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ORIGINAL

EFEECTO DE LA CANTIDAD DE RESPIRACIONES POR BRAZADAS EN EL NADO CRAWL

THE EFFECT OF BREATH STANDARDS BY STROKES IN CRAWL SWIMMING

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ABSTRACT

Objective: The aim of the study was to analyze the amateur's performance of crawl swimming in different types of respiratory standards. The sample was composed of 32 swimmers of both sexes (37.12 ± 12.51 years). They were filmed at 25 meters of crawl swimming at maximum speed. There were no significant differences in the duration of the test and speed between respiratory standards. However, the stroke cycle of the R2 and R3 standards presented better results ($p < 0.05$). The Body Mass Index increased the time necessary for the completion of the test ($\beta = 0.39$). In conclusion, the R2 standard was more effective for amateurs.

KEY WORDS: swimming, crawl stroke, breath.

RESUMEN

El objetivo de este estudio es investigar los efectos de la cantidad de respiraciones realizadas por brazada en el desempeño del nado crawl. Participaron del estudio 32 nadadores de ambos géneros (37.12 ± 12.51 años). Los sujetos fueron grabados nadando 25 metros en el estilo crawl a velocidad máxima. No hubo diferencia significativa entre el tiempo de duración de la prueba y la velocidad promedio de los patrones respiratorios, sin embargo, los ciclos de brazadas de los patrones R2 y R3 presentaron mejores resultados ($p < 0.05$). La frecuencia de brazada de los patrones respiratorios R2 (0.64 ciclo/s) y R3 (0.65 ciclo/s) fueron menores ($p < 0.04$) en comparación con los patrones R4 y R5. El IMC aumenta el tiempo necesario para el rendimiento óptimo de la prueba ($\beta = 0.39$). Se concluye que el patrón respiratorio R2 fue el más eficaz para nadadores aficionados.

PALABRAS CLAVE: natación, nado crawl, respiración.

INTRUDUCTION

Swimming is a modality present in a significant portion of the population at global levels, utilized mostly as a rehabilitation sport for patients with some physical or muscular injury (da Silva, de Oliveira, & Conceição, 2005). This is one of the essential factors for the popularity of this sport in Brazil and consequently, it has an improvement and learning of the different swimming styles as crawl stroke, backstrokes, breaststroke and butterfly stroke (Massaud & Côrrea, 2008).

The crawl stroke is one variety of the styles inside this sport, each one needs several movement factors for a correct execution, such as the stroke, which is the main propulsion element; the leg stroke is the movement that gives stability to the body during the movement; the trunk, that helps to conserve the lateral alignment of the body and breath, which is necessary to provide the necessary oxygen (Marcos Roberto Apolinário, 2010). Identification of the biomechanics factors, like frequency of stroke, average speed and stroke index are important. These factors have higher influence over the drag and development of propulsion force (de Souza Castro, Guimarães, Moré, Lammerhirt, & Maques, 2005; Toussaint & Hollander, 1994).

While for the breath, it is understood that a lower amount of breath by stroke cycles will provide a better performance for the swimmer. This occurs for the active drag effect caused by the body's movements during the breath, promoting an increase of the time for displacement (Apolinario et al., 2012; Marcos Roberto Apolinário, 2010).

Although this literature's evidences were based on high-performance athletes, in which there are high levels of ability, they have the capacity to quickly adapt

to the changes in breath standard (Apolinário et al., 2007). Furthermore, it becomes fundamental to the professors of physical education a search in researches that have to do with this topic, like if less amount of breath causes a lower performance for beginner swimmers or similar topics. These data can be utilized for the planning and execution of the classes in terms of its objectives and contents to be worked. Thus, the aim of this study was to analyze the performance of amateurs of crawl swimming in different types of respiratory standards.

MATERIALS AND METHODS

PARTICIPANTS

The sample was composed of 32 amateur swimmers of both sexes (37.12 ± 12.51 years) belonging to a project in a public university in the state of Paraná. The inclusion criteria were: (1) being between 18 and 60 years old; (2) practicing swimming at least 2 times a week. The exclusion criteria were: (1) presenting some musculoskeletal injury; (2) having less than 4 months of swimming practice. The study was approved by the local ethics and research committee (Opinion No. 2.927.011) and, after the consent, volunteers were invited to sign the informed consent necessary for the study.

PROCEDURES

The swimming practice of each participant was recorded with a Samsung® Canon camera. The researcher recorded the entire course of the test, from the outer side edge of the pool to the end of it.

