13 - EFFECT OF SWIMMING TRAINING ON THE ANAEROBIC THRESHOLD AND CRITICAL SPEED DETERMINED FROM DIFFERENT DISTANCES IN YOUNG SWIMMERS

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Introduction

In swimming, technical ability and physiological aspects may interfere in a significant manner on the performance. In relation to physiological indexes, the blood lactate response during submaximal speeds have been extensively used to predict aerobic performance (OLBRECHT et al., 1985; WAKAYOSHI et al., 1993a; DENADAI et al., 2002; DEKERLE et al., 2005), aerobic training prescription (OLBRECHT et al., 1985; LA HARPE et al., 1989; MAGLISCHO, 1999) and evaluation of training effects (COSTILL, 1992; WAKAYOSHI et al., 1993b; SMITH et al., 2002).

However, due to the difficulties related to equipment and evaluation cost with blood lactate analysis, studies have proposed the critical swimming (CS) as an indirect method to determine aerobic capacity. It had presented high correlation level with anaerobic threshold (4 mM of blood lactate) (AT) (WAKAYOSHI et al., 1992; DENADAI et al., 2000), and aerobic swimming performance (OLBRECHT et al., 1985; WAKAYOSHI et al., 1992; DEKERLE et al., 2002; GRECO et al., 2003).

Is swimming, some studies have verified improvement (WAKAYOSHI et al., 1993; PYNE et al., 2001) or maintenance (CAPUTO et al., 2002; GRECO, DENADAI, 1998) of aerobic capacity after a period of training. Factors that can explain these contradictions may be related to different training conditions, as duration of the training period, the specialty of the swimmers (short, middle or long distance distances), the stroke emphasized in training and used in the evaluation process.

In general, when the swimmer is at the initial phase of the season the training is directed to aerobic performance improvement and the AT presents an increase after the training period (WAKAYOSHI et al., 1993b). However, this response may be different after a more intense period of training, with the increase of the anaerobic stimulus (PELAYO et al., 1996). There are no studies that had analyzed the response of CS determined form different distances to swimming training, since this aspect may modify the values and relationship with AT (GRECO et al., 2003). As performance at short distances (25 to 100 m) can be dependent mainly of anaerobic adaptations, the use of these distances on the regression equation may modify its response to training. Thus, the objective of this study was to verify the effect of swimming training in AT and CS determined from different distances, in swimmers aged 13 to 15 years.

Material and Methods

Experimental design

This study had a total duration of 16 weeks. In the 1st week, tests for determination of performance (25, 50, 100, 200 and 400 m), anaerobic threshold (4 mM of blood lactate) (AT) and critical speed (CS) were performed. After this, the athletes training for 14 weeks. Training was elaborated and prescribed by the their coach. In the 16th week, the athletes performed the same tests battery of the 1st week.

Subjects

Participated of this study 11 swimmers (5 boys and 6 girls) aged 13 to 15 years, who were in the training phase, and had the at least 3 to 5 years of experience in competitive swimming. The physical characteristics were: age = 13.54 ± 0.52 yr., body mass = 52.42 ± 4.03 kg and stature = 1.60 ± 0.06 m. The subjects were competing at a regional level, in events of 50 and 100 m front crawl stroke, and involved in a program of training 3 to 5 times per week with a weekly mean volume between 8000 and 20000 m. Before the participation in the study, the swimmers and their parents or guardians were informed of all procedures of the tests and they provided voluntary written informed consent to participate of the study. The protocol was approved by the university's ethics committee.

Determination of anaerobic threshold

The AT was determined trough the methodology proposed by Mader et al. (1976), using a fixed blood lactate concentration of 4mM. Two submaximal repetitions of 200 m were performed at 90 e 95% of maximal speed for the distance, with a passive recovery period of 15 to 20 minute. The swimmers were advised of the proper pace through visual signals expressed by an examiner beside the pool. After the 1st and 3rd minute of each repetition, 25 l of arterialized blood were collected from the ear lobe through a heparinized capillary, and immediately transferred to microcentrifuge tubes containing 50 l NaF (1%), for lactate measurement (YSL 1500 STAT, Yellow Springs, OH). Time to blood collection was 30 sec approximately. After each repetition, heart rate was recorded using a heart rate monitor (Polar X-Trainer Plus, Kempele, Finland). The speed corresponding to 4 mM was determined trough linear interpolation between the highest blood lactate concentration of each repetition and the respective speed.

