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ORIGINAL ARTICLE

High intensity intermittent vs race pace 200-m swimming

Nikolaos Beidaris ✉. *School of Physical Education and Sport Science. National and Kapodistrian University of Athens. Athens, Greece.*
Theodoros Platanou. *School of Physical Education and Sport Science. National and Kapodistrian University of Athens. Athens, Greece.*

ABSTRACT

This study aimed to investigate the physiological responses and performance characteristics of high intensity intermittent swimming with different resting intervals, compared to high intensity race pace continuous swimming. Twelve young male competitive swimmers (aged: 15.46 ± 1.45 years) were tested in 4 exercise conditions: in a continuous maximum 200-m freestyle swim and in 4x50-m freestyle with 5, 10 and 20s rest intervals between splits. In all conditions, oxygen consumption, blood lactate concentration, heart rate, performance characteristics, and ratings of perceived exertion were measured.Blood lactate concentration and oxygen uptake were no different between conditions (p = .98 and p = .39). Overall performance time of the 200-m swimming was faster with the 20s rest intervals (137.12 ± 7.78 vs 149.33 ± 9.27 sec, p = .004), and a heart rate was higher (195.38 ± 11.87 vs 184.23 ± 5.26 beat·min^{-1}, p = .01) than in 200-m continuous swimming. The velocity and the number of strokes remained constant between every 50-m split of the 4x50-m swim with 20s rest interval, as opposed to the decreasing velocity in the continuous high intensity race pace 200-m condition (p < .05). Differences in the intermittent conditions of shorter rest interval (5 and 10-sec) were limited only to decrements of speed between the splits (p < .05). Despite the similar lactate and VO_2 responses between all conditions, swimmers were swimming at a higher intensity and a constant velocity in the 4x50-m trial with 20s rest interval, while the conditions with 5 and 10-sec rest intervals matched the performance characteristics of the 200-m continuous swim.
Keywords: Performance analysis, VO_2, Blood lactate, Heart rate, Maximum velocity, Stroke rate.

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✉ **Corresponding author.** *School of Physical Education and Sport Science. National and Kapodistrian University of Athens. Athens, Greece.*
E-mail: nmpeintaris@phed.uoa.gr
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INTRODUCTION

To maximize performance in competitive swimming various modes of training such as high intensity interval training, repetition training, race pace training, ultra-short race pace training (USRPT), have been used. The use of high intensity intermittent training, also referred to as "*broken swimming*" is usually applied to optimize performance and maintain a particular race tempo (Maglischo EW., 1993). Recently (Nugent F, Comyns T. & et al., 2019) mentioned that swimming events of <200-m (50 and 100-m) are more dependent on alactic-anaerobic and lacticanaerobic energy supply, and >200-m on aerobic energy supply. The event of 200-m is at the crossroads of energy providing systems, and training with high intensity intermittent training of short breaks can stimulate the desired adaptations. High intensity interval training can be superior to medium intensity continuous training in terms of increasing mitochondrial content to a similar or better extent, despite a reduced exercise volume (MacInnis MJ & Gibala MJ., 2017). This has been already confirmed during swimming training, with competitive swimmers (Nugent FJ, Comyns TM & et al., 2017). High intensity interval swimming of short distances during training often elicit higher velocities that can contribute to improvements of race pace velocities, due to metabolic and neural adaptations (Mujika I, Busson T & et al., 1996; Sperlich B, Haegele M & et al. 2009). Some have suggested that the pace in swimming sets during high intensity training should be faster than race pace, in order to improve the swimmers' performance (Rinehardt KF, Axtell RS & et al. 2002), while others have suggested that the velocity of intermittent short distance training should be kept at race pace (Rushall BS., 2013). Training at race pace allows swimmers to improve their technique at the specific velocity of their competitive event, concurrently with the adaptations that take place to provide the energy sources required at a high metabolic rate (Rushall B.S., 2018).

The duration of the resting interval between the repetitions is important for high intensity swimming training. With short resting periods it is possible to practice at a high intensity using a specific technique and energy systems without the devastating results of exhaustion. The physiological demands and the performance characteristics of an attempt are very important for coach who needs to analyze the training data and to gain feedback for the results of a method as a way for achieving the competition goals. In the existing literature it still remains unclear how different duration rest intervals in high intensity intermittent swimming, compare to the continuous targeted swimming event. Therefore, the purpose of this study was to compare the physiological responses, the swimming velocity and performance characteristics of a 200-m freestyle swimming event, to 3 modes of high intensity intermittent swim bouts of 4×50-m freestyle, with three different rest intervals: 5, 10 and 20s between the splits. We further anticipate to find which of the three rest intervals matches the best the velocity and performance characteristics of the 200-m freestyle event. The hypothesis was that the longer the rest intervals in 4×50-m high intensity intermittent swimming, as compared to the continuous race pace 200-m freestyle swim, the better the performance characteristics will be, with no major changes in physiological responses.