The participants performed a 10-minute warm-up according to the pattern adopted in Apolinário (2010)'s study. Assuming that this amount of minutes is sufficient to cause an increase in heart rate and activate the main muscles involved in the activity to be performed.

After the warm-up, the technical instructions of the crawl swim were delivered for a proper execution, the swimmer's initial position should be inside the pool, with the body in horizontal position and feet on the wall. After the signal made by a whistle sound, the swimmer began his crawl swim traveling 25 meters in test pace and in the breathing condition requested by the experimenter. Each participant executed the following breathing patterns: two breathing strokes (crawl R2); Three strokes to breathe (crawl R3); four strokes to breathe (crawl R4); five strokes for breathing (crawl R5) and free-breathing (crawl FB). In pair breaths, the swimmer chose his favorite side for breathing. The order of respiratory patterns by the swimmers was randomly defined through a raffle on an excel form.

At the end of each 25-meter series, the subject moved to a different lane to give way to the next participant. After the swimmer performed the swim with the first respiratory pattern requested by the researcher, he was granted a break of approximately 5 minutes to minimize the effect of fatigue. According to

Maglischo & do Nascimento (1999), in 25m tests there are two causes for fatigue: the decrease in muscle creatine phosphate (CP) reserves and the inability to make anaerobic metabolism operative quickly. After 5 minutes, the procedures for the second pattern were restarted and so on until the fifth respiratory pattern.

STUDY VARIABLES

To evaluate the performance of crawl swimming, the variables suggested by Caputo, De Lucas, Greco, & Denadai, (2008) and Hay (1981), were utilized, such as Stroke cycle, corresponding to the total of complete strokes made during the test; Stroke length (SL) which is the average horizontal distance traveled during the execution of a complete cycle of the arms; Stroke frequency (SF) which is the average number of complete cycle of the arms executed per second; Average speed (AS), the speed that the swimmer moves in the water; Stroke rate (SR) obtained by the product between the average speed and stroke length. According to Caputo et al., (2008) the higher the stroke rate, the swimmer's technique will be more effective.

The anthropometric measurements of body mass and height were obtained utilizing a calibrated digital scale with a maximum load of 180 kg and 0.1 kg scale, and a wooden stadiometer with 0.1 cm scale following the procedures described by Guedes (2006).

STATISTICAL ANALYSIS

For the statistical analysis, the Shapiro-Wilk test was utilized to verify the data normality. The repeated-measures ANOVA was used for the comparison of the dependent variables "duration", "stroke cycle", "stroke length", "stroke frequency", "average speed" and "stroke rate" between the respiratory patterns (R2, R3, R4, R5 and FB), followed by Bonferroni's post-hoc to identify where the differences between each one were.

Consequently, an multivariate statistical procedure named Cluster Analysis (Marôco, 2014) was utilized through the non-hierarchical K-means method, in order to classify swimmers into two technical performance groups (cluster 1 - worst technical performance: n = 21, cluster 2 - best technical performance: n = 11), where the variable "stroke rate" was used in the model. From the creation of the groups, the t-test for independent samples was used to compare indicators of body size, age, and frequency in training of both groups. Finally, a multiple linear regression analysis was performed to estimate the relative contributions of anthropometric and technical variables on the time (seconds) of swimmers in different swimming conditions, such as sex, age, and weekly training frequency.

RESULTS

Table 1 presents the anthropometric characteristics of the swimmers

Table 1. Anthropometric Characteristics of the sample.

	Mean	Standard Deviation	Minimum	Maximum
Age (years)	37.12	12.51	18.00	60.00
Height (m)	1.71	0.10	1.46	1.89
BM (kg)	74.30	12.17	55.90	100.20
BMI (kg/m²)	25.15	3.24	20.99	36.21

Note: m = meters; kg = kilograms.

Table 2 presents the comparison between the “duration”, the number of stroke cycles, stroke frequency, average speed and stroke rate in the respiratory patterns R2, R3, R4, R5 and FB.

Table 2. Comparison between the duration, number of strokes cycles, stroke frequency, average speed and stroke rate between the respiratory patterns of subjects

	R2	R3	R4	R5	FB
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Duration (s)	20.93 (4.23)	21.31 (4.08)	21.12 (3.98)	21.37 (4.40)	21.09 (4.34)
Average Speed (m/s)	1.23 (0.23)	1.21(0.23)	1.22 (0.23)	1.21 (0.24)	1.23 (0.24)
Number of Stroke cycles (cycles)	13.50 (3.02) ^{bcd}	13.78 (2.79) ^{bcd}	14.21 (3.00)	14.40 (3.03)	14.65 (3.00)
Stroke Length (m/cycle)	1.95 (0.50) ^{bcd}	1.88 (0.39) ^{cd}	1.84 (0.45)	1.81 (0.40)	1.77 (0.35)
Stroke Frequency (cycle/s)	0.64 (0.09) ^d	0.65 (0.09) ^d	0.67 (0.10)	0.68 (0.10)	0.70 (0.10)
Stroke Rate (m²/cycle*s)	2.50 (1.03) ^{bcd}	2.35 (0.85)	2.33 (0.93)	2.27 (0.88)	2.24 (0.81)

Note: ^aDifference for R3; ^bDifference for R4; ^cDifference for R5; ^dDifference for FB. s= seconds; m= meters.