Determination of critical speed

The critical speed (CS) was determined in accordance to Wakayoshi et al. (1992). During training sessions, the participants were instructed to swim distances of 25, 50, 100, 200 and 400 m, using the front crawl stroke, as quickly as possible; they were not instructed to swim at a constant speed. The time taken to swim each distance was recorded using a manual chronometer. One event was swum per day in random order. CS was determined as the slope of the linear regression between swimming distances and the time taken to swim them. For the determination of CS1 (25, 50 and 100 m), CS2 (50, 100 and 200 m) and CS3 (100, 200 and 400 m) different distances were used. Previous studies verified the validity of CS in children and adolescents as determined in this study (HILL et al., 1995; DENADAI et al., 2000).

Training Protocol

Training consisted of 14 weeks which were contained in a macrocycle of 6 months. These weeks corresponded to the specific (8 weeks) and competitive (6 weeks) periods. In this period, the week volume was between 8000 and 20000, approximately, and was performed in 3 to 5 weekly sessions. The main objective of training was the improvement of short and middle distance performance (50, 100 and 200 m). The intensity of the series was classified in 5 progressive effort levels, as follows: Resistance 2 (R2) series of 750 to 2000 m, Maximal oxygen uptake (VO_2) series of 1000 m, Tolerance (T) series of 1000 m, Power (P) series of 400 to 800 m and Race pace (RP) series of 200 to 800 m. The series of Power and Race pace were the most specific for the distances of 50, 100 and 200 m, as the intensity was similar or higher than the race. Table 1 shows the mean values of volume, week frequency and effort levels emphasized at different training weeks.

Table 1. Mean mean values of volume, week frequency and effort levels emphasized at different weeks.

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Week	Volume/week (m)	Volume/day (m)	Week frequency (sessions/week)	Effort level
1	11550	3850	3	R2
2	18000	3600	5	R2, VO2
3	15600	3900	4	R2, VO2
4	17700	3540	5	R2, P, RP
5	16500	3300	5	R2, P, RP
6	11900	3683	3	RP
7	20000	4000	5	R2
8	15000	3750	4	R2, P
9	19250	3850	5	R2
10	20050	4010	5	R2, P
11	15500	3500	4	RP
12	7500	2500	3	RP
13	12000	3000	4	R2, RP
14	15000	3000	5	R2, RP

R2 – Resistance 2, VO_2 – Maximal oxygen uptake, T - Tolerance, P – Power and RP - Race pace

Statistical analysis

The values were expressed as mean ± SD. The comparison of CS1, CS2, CS3 and AT was made using one-way ANOVA for repeated measures, with Tukey's post-hoc tests were appropriate. The comparison of performance, CS1, CS2, CS3 and AT before and after training was made by Student *t* test for paired data. Significance was set at $p < 0.05$.

Results

Table 2 presents the mean values of performance (m/s) obtained at distances of 25, 50, 100, 200 and 400 m, before (Pre) and after (Post) training period. There was an increase at the distances of 50, 100 and 200 m ($p < 0.05$).

Table 2. Mean values of performance (m/s) obtained at distances of 25, 50, 100, 200 and 400 m, before (Pre) and after (Post) training period. N = 11

	Pre	Post
25	1.56 ± 0.13	1.60 ± 0.16
50	1.40 ± 0.12	1.45 ± 0.13*
100	1.25 ± 0.13	1.32 ± 0.14*
200	1.12 ± 0.13	1.18 ± 0.13*
400	1.07 ± 0.12	1.09 ± 0.12

* $p < 0.05$ in relation to pre training value.

Table 3 shows the mean values (m/s) of CS1 (25, 50 and 100 m), CS2 (50, 100 and 200 m), CS3 (100, 200 and 400 m) and AT obtained before (Pre) and after (Post) training period. CS1 and CS2 were significantly higher than CS3 and AT pre and post training period ($p < 0.05$). There was no significant difference between CS3 and AT pre and post training period. There was an increase of CS1 and CS2 after the training period ($p < 0.05$).