MATERIAL AND METHODS

Experimental design and measures

In a repeated measures experimental design, swimmers were tested in four exercise conditions: 1) in a continuous race pace maximum 200-m freestyle swim condition, 2) in an intermittent high intensity swim condition of 4×50-m freestyle swimming with 5s rest interval between splits, 3) in an intermittent high intensity swim condition of 4×50-m freestyle swim with 10s rest interval between splits, and 4) in an intermittent high intensity swim condition of 4×50-m freestyle with 20s rest interval between splits.

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Participants

Twelve young male competitive swimmers (age: 15.46 ± 1.45 years, height: 172.38 ± 9.08 cm, body mass: 63.41 ± 10.81 kg and 100-m freestyle best performance 65.9 ± 2.2s) participated at this study. The choice criterion of the swimmers was to have at least five years of training experience and participation at two final championships of their age category. The participants and the parents of the adolescent participants signed a consent form with explained protocol. All athletes provided a written informed consent before the commencement of the study. The study was approved by the Faculty review board and conformed to the declaration of Helsinki.

Instruments and procedures

In all conditions, the following physiological and performance variables were measured: a) oxygen consumption (VO2000 Breeze Lite, MedGraphics, USA), b) blood lactate concentration (Accusport, Boehringer, Germany), c) heart rate (Polar, Vantage NV, Finland), d) performance characteristics: performance time, mean velocity and number of strokes, and e) ratings of perceived exertion (Borg scale). All tests were conducted within two weeks for all subjects, from the first to the last of the four exercise conditions. The tests took place in a 50-m swimming pool at the end of the general microcycle. The temperature and the humidity was 21.16 ± 2.5º and 46.85 ± 12.73% respectively. In addition, the participants did not trained at all, 48 hours before the experiments. A same warm-up was followed by all swimmers before the conditions (600-m moderate swimming of all strokes, including kicking and short sprints crawl), to avoid any undesirable effects their athletic performance. All measurements were conducted at the same time (17:00-20:00).

In the beginning, a VO_{2max} test (400-m free style swimming) was conducted to estimate the maximal oxygen consumption using the backward extrapolation method (Leger LA, Seliger V, & et al. 1980; Montpetit RR, Leger LA & et al., 1981). According to that method, the air is collected at the end of exercise in 4 different times of 20s and then a linear backward regression is conducted. Next, each participant swam on separate days either, 200-m or 4×50-m freestyle swimming at maximum intensity with either a 5, 10 or 20s rest interval between splits. At the end of each test, the O_2 deficit was calculated by measuring the exhaled air for 2 minutes during recovery. Immediately after the swimming test, the participants exhaled directly into a respiratory valve connected to the metabolic card. During each test, heart rate was recorded every 5s. The first pulse that recorded after the finishing of every attempt at the start of the next calculated as the pulse of 5s interval. The rate of perceived exertion (RPE) was measured at the end of the test using the 15-Borg scale (Borg AG., 1982). Blood samples for lactate concentration measurement were taken at the beginning of 3rd, 5th and 7th minute of rest, by a nurse with great professional experience at hospital health care. The performance time was recorded with digital chronometers (Casio, Japan) for each 50-m split and for the total distance by two timekeepers, with training experience more than 10 years. The total number of strokes were measured by videotape analysis. A SVHS video camera (Panasonic MS5, Japan, 50Hz, 720X576 resolution) located perpendicular to the swimmer's motion was used to record all swimming trials for stroke numbers. Thereafter, the recorded video were analysed using a Hitachi M348, Japan Unit. Each frame image could be viewed in forwards or reverse mode at any chosen speed, permitting multiple viewing and movement analysis. The total swim time of each athlete was measured by subtracting the resting time given between distances from the total time achieved of the total time of the test.

Statistical analysis

All results are expressed as mean values (±SD). One way ANOVA for dependent samples was used to define the overall differences between swim conditions in each variable. Furthermore, one way ANOVA for dependent samples with repeated measurements was used to define differences in each variable between

50-m swims. A 4X4 Anova was used for performance and number of strokes in 4 splits and in 4 conditions. A Tukey post-hoc test was employed to assign specific differences.

