growth is imperative, since chronological age is quite limited in the assessment of maturation. According to Beunen and Malina (1996) and Baxter-Jones and Maffulli (2002), and altough there is no data to demonstrate the relevance sexual maturation in boys, the pubertal development of girls who play sports and those who do not practice is quite similar. In other words, the training does not affect the time or the progress of secondary sex characteristics of girls. As can be seen in the results obtained in the present study there was no differences over the 28 weeks of training in swimmers maturational stages, thus making it impossible to verify that anthropometric differences, biomechanical and performance would be caused by modifications of them.

Conclusions

We can conclude that the training planning during 28 weeks of training was effective in obtaining better performance in young swimmers for distances of 25 meters and 50 meters front crawl and in the best stroke technique, being shown the importance of aerobic and speed performances over short distances and also the importance of training volume. Over the 28 weeks of training an increase in the anthropometric (as expected) and biomechanical variables was found, which are consistent with the hypothesis that the SL is the main factor that should be improved to allow improvement in performance. Note that all these parameters can be used to allow monitoring the training and performance over a season without the use of sophisticated equipment.

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