Table 3. Mean values (m/s) of CS1 (25, 50 and 100 m), CS2 (50, 100 and 200 m), CS3 (100, 200 and 400 m) and AT obtained before (Pre) and after (Post) training period. N = 11

	Pré	Pós
VC1 (25/50/100)	1.16 ± 0.14†	1.25 ± 0.13*†
VC2 (50/100/200)	1.04 ± 0.13†	1.10 ± 0.13*†
VC3 (100/200/400)	1.01 ± 0.12	1.05 ± 0.15
LAn	1.05 ± 0.09	1.01 ± 0.11

* $p < 0.05$ in relation to pre training. † $p < 0.05$ in relation to AT and CS3.

Discussion

The objective of this study was to analyze the effect of training on the anaerobic threshold (AT) and critical speed (CS) determined from different distances in young swimmers. The main finding was that AT did not present and increase after training. However, the response of CS to training is influenced by the distances used on its determination.

Our finding about AT response to training disagree with other data obtained in the literature which verify an improvement of this variable after training in trained swimmers. Wakayoshi et al. (1993) found an increase on the AT (pre = 1.32, post = 1.35 m/s) and performance of 400 m (pre = 1.43, post = 1.47 m/s) after 6 months of swim training, that had the objective the improvement of aerobic performance. In this study, the aerobic training volume corresponded to more than 90% of total volume, which was 3000 to 8000 m per day and 24000 to 64000 m per week.

In another study, Pyne et al. (2001) analyzed the submaximal blood lactate response during a season in high trained swimmers, which competed in events ranging in duration from 50 to 1500 m. All testes were performed at the specific stroke of the swimmer. At 20 weeks that preceded taper for the main competition, the athletes performed a mean week volume of 54000 m. The objectives of the training sessions were to improve anaerobic and aerobic aspects of performance, depending on the specialty of swimmer. The speed corresponding to lactate threshold, determined trough the lactate-intensity curve obtained at incremental test improved after the 20 weeks (pre = 1.38, post = 1.41 m/s). The performance obtained at the incremental test increased, but competitive performance did not improve. There was no relationship between lactate threshold and performance variations. The authors suggest that is very difficult to improve performance in high trained athletes and that factors such psychological, technical and tactical could influenced the performance (FOSTER et al., 1994) beyond physical fitness.

However, our data are in accordance with Caputo et al. (2002) and Greco and Denadai (1998). Caputo et al. (2002) verified that the AT did not modified after 8 weeks of training, which corresponded to the specific period of the periodization. Greco and Denadai (1998) found a maintenance of AT in front crawl and an improvement at backstroke, after a specific period, in backstroke swimmers. In this study, the authors suggest that the AT improves in function of the higher swim volume performed by athletes in this stroke.

Thus, the response of AT to a period of training in swimming seems to be associated to the phase of periodization and stroke analyzed. In the present study the maintenance of AT probably occur by high intensity of training due to increase of the volume of anaerobic series for the improvement of short duration performance. Probably, these procedures promoted adaptations predominantly anaerobic, as yet demonstrated in the literature (PELAYO et al., 1996).

CS had been considered valid to determine AT (WAKAYOSHI et al., 1993; DENADAI et al., 2000; GRECO; DENADAI, 2005) and to estimate the aerobic training speed in swimming (FERNANDES, VILLAS-BOAS, 2000). However, it is influenced by duration of predictive workloads (HILL, 1993), as the shorter durations generate higher values. In a study performed by Greco et al. (2003) the authors verified in young swimmers, that this aspect may influence in the relationship with AT. There is no study that had verified the effect of training on the CS determined from different distances. In our study, only the CS determined from shorter distances (CS1 and CS2) presented improvement with training. When the greater distance (400 m) was incorporated, it presented the same behavior of AT. Although AT was determined using a fixed concentration, it had been extensively used on the determination of aerobic capacity in swimming (OLBRECHT et al., 1985, LA HARPE et al., 1989, WAKAYOSHI et al., 1993a; SMITH et al., 2002). Thus, in swimming, the distances used on the determination of CS interfere in the relationship with AT and response to training. When determined from longer distances, the CS have a similar behavior of AT after a specific training period.