As a measure of effect size the Cohen's d was calculated by dividing the difference between sample means by the standard deviation of difference scores. Values of 0.20, 0.50 and above 0.80 were considered as small, medium and large, respectively (Cohen J., 1988). Significance level was set at $p \leq .05$. All procedures were performed using SPSS 29.0 statistical software (SPSS Inc., Chicago, IL, USA).

RESULTS

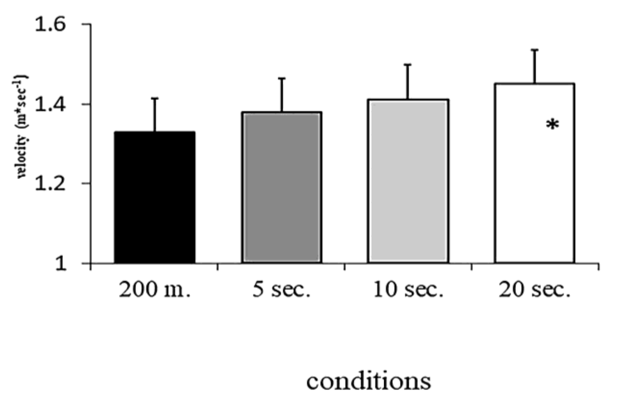
Physiological parameters and rate of perceived exertion in four swimming conditions

The mean VO_{2max} for all participants was 2.83 ± 0.69 $l·min^{-1}$. No significant differences in blood lactate concentration and oxygen uptake between swim conditions were detected ($p = .98$ and $p = .39$). Significant differences were only observed for the heart rate ($F = 3.31$, $p = .03$). In particular, the mean heart rate was significantly higher between the intermittent high intensity and the continuous race pace 200-m swimming (195.38 ± 11.87 vs 184.23 ± 5.26 $beats·min^{-1}$, $p = .01$, d=1.30), in the condition with the 20s rest interval (Table 1).

Table 1. Mean values, standard deviation and significant differences into physiological variables and RPE between 12 swimmers at 200-m continuous swimming and "*broken*" swimming 4×50-m with 5, 10 and 20s rest interval.

Parameters	Swimming conditions				Sig.
	200-m	4×50-m 5s	4×50-m 10s	4×50-m 20s	
La ($mmol·l^{-1}$)	7.58 ± 2.51	7.30 ± 2.15	7.38 ± 1.82	7.53 ± 1.61	n.s.
HR ($beats·min^{-1}$)	184.23 ± 5.26 *	190.61 ± 9.47	189.53 ± 8.42	195.38 ± 11.87	.015
VO_{2peak} ($ml·kg·min^{-1}$)	45.45 ± 15.14	39.76 ± 14.05	44.72 ± 12.43	44.47 ± 13.03	n.s.
$l·min^{-1}$	2.81 ± 0.85	2.45 ± 0.74	2.79 ± 0.82	2.77 ± 0.89	n.s.
VO_{2max}	47.84 ± 15.73	41.33 ± 14.24	45.65 ± 12.01	46.22 ± 13.33	n.s.
RPE	17.69 ± 0.85	17.61 ± 0.76	17.38 ± 0.96	17.76 ± 0.72	n.s.

*Note. HR = heart rate, La = accumulation of galactic acid, VO_{2peak} = peak of maximum oxygen uptake, VO_{2max} = maximum of oxygen uptake, RPE = 15 points scale of perceived exertion (*statistical significance, between 200-m continuous swimming and 4×50-m with 20s rest interval, $p < .05$).*



Note. (*) Significant difference between 200-m and 4×50-m with 20s interval time, $p < .05$.

Figure 1. Mean swimming velocity of 12 swimmers ($m·s^{-1}$), in the continuous 200-m freestyle and the race pace "*broken*" (4×50-m) swim with 5, 10 and 20s rest intervals.

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Performance characteristics in four swimming conditions

Significant differences in overall performance time (F = 4.27, *p* = .00) and mean swimming velocity (F = 4.15, *p* = .01) between conditions were detected. Similarly to heart rate a statistically significant higher velocity was also only observed between the intermittent high intensity swimming condition with the 20s rest interval and the continuous race pace 200-m swimming (1.45 ± 0.09 vs 1.33 ± 0.08 $m \cdot s^{-1}$, *p* = .00, d = 1.41, Figure 1).

Performance time and stroke number

Performance time in each 50-m split of the four experimental conditions is depicted in Table 2. Within groups in the 200-m continuous swim and in the 4×50-m intermittent high intensity swim with 5 and 10s rest intervals, every next 50-m split was significantly slower than the initial 50-m (*p* < .05, d = 1.16, 1.79 and 1.44, respectively). However, in the 4×50-m intermittent high intensity swim with the 20s rest interval, the performance times between all 50-m split swims was similar.