Significant differences were not observed between the variables “duration” and “average speed” in the respiratory patterns, which shows similarity in performance. However, the stroke cycle presented a difference between the patterns R2 and R3 with the rest of respiratory patterns ($p < 0.05$). The stroke height in R2 pattern presented a significant difference with the R4, R5 and FB.

Meanwhile, Table 3 presents the comparison between the variables related with body size, age and frequency in swimming classes between the subjects that presented worst and better technical performance.

Table 3. Anthropometric characteristics of the amateur swimmers.

	Cluster 1 (n=21)	Cluster 2 (n=11)
	Mean (SD)	Mean (SD)
SR (m²/cycle*s)	1.80 (0.43)	3.36 (0.58)*
Age (Years)	39.85 (11.56)	31.90 (13.12)
Height (m)	1.68 (0.11)	1.77 (0.04)*
BM (Kg)	72.80 (13.90)	77.18 (7.65)
TF (cant.)	2.61 (0.49)	2.54 (0.52)

Note: m = meters; kg = kilograms; quantitative = quantity; SR = Stroke rate; BM = Body Mass; FE = Training Frequency; (cluster 1 – worst technical performance, cluster 2 – better technical performance); * $p < 0.05$.

It is observed that the height of the group that showed better technical performance (cluster 2) was higher than the group with worst technical performance ($t = -2.88$, $p = 0.01$), indicating that swimmers with greater stature have an advantage in the execution of movements related to crawl swimming. The kilograms ($t = -1.14$; $p = 0.26$), age ($t = 1.76$; $p = 0.08$) and the weekly training frequency ($t = 0.39$; $p = 0.69$) do not show significant differences between the mentioned groups.

When it was analyzed, the influence of anthropometric variables in the test duration (table 4), adjusted by sex, age and training frequency, only the IMC maintains the correlation with the total duration of the test in all respiratory patterns. The body mass presented a significant relation only in the respiratory patterns R2 and R3. Of the technical variables, the stroke frequency was the only one that did not obtain significant differences. The variables of stroke height and stroke rate have positive influence in the performance of all the respiratory patterns, resulting in a negative β , the stroke length being the variable that has the greatest impact on crawl swim performance, however, stroke cycles increase the test time by approximately 0.75 seconds in each new stroke cycle.

Table 4. Multiple linear regression between anthropometric and technical variables with test duration.

	Beta Coefficient (β) of Respiratory Patterns				
	R2	R3	R4	R5	FB
BM (kg)	0.11 (0.05)*	0.11 (0.05)*	0.10 (0.05)	0.11 (0.55)	0.11 (0.06)
Height (m)	-5.47 (8.19)	-1.21 (8.08)	-2.96 (8.68)	-3.88 (8.90)	-10.28 (9.0)
BMI (kg/m²)	0.40 (0.15)*	0.36 (0.14)*	0.35 (0.16)*	0.39 (0.16)*	0.49 (0.16)*
Stroke Cycle (cycles)	0.75 (0.16)*	0.73 (0.17)*	0.74 (0.17)*	0.72 (0.18)*	0.81 (0.17)*
Stroke Height (m/cycles)	-3.51 (1.05)*	-4.81 (1.20)*	-3.83 (1.19)*	-5.04 (1.35)*	-6.08 (1.51)*
Stroke frequency (cycle/s)	-1.47 (5.66)	-3.03 (5.77)	-5.30 (5.66)	-5.38 (5.85)	-7.70 (6.06)
Stroke Rate (m²/cycle*s)	-2.49 (0.45)*	-3.27 (0.45)*	-2.94 (0.47)*	-3.35 (0.51)*	-3.92 (0.52)*

Note: All variables were grouped by sex, age and training frequency. *= $P < 0.05$.