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EFFECT OF SWIMMING TRAINING ON THE ANAEROBIC THRESHOLD AND CRITICAL SPEED DETERMINED FROM DIFFERENT DISTANCES IN YOUNG SWIMMERS

The objective of this study was to verify the effect of training on the anaerobic threshold (4 mM of blood lactate) (AT) and critical speed (CS) determined from different distances, in swimmers aged 13 to 15 years. Participated of this study 11 swimmers (6 girls and 5 boys), with 3 to 5 years of experience in the modality. Their physical characteristics were: age = 13.54 ± 0.52 yr., body mass = 52.42 ± 4.03 kg and stature = 1.60 ± 0.06 m. The swimmers are involved in a training program 5 times per week with a mean week volume between 8000 and 20000 m, approximately. At was determined trough linear interpolation between speed and lactate concentration obtained in two submaximal repetitions of 200 m. For the determination of CS1 (25, 50 and 100 m), CS2 (50, 100 and 200 m) and CS3 (100, 200 and 400 m) different distances were used. Training consisted of 14 weeks contained in a macrocycle of 6 months, which corresponded to the specific (8 weeks) and competitive (6 weeks) periods. At two moments of training, CS1 and CS2 were significantly higher than CS3 and AT. There was an improvement in the

performance (m/s) on the distances of 50 (1.40 ± 0.12 and 1.45 ± 0.13), 100 (1.25 ± 0.13 and 1.32 ± 0.14) and 200 m (1.12 ± 0.13 and 1.18 ± 0.13), and the speed (m/s) corresponding to CS1 (1.16 ± 0.14 and 1.25 ± 0.13) and CS2 (1.04 ± 0.13 and 1.10 ± 0.13), after training. Thus, in swimming, the distance used in the determination of CS interferes on its relationship with AT and response to training. When determined trough longer distances, CS have a similar behavior of AT after a specific training period. **- Keywords:** training, aerobic capacity, swimming.

L'EFFET DE L'ENTRAÎNEMENT DE LA NATATION AU SEUIL ANAÉROBIE ET À LA VITESSE CRITIQUE DÉTERMINÉE PAR LES DISTANCES DIFFERENTES ENTRE LES JEUNES NAGEURS

Le but de cette étude a été de vérifier l'effet de l'entraînement au seuil anaérobie (4 mM de lactate sanguin) (SA) et la vitesse critique déterminée par les différentes distances, entre nageurs de 13 à 15 ans. Onze nageurs ont participé à l'étude (6 fillettes et 5 garçonnets) ayant trois à cinq années d'expérience dans cette catégorie. Leurs caractéristiques physiques étaient : âge = 13,54 ± 0,52 ans, la masse corporelle = 52,42 ± 4,03 kg et la taille de 1,60 ± 0,06 m. Les nageurs étaient engagés dans un programme d'entraînement de cinq fois par semaine avec un volume moyen hebdomadaire entre 8000 et 20000 m, approximativement. Le SA était résolu à travers l'interpolation linéaire entre la vitesse et la concentration de lactate obtenue pendant deux répétitions au maximum de 200 m. Pour la détermination de la VC1, (25, 50 et 100 m), VC2 (50, 100 et 200 m) et VC3 (100, 200 et 400 m) différentes distances ont été employées. L'entraînemente consistait en 14 semaines consécutives dans le macrocycle de 6 mois, qui correspondaient aux périodes spécifiques (8 semaines) et compétitives (6 semaines). Pendant les deux périodes de l'entraînement, les VC1 et VC2 furent significativement supérieurs à VC3 et au SA. Il y eut amélioration dans la performance (m/s) dans les distances de 50 (1,40 ± 0,12 et 1,45 ± 0,13), 100 (1,25 ± 0,13 et 1,32 ± 0,14) et 200 m (1,12 ± 0,13 et 1,18 ± 0,13), et la vitesse (m/s) correspondante à VC1 (1,16 ± 0,14 et 1,25 ± 0,13) et VC2 (1,04 ± 0,13 et 1,10 ± 0,13) après l'entraînement. En conséquence, en natation la distance employée dans la détermination de la VC interfère dans son rapport avec le AS et dans la réponse à l'entraînement. Quand, déterminée à travers les distances plus longues, la VC se comporte de manière semblable au AS aprés une période spécifique d'entraînement.

De mots-clés: l'entrainement, capacité aeróbie, natation.