Performance time between the 4×50-m intermittent high intensity splits with the longest (20s) rest intervals, were significantly faster than the 50-m splits of the continuous race pace 200-m for the 2nd, 3rd and 4th 50-m swim (*p* < .05, d = 1.41, 1.67 and 1.72, respectively) (Table 2).

Table 2. Swimming performance time for every 50-m split in the continuous 200-m freestyle and the race pace "*broken*" (4×50-m) swim with 5, 10 and 20s rest intervals. All values are mean ± SD.

Conditions	1st 50-m split (s)	2nd 50-m split (s)	3rd 50-m split (s)	4th 50-m split (s)	Mean split (s)
200-m	34.70 ± 2.48	37.82 ± 2.88*	38.88 ± 2.19*	37.93 ± 2.01*	37.33 ± 2.83
4X50-m (5s)	33.50 ± 2.38	36.42 ± 2.20*	37.32 ± 2.26*	37.15 ± 1.93*	36.10 ± 2.64
4X50-m (10s)	33.48 ± 2.42	35.62 ± 2.27*	36.43 ± 2.28*	36.06 ± 2.05*	35.40 ± 2.48
4X50-m (20s)	32.87 ± 2.42#	34.38 ± 1.99*,#	35.20 ± 2.21*,#	34.66 ± 1.80*,#	34.28 ± 2.23**

Note. (*) Significant difference between 1st and 2nd, 3rd, 4th 50-m for all conditions. (#) Significant difference between conditions 200-m continuous swimming and race pace "broken" swim (4×50-m) with 20s rest interval at the 2nd, 3rd, 4th 50-m split. (**) Significant difference between 200-m continuous swimming and race pace "broken" swim (4×50-m) with 20s rest interval (p < .05).

Furthermore, differences in stroke number were observed within 50-m swims. The only significant changes observed were in the 200-m continuous swim, with the stroke number in the 3rd and 4th splits increasing significantly compared to the 1st and 2nd splits. Small differences observed between 1st and 4th split, 2nd and 3rd split, 2nd and 4th split. (*p* < .05, d = 0.32, 0.32 and 0.35, respectively). Also, the stroke number of only the 4th split of the 4×50-m intermittent high intensity condition with the 10s rest interval, was significantly higher than the 2nd split. No significant differences were observed between the different conditions (Table 3).

Table 3. Stroke count for every 50-m split in the continuous 200-m freestyle and the race pace "*broken*" (4×50-m) swim with 5, 10 and 20s rest intervals. All values are mean ± SD.

Conditions	1st 50-m split (number of strokes)	2nd 50-m split (number of strokes)	3rd 50-m split (number of strokes)	4th50-m split (number of strokes)	Mean (number of strokes)
200-m.	46.53 ± 4.99*	46.38 ± 4.92#, **	48.00 ± 5.21	48.15 ± 5.14	47.26 ± 4.98
4×50-m. (5s)	48.07 ± 6.07	48.00 ± 5.53	49.46 ± 5.93	49.46 ± 5.51	48.75 ± 5.64
4×50-m. (10s)	47.84 ± 5.52	47.38 ± 5.76**	48.76 ± 5.10	48.92 ± 5.07	48.23 ± 5.25
4×50-m. (20s)	47.15 ± 4.94	46.84 ± 5.32	48.23 ± 5.71	48.30 ± 5.32	47.63 ± 5.21

Note. (*) Significant difference between the 1st and the 4th50-m split. (#) Significant difference between the 2nd and the 3rd 50-m split. (**) Significant difference between 2nd and 4th 50-m splits (p < .05).

Recovery heart rates between the 50-m split rest intervals were significantly different. The mean recovery heart rate in 20 and 10s was significantly lower than in 5s (Table 4), (182.72 ± 9.93 and 184.55 ± 8.82 vs 190.08 ± 12.42 beats·min^{-1}, $p < .05$, d = 0.66 and 0.52, respectively).

Table 4. Recovery heart rate values after every 50-m split in the race pace "*broken*" (4×50-m) swim conditions with 5, 10 and 20s rest intervals. All values are mean ± SD.