DISCUSSION

The aim of this study was to investigate the effect of the amount of stroke breaths on crawl performance. As an initial hypothesis, it is understood that the lower amount of breathing per stroke cycle would result in a better swimmer performance due to the effect of active drag caused by body movements during breathing (Marcos Roberto Apolinário, 2010). This hypothesis was confirmed by studies with high performance athletes (Apolinario et al., 2012; Marcos Roberto Apolinário, 2010, 2016; Maglischo & do Nascimento, 1999; Payton, Bartlett, Baltzopoulos, & Coombs, 1999). In the present study, this hypothesis was partially proven because the swimming velocity, which is generally considered in the comparisons, was not influenced by the breathing pattern. However, subtle differences were found in the variables that make up the movement cycle and that for the teaching-learning process can influence the technical execution.

Regarding the “number of stroke cycles”, patterns R2 and R3 presented lower averages compared to the other patterns, which suggests lower energy expenditure to perform the race (25m). Similarly, the “stroke length”, represented by the distance traveled during a complete cycle of the swimmer's arms, was higher in the breathing patterns R2 and R3 compared to the others, which indicates a better stroke length in the conditions in which one breathed every two or three strokes.

Improvement in performance by decreasing and even absence of breathing pattern during the race was found in a study by Apolinario et al., (2012), who investigated the effects of different breathing patterns on crawl performance, and found that the apnea breathing condition caused better average velocities, frequency and stroke length when compared to bilateral, preferred side and non-preferred side stroke conditions. Possibly, the action of breathing has an effect on the propulsive and aquatic phases of the crawl stroke (Apolinario et al., 2012; Marcos Roberto Apolinário, 2010, 2016; de Souza Castro et al., 2005; Moré, Carpes, & Castro, 2007).

Moreover, when the results presented are analyzed collectively, they suggest that the use of breathing patterns did not improve the average velocity and duration, but amateur swimmers employed higher stroke rates in the breathing patterns R4, R5 and RL, which indicates a greater effort and energy expenditure for the 25 m race in these conditions. Possibly, breathing interferes with the swimmer's position in such a way that it causes a greater oscillation at the moment of the trunk rolling (Maglischo & do Nascimento, 1999; Payton et al., 1999).

Therefore, it is observed that amateur swimmers should prioritize the quality of the stroke movement execution in order to obtain a longer length, because this feature could be confirmed with the stroke index results. The R2 breathing pattern had a better stroke rate compared to all four other swimmers.

We also noticed that for amateur swimmers there is a natural selection because of the anthropometric parameters. It was observed that the subjects that

obtained the best technical qualification were those with the highest stature. Possibly associated with greater stature is the largest wingspan. In displacement over water, therefore, a larger wingspan allows a greater possibility of stroke length.

Multiple linear regression showed that for amateur swimmers, the number of stroke cycles has a negative influence on the 25-meter swimming performance. However, stroke length and stroke rate are variables that positively influence performance. Unlike competitive swimmers who require longer stroke cycles, the swimmers in this sample show better results when stroke length is longer, demonstrating that movement efficiency is a predominant factor in Crawl swimming in this population.

The IB appears to be an appropriate measure of swimming technique, the higher its value the better its movement. For swimmers of moderate performance over short and moderate distances, IB is a good predictor of the crawl technique (Caputo et al., 2008). This was found in the present study, in which each IB unit improves the race time by approximately 3 seconds (β mean = 3.19). Thus, the stroke index can be used as a variable of performance and movement efficiency, also proved by the present study.

Considering that both frequency and length are interdependent on freestyle performance and that, for improved performance, the swimmer needs to increase one of these variables and must ensure that does not significantly decrease the other (Hay, 1981), the percentage variation of Beta ($PV\beta$) confirmed that, for the population studied, the R2 pattern was more efficient.

We admit that there is a limitation in this study, because the age range of volunteers is heterogeneous (18 to 60 years), which makes it difficult to generalize the results found for certain ages. However, the results showed an understanding of the influence of breathing in a population that seeks swimming for health and not for competitive bias. It is suggested that further studies be conducted analyzing different modalities of swimming, populations and a smaller range of participants and sample age. As practical applications, the use of the R2 breathing pattern is recommended in order to obtain better rates of technical development and the planning of pedagogical procedures that seek the execution of a greater range of motion, which may, in the near future, lead acquisition of wider movements.

CONCLUSION

It was concluded that the R2 breathing pattern was more effective for amateur swimmers, as it helped to balance the technical variables in the 25 m race. Velocity for these amateur swimmers is rated in R2, more for length than stroke frequency, and BMI was an indicator that it had a negative influence on race time in different breathing patterns, suggesting that body size may be a limiting factor. In this sense, we suggest the adoption of $PV\beta$ as a complementary diagnostic variable on swimming quality for this population.

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