EFECTO DEL ENTRENAMIENTO DE NATACIÓN EN EL UMBRAL ANAEROBICO Y EN LA VELOCIDAD CRÍTICA DETERMINADA A TRAVÉS DE DIFERENTES DISTANCIAS EN NADADORES JÓVENES

El objetivo de este estudio fue verificar el efecto del entrenamiento en el umbral anaeróbico (4 mM del lactato sanguíneo) (UA) y en la velocidad crítica (VC) determinada a través de diferentes distancias, en nadadores de 13 a 15 años. Participaron del estudio 11 nadadores (6 niñas y 5 niños), con tres a cinco años de experiencia en la modalidad. Sus características físicas eran: edad = 13,54 ± 0,52 años, masa corporal = 52,42 ± 4,03 kg y estatura = 1,60 ± 0,06 m. Los nadadores estaban envueltos en un programa de entrenamiento cinco veces a la semana con un volumen medio semanal entre 8000 y 20000m, aproximadamente. El UA fue determinado a través de interpolación lineal entre la velocidad y la concentración de lactato obtenidos en dos repeticiones submáximas de 200 m. Para la determinación de la VC1 (25, 50 y 100 m), VC2 (50, 100 y 200 m) y VC3 (100, 200 y 400 m) fueron utilizadas diferentes distancias. El entrenamiento consistió en 14 semanas contenidas en un macrociclo de 6 meses, que correspondieron a los periodos específico (8 semanas) y competitivo (6 semanas). En los dos momentos del entrenamiento, las VC1 y VC2 fueron significantemente mayores de que la VC3 y el UA. Hubo mejoría en la performance (m/s) en las distancias de 50 (1,40 ± 0,12 y 1,45 ± 0,13), 100 (1,25 ± 0,13 y 1,32 ± 0,14) y 200 m (1,12 ± 0,13 y 1,18 ± 0,13), y en la velocidad (m/s) correspondiente a la VC1 (1,16 ± 0,14 y 1,25 ± 0,13) y VC2 (1,04 ± 0,13 y 1,10 ± 0,13), después del entrenamiento. Por lo tanto, en la natación, la distancia utilizada en la determinación de la VC interfiere en su relación con el UA y en la respuesta al entrenamiento. Cuando determinada a través de distancias más largas, la VC se comporta de forma similar al UA después de un periodo de entrenamiento específico.

Palabras-claves: treinamiento, capacidad aerobica, natation.

EFEITO DO TREINAMENTO DE NATAÇÃO NO LIMIAR ANAERÓBIO E NA VELOCIDADE CRÍTICA DETERMINADA ATRAVÉS DE DIFERENTES DISTÂNCIAS EM NADADORES JOVENS

O objetivo deste estudo foi verificar o efeito do treinamento no limiar anaeróbio (4 mM de lactato sanguíneo) (LAn) e na velocidade crítica (VC) determinada através de diferentes distâncias, em nadadores de 13 a 15 anos. Participaram do estudo 11 nadadores (6 meninas e 5 meninos), com três a cinco anos de experiência na modalidade. Suas características físicas eram: idade = 13,54 ± 0,52 anos, massa corporal = 52,42 ± 4,03 kg e estatura = 1,60 ± 0,06 m. Os nadadores estavam envolvidos em um programa de treinamento cinco vezes por semana com um volume médio semanal entre 8000 e 20000m, aproximadamente. O LAn foi determinado através de interpolação linear entre a velocidade e a concentração de lactato obtidos em duas repetições submáximas de 200 m. Para a determinação da VC1 (25, 50 e 100 m), VC2 (50, 100 e 200 m) e VC3 (100, 200 e 400 m) foram utilizadas diferentes distâncias. O treinamento consistiu de 14 semanas contidas em um macrociclo de 6 meses, que corresponderam aos períodos específico (8 semanas) e competitivo (6 semanas). Nos dois momentos do treinamento, as VC1 e VC2 foram significantemente maiores do que a VC3 e o LAn. Houve melhora na performance (m/s) nas distâncias de 50 (1,40 ± 0,12 e 1,45 ± 0,13), 100 (1,25 ± 0,13 e 1,32 ± 0,14) e 200 m (1,12 ± 0,13 e 1,18 ± 0,13), e na velocidade (m/s) correspondente à VC1 (1,16 ± 0,14 e 1,25 ± 0,13) e VC2 (1,04 ± 0,13 e 1,10 ± 0,13), após o treinamento. Portanto, na natação, a distância utilizada na determinação da VC interfere na sua relação com o LAn e na resposta ao treinamento. Quando determinada através de distâncias mais longas, a VC comporta-se de forma similar ao LAn após um período de treinamento específico.

Palavras-chave: treinamento, capacidade aeróbia, natação.