Conditions	1st to 2nd 50-m (beats·min^{-1})	2nd to 3rd 50-m (beats·min^{-1})	3rd to 4th 50-m (beats·min^{-1})	Mean (beats·min^{-1})
4×50-m. (5s)	191.58 ± 11.95	188.00 ± 10.88	190.66 ± 14.90	190.08 ± 12.42
4×50-m. (10s)	185.91 ± 9.39*	184.50 ± 9.04	183.25 ± 8.59*	184.55 ± 8.82*
4×50-m. (20s)	183.83 ± 8.95**	183.08 ± 10.80**	181.25 ± 10.63**	182.72 ± 9.93**

Note. (*) Significant difference in recovery heart rate values between swim conditions with 5, 10 and 20s rest interval. (**) Significant difference between swim conditions with 5 and 20s rest interval (p < .05).

DISCUSSION

The study compared the physiological responses, the swimming velocity and performance characteristics between the continuous race pace 200-m freestyle swimming event to the intermittent high intensity (4×50-m) swim trials with 3 different rest intervals of 5, 10 and 20s During intermittent high intensity swimming with a 20s rest interval swimmers were able to produce faster than the actual event's velocities in all splits, while maintaining similar lactate and O_2 consumption rates. However, during intermittent all-out high intensity swimming with 5 and 10s they produced slower velocities in all splits but similar to those of the continuous 200-m race pace freestyle swim.

Training to achieve peak velocity during events <200-m, can be accomplished by applying various training methods (Nugent FJ, Comyns TM & et al., 2017). Interval training, race pace training, ultra-short race pace training (USRPT) have been used interchangeably, most of all falling under the category of high intensity interval training (HIIT) often times addressing, but not defining the exact amount of intensity or duration of rest intervals (Nugent FJ, Comyns TM & et al. 2018; Nugent F, Comyns T & et al., 2019; Rushall BS 2013, Rushall BS 2018). Intermittent high intensity swimming of a competitive distances of <200-m, is a training method basically intended to reproduce the velocity and performance of the event it is used to model. This has previously been referred to as "*broken race pace*" swimming, and the interval time has been proposed be short between splits (Maglischo, E. W., 2003). So far, no studies in swimming have determined the difference in physiological and performance characteristics of variable lengths of resting time between splits during 200-m intermittent crawl swimming, compared to the continuous event. A high competitive performance in events <200-m is usually achieved when swimmers maintain their highest race pace velocity (max-Velocity) throughout most of the distance (Nugent F, Comyns T & et al. 2019; Figueiredo P, Zamparo P & et al. 2011). As a training method this has been also traditionally observed in many runners to stay that have demonstrated that intermittent runs enable runners to remain at maximal oxygen uptake for longer time than intense but continuous runs (Billat LV, Slawinski J & et al. 200).

Energetics of intermittent and continuous 200-m competitive freestyle swimming

Energetically the 200-m crawl swimming appears to derive approximately 65.9% of its energy intake from aerobic metabolism, 13.6% from anaerobic-lactate metabolism, and 20.4% from the lactic anaerobic metabolism (Figueiredo P, Zamparo P & et al. 2011). In the same study the aerobic contribution between each 50-m lap, in 200-m crawl swim was shown to increase from 44.6, to 73.2, to 83.3 to 66.6% for the final 50-m, with expectable decreases in the anaerobic lactic (14.1, 5.0, 4.4 and 28.1%) and anaerobic alactatic

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(41.3, 21.8, 12.3 and 5.2%) contributions. Sousa AC, Figueiredo P & et al. (2011) studied the VO_2 kinetics of the 200-m freestyle swim at a race pace intensity and confirmed a high reliance (78.6%), on aerobic energy contribution. In the present study, the calculated energy expenditure based on the percentage on % of VO_{2max} was >86.57%, for all durations of intermittent breaks, with no major differences between variations and the continuous swim. Also, the lactate concentration values, and the rate of perceived exertion were similar in all three different rest intervals (5,10 and 20s) and the 200-m continuous swimming (Table 1).

Similar lactate concentration between intermittent and continuous 200-m swim has also been observed in several other studies, confirming that metabolically the energy requirements of the intermittent high intensity swimming with short intervals is similar to continuous swimming (Pelayo P, Mujika I & et al., 1996; Aujouannet YA, Bonifazi M & et al. 2006; Bonifazi M, Martelli G, 1993). It is possible that the above indices that the data (VO_2 consumption, lactate) may not be significantly correlated, or be the best predictors of fatigue occurrence in single experimental short bouts of all-out swim trials 200-m and below.

The participants experience during the impact of the 5, 10 and 20s rest intervals in intermittent vs the continuous 200-m freestyle

The study observed the impact of the duration of the rest intervals between the intermittent swimming and the race pace velocities of the 200-m continuous freestyle swim on the performance and other responses. The velocities attained during the 4×50-m swimming splits with 20s rest intervals, were higher than the pace velocities of the 200-m continuous swimming. With 20s rest, higher mean velocity and better performance time, were elicited, when compared to the 200-m continuous swim (Figure 1). Swimmers maintained their swimming velocity and stroke number constant with non-significant differences between the 50-m splits. The advantage of the intermittent high intensity swim with 20s rest between splits, is allowing more time for recovery and thus a greater reliance on anaerobic metabolism and consequently a higher swimming velocity. Additionally, the intensity of swimming, as reflected by heart rate, was significantly higher only with the 20s rest interval, and not with the shorter rest intervals or continuous swimming. As the data demonstrate, the longer the rest interval, the greater the fall of the recovery heart rate, prior to every next 50-m swim (182.72 ± 9.93 beats·min^{-1} with 20s rest vs 184.55 ± 8.82 with 10s rest and 190.08 ± 12.42 with 5-min rest). This rest time may allow greater immediate energy store replenishment, than in shorter rest intervals. Stroke count and velocity were constant between 50-m splits with 20s of rest.

The 200-m freestyle tests with the rest interval of 5s and 10s demonstrated similar responses to the 200-m continuous swim. The velocity in 200-m continuous swim in the 2^{nd}, 3^{rd} and 4^{th} 50-m decreased significantly compared to the first 50-m lap and in the study it was also demonstrated with the 5 and 10 s rest intervals. This is also confirmed by Figueiredo's P, Zamparo P & et al. (2011) observations has previously observed. Figueiredo P, Zamparo P& et al. (2011), suggested that fatigue sets in progressively and is reflected by the decrease in arm stroke efficiency simultaneously with the velocity progressive decrease, in the 200-m freestyle swim, which become considerably lower in the last 50-m split compared to the first. A progressive increase in the energy cost of the swim was observed in their study. In another study, by the same group of researchers, the changes in arm stroke technical characteristics throughout the 200-m were proven to be a result of arm fatigue. This was confirmed by electromyographic evaluation, that showed lower contribution of lower-limb to swimming propulsion (Figueiredo P, Rourard A & et al., 2013). They observed a simultaneous decrease of both the velocity and stroke length from the beginning to the end of the effort with a rise in stroke frequency in order to maintain speed. In the presented study, the stroke count progressively increased and the velocity decreased from the 1^{st} to the 4^{th} split only in the continuous 200-m swim suggesting that there probably were also variations in stroke length.

The race pace strategy for swimming the 200-m front crawl during competition and training has been challenging. Swimming at a higher than race pace intensity could either benefit a swimmer if the purpose of the training was to provide a greater intensity work out, or could halt the swimmer's performance if it was used as a tapering method to only improve race performance of the 200-m freestyle event. Rushall BS. (2013, 2018) suggests that training stimuli should be as close to the intensity of the event itself so to produce the necessary neuromuscular and metabolic adaptations specific to the events. On the other hand swimming on race pace velocity exposes different adaptations. Research supports the fact that race pace stimulation for warm-up prior to a sprint event such as 100-m freestyle may be favourable when the swimmer wants to reach a high stroke frequency soon after the warm-up period (Neiva HP, Marques MC & et al., 2017).

The benefit of using supra-maximal high intensity intermittent 200-m bouts of swimming with longer rest intervals could be attributed to the quicker improvement of a swimmer's aerobic capacity. MacInnis MJ & Gibala MJ. (2017) have suggested that if an athlete wants to achieve maximal "*oxidative*" adaptations in the fast twitch fibres, they need to train at high intensities and not for very long (Cochran A, Percival M & et al., 2014) on investigating the importance of the interval in HIIT against its continuous form concluded that even a small volume of intermittent allout effort was able to induce similar acute muscle adaptations to high volume training. However, after 6 weeks of training with the intermittent HIIT bout, the adaptations were maximal. Consequently, high-intensity training, with exercises experiences that have incorporated higher than usual swimming velocities, have been associated with improved race or simulated race performances (Mujika I, Busson T & et al. 1996; Sperlich B, Haegele M & et al. 2009).

Limitations and future studies recommendations

While this study´s primary purpose was to identify the impact of interval swimming training vs continuous swimming training in swimmers, some limitations should be known. The sample, which was limited to young male competitive swimmers (age: 15.46 ± 1.45 years) then the outcomes should be carefully analyzed when applied to different populations such as different sex, age or swimming level. Considering the objective of the study that was 200-m distance and specific interval, future studies could consider these limitations including high level swimmers, womens, older age, other swimming strokes (backstroke, breastroke, butterfly), largest interval time (30 and 45s) or distances more than 200-m.

CONCLUSIONS AND PRACTICAL APPLICATIONS

Our results verified our hypotheses. Regardless of the interval time between sets in "*broken*" swimming, the maximum lactate concentration and O_2 deficit were similar at the end of each condition and the continuous 200-m swim. The heart rate in condition of 20s interval time was higher than in conditions of shorter interval time due to the greater exercise intensity. In this study, the only rest interval that produced a velocity higher than the race pace (compared to the 200-m continuous swim velocity) was the 20s rest interval. With the 20s interval the velocity was maintained constant between the 50-m splits while with the shorter rest intervals (5 and 10s) and the continuous 200-m swim, velocity gradually dropped which also affected the overall performance and total swim time. Our data suggest that in intermittent high intensity swimming rest intervals can determine whether the velocity will be at race pace or above race pace. If performance enhancement is the goal of the training stimulus, then the intermittent interval swimming needs the concrete rest interval time of 20 seconds. But if the goal is to replicate the race pace of the 200-m swim, for technique drills at race pace, then shorter rest-intervals can match those physiological and performance characteristics. The trainers in applying the results of this study should focus on what they intend to improve and realize that distance, velocity and intensity can all vary and be manipulated by increasing or decreasing rest intervals between split intervals of swimming events or sets.

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AUTHOR CONTRIBUTIONS

The article is the result of a collaborative work by all the authors. NB and TP contributed to the preparation and research design, data collection, data analysis, result, interpretation, manuscript writing, supervision of the study, and review of the final version. TP is the scientific coordinator of the study. All authors have read and agreed to the final version of the manuscript and consent to its publication in SJSP.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

ETHICAL APPROVAL

These swimming trials are conducted in accordance with ethical principles of the Declaration of Helsinki. Declaration of Helsinki Ethical Principles for Medical Research involving human subjects (WMA, 2013).

CONSENT TO PARTICIPATE

The swimmers' parents signed an informed consent for, authorizing their participation in the study.

DATA AVAILABILITY STATEMENT

Data available on request.

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REFERENCES

Aujouannet, Y. A., Bonifazi, M., Hintzy, F., Vuillerme, N., & Rouard, A. H. (2006). Effects of a high-intensity swim test on kinematic parameters in high-level athletes. Applied Physiology, Nutrition and Metabolism, 31: 150-158. https://doi.org/10.1139/h05-012

Billat, L. V., Slawinski, J., Bocquet, V., Demarle, A., Lafitte, L., Chassaing, P., & Koralsztein J.P. (2000). Intermittent runs at the velocity associated with maximal oxygen uptake enables subjects to remain at maximal oxygen uptake for a longer time than intense but submaximal runs. European Journal of Applied Physiology, 81: 188-196. https://doi.org/10.1007/s004210050029

Bonifazi, M., Martelli, G., Marugo, L., Sardella, F., & Carli, G. (1993). Blood lactate accumulation in top level swimmers following competition. The Journal of Sports Medicine and Physical Fitness, 33:13-18. https://doi.org/10.1007/s004210000230

Borg, A. G. (1982). Psychophysical bases of perceived exertion. Medicine and Science in Sports and Exercise, 14: 377-381. https://doi.org/10.1249/00005768-198205000-00012

Cochran, A., Percival, M., Tricarico, S., Little, J., Cermak, N., Gillen, J., Tarnopolsky, M., & Gibala, M. (2014). Intermittent and continuous high-intensity exercise training induce similar acute but different chronic muscle adaptations. Experimental Physiology, 99(5):782-791. https://doi.org/10.1113/expphysiol.2013.077453

Cohen, J. (1988). Statistical power analysis for the behavioral sciences (2nd edition). New York, Lawrence Erlbaum Associates, Publishers. https://doi.org/10.2307/2290095

Leger, L. A., & Seliger, V., Brassard, L. (1980). Backward extrapolation of VO2max values from the O2 recovery curve. Medicine and Science in Sports and Exercise, 12: 24-27. https://doi.org/10.1249/00005768-198021000-00006

Figueiredo, P., Zamparo, P., Sousa, A., Vilas-Boas, J. P, & Fernandes, R. J. (2011). An energy balance of the 200-m front crawl race. European Journal of Applied Physiology, 111 (5): 767-77; https://doi.org/10/1007/s00421-010-1696-z

Figueiredo, P., Rourard, A., Villas-Boas, J. P., & Fernandes, R.J. (2013). Upper- and lower-limb muscular fatigue during the 200-m front crawl. Applied Physiology, Nutrition and Metabolism, 38(7): 716-24. https://doi.org/10.1139/apnm-2012-0263

MacInnis, M. J. & Gibala, M. J. (2017). Physiological adaptations to interval training and the role of exercise intensity. Journal of Physiology, 595(9): 2915-2930. https://doi.org/10.1113/JP273196

Maglischo, E. W. (1993). Swimming Even Faster, Mayfield Pub. Co., Mountain View, Calif, 417-450.

Maglischo, E. W. (2003). Swimming fastest: Human Kinetics, 478-479.

Montpetit, R. R., Leger, L. A., Lavoie, J. M, & Cazorla, G. (1981). VO2 peak during free swimming using the backward extrapolation of the O2 recovery curve. European Journal of Applied Physiology and Occupational Physiology, 47(4): 385-391. https://doi.org/10.1007/BF02332966

Mujika, I., Busson, T., Geyssant, A., & Chatard, J. C. (1996). Training content and its effects on performance in 100 and 200-m swimmers. In Troup JP, Hollander AP, Strasse D, Trappe SW, Cappaert J. M., Trappe, T. A. (Eds.), Biomechanics and Medicine in Swimming VII. London: E & FN Spon; 201-207. https://doi.org/10.4324/9780203993354

Neiva, H. P., Marques, M. C., Barbosa, T. M., Izquierdo, M., Viana, J. L., Teixeira, A. M., & Marinho, D.A. (2017). Warm-Up for sprint swimming: race-pace or aerobic stimulation? A randomized study. The Journal of Strength and Conditioning Research, 31: 2423-2431. https://doi.org/10.1519/jsc.0000000000001701

Nugent, F. J., Comyns, T. M., Burrows, E., & Warrington, G. D. (2017). Effects of low-volume, high-intensity training on performance in competitive swimmers: a systematic review. Journal of Strength and Conditioning Research, 31: 837-847. https://doi.org/10.1519/JSC.0000000000001583

Nugent, F. J,, Comyns, T. M., & Warrington, G. D. (2018). Effects of increased training volume during a ten-day training camp on competitive performance in national level youth swimmers. Journal of Sports Medicine and Physical Fitness, 58(12): 1728-1734. https://doi.org/10.23736/S0022-4707.17.07838-0

Nugent, F., Comyns, T., Nevill, A, & Warrington, G. D. (2019). The Effects of Low-Volume, HighIntensity Training on Performance Parameters in Competitive Youth Swimmers. International Journal of Sports Physiology and Performance, 14(2): 203-208. https://doi.org/10.1123/ijspp.2018-0110

Nugent, F., Comyns, T., Kearney, P., & Warrington, G. (2019). Ultra-Short Race-Pace Training (USRPT) In Swimming: Current Perspectives. Open Access Journal of Sports Medicine, 10: 133-144. https://doi.org.gr/10.2147/OAJSM.S180598

Rinehardt, K. F., Axtell, R. S., Kleine, S., Upson, D., Woznica, D., Quill, T. & et al. (2002). Response in performance, metabolic indices, and perception during a season of collegiate competitive swim training. Medicine and Science in Sports Exercise, 2002; 34 (5), Supplement abstract 1099. https://doi.org.10.1097/00005768-200205001-01099

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Pelayo, P., Mujika, I., Sidney, M., & Chatard, J. C. (1996). Blood lactate recovery measurements, training, and performance during a 23-week period of competitive training. European Journal of Applied Physiology, 74:107-113. https://doi.org/10.1007/BF00376502

Rushall, B. S. (2013). The mechanisms of ultra-short training: The translation of Christensen's thinking into swimming terms and its place in training programs. Swimming Science Bulletin. Edited Rushall, San Diego State University. Retrieved from [Accessed 2025, March 14]: https://coachsci.sdsu.edu/swim/bullets/45g%20MECHANISMS.pdf

Rushall B. S. (2018). Swimming energy training in the 21st century: the justification for radical changes (second edition). Swimming Science Bulletin. Edited Rushall, San Diego State University, 39:1-58. Retrieved from [Accessed 2025, March 14]: https://coachsci.sdsu.edu/swim/bullets/energy39.pdf

Sousa, A. C., Figueiredo, P., Oliveira, N. L., Oliveira, J., Silva, A. J., Keskinen, K. L., & Fernandes R. J. (2011). VO2 kinetics in 200-m race-pace front crawl swimming. International Journal of Sports Medicine, 32(10): 765-70. https://doi.org/10.1055/s-0031-1279772

Sperlich, B., Haegele, M., Achtzehn, S., De Marees, M., & Mester, J. (2009). High intensity exercise in children: Results from different disciplines. A paper presented at the 14th Annual Congress of the European College of Sport Science, Oslo, Norway: Book of abstracts (Vol.78).

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