

# THE EFFECTS OF TWO DIFFERENT HIIT RESTING PROTOCOLS ON CHILDREN'S SWIMMING EFFICIENCY AND PERFORMANCE

Konstantinos Papadimitriou,<sup>1, A, B, C, D</sup> Stratos Savvoulidis<sup>2, D</sup>

<sup>1</sup>Laboratory of Evaluation of Human Biological Performance, School of Physical Education and Sport Science, Aristotle University of Thessaloniki, Greece

<sup>2</sup>School of Physical Education and Sport Science, Aristotle University of Thessaloniki, Greece

<sup>A</sup> Study Design; <sup>B</sup> Data Collection; <sup>C</sup> Statistical Analysis; <sup>D</sup> Manuscript Preparation

## Address for correspondence:

Papadimitriou Konstantinos  
Thetidos 5, Evagelistria  
54636, Thessaloniki, Greece  
E-mail: Kostakispapadim@gmail.com

**Abstract** On children, HIIT program is being used by coaches as a way of rapid improvement. The values of the intervals vary from the target of the period. The study's purpose was to find out if HIIT in different interval protocols improves children's swimming performance. In the study participated 18 rookie swimmers (9 boys and 9 girls), aged  $11.6 \pm 1.5$ . The HIIT protocol in both groups included the set of  $2 \times 4 \times 17.5$  m (freestyle and freestyle kick, respectively). The first group (HIIT 1) had a 10 sec interval while the second (HIIT 2) – a 1 min between the HIIT reps. Swimmers performed in 35 m freestyle (35F) and 2 min free kick (2' FK) trials at maximum effort. The performance (T), the number of strokes (SN) and the stroke length (SL) were measured at 35F, the covered distance at 2' FK and the heart rate (HR), the rated perception of exertion (RPE) at 35F and 2' FK. Regarding the results, all parameters improved significantly ( $p = 0.01$ ). The use of a 4-week swimming program with training 4 times per week, in which two were HIIT, improved children's performance and efficiency in swimming. Intervals of 10 sec or 1 min did not alter the improvement.

**Key words** swimming training, performance, intensity, interval, children

## Introduction

Many of training methods contribute to the athletes' increase of physiological adaptations and performance. Common training methods are High Volume Training (HVT) and High-Intensity Training (HIT). These two methods seem to be helpful for an athlete's performance (Sperlich, Haegele, Achtzehn, De Marees, Mester, 2009a; Sperlich et al., 2009b). These training methods are used as the main part of a training session.

A training method which proves the most interesting in studying is High-Intensity Interval Training (HIIT). HIIT training is one of the most beneficial methods to improve almost all physiological and performance responses in a wide range of training. Moreover, they found significant performance improvements that reached from 6–20%.

Endurance performance, peak oxygen uptake, maximal oxygen uptake, running economy and distance cover were the parameters that got improved. The improvements concerned the sports of soccer, track, rowing, kayak and cycling (Helgerud, Engen, Wisloff, Hoff, 2001; Mosey, 2009; Buchheit, Bishop, Haydar, Nakamura, Ahmaidi, 2010).

HIIT is a training method that both male and female athletes can use with excellent results in physiological parameters such as maximal oxygen uptake, running economy, heart rate, perceived exertion (Buchheit, Simpson, Mendez-Villanueva, 2013), VO<sub>2</sub>max and anaerobic capacity (Tabata et al., 1996; Tabata et al., 1997; Buchheit, 2010). Moreover, HIIT can be used from prepubertal athletes too, with beneficial effects in speed performance between training protocols with maximal sprinting and aerobic speeds (Mendez-Villanueva et al., 2010).

Most of the studies in sports, particularly in football, showed that HIIT in different protocols can improve the performance and the physiological parameters like oxygen uptake, endurance, heart rate, and muscle energy sources (Dellal, Varliette, Owen, Chirico, Pialoux, 2012). These improvements associate both in adults and prepubertal athletes. On the other hand, it does not suggest that all young footballers are affected by repeated sprints because of different physical position demands that are needed in a match (Helgerud et al., 2001). In other study similar results reported with the use of HIIT and small side games after a six-week program with 5.1 and 6.6% improvement in Vameval test. Furthermore, improvements were found in the aerobic and recovery capacity (Dellal et al., 2012).

Other study, in football, proved that repeated sprint training is more beneficial in certain aspects than interval training, with greater effects in Yo-Yo test and repeated sprint ability. Specifically, it showed greater improvement regarding the Yo-Yo test in the repeated sprint training method, with an increase from 1,917 m to 2,455 m in addition with the interval training group which was from 1,846 m to 2,077 m (Ferrari et al., 2008).

A sport which can be an interesting field to examine HIIT effects is swimming, as it includes many sportsmen in different ages (especially children and adolescents) and there are many factors that affect performance. Although there are studies for the effects of HIIT training in swimmers, less attention has been paid as regards the role of HIIT on children. In K. Papadimitriou and S. Savvoulidis' (2017) research, many studies about HIIT's effectiveness in different ages of swimmers were reviewed. In this review, only one study examined the effects of a 5-week HIIT program versus high volume training in 9–11-year-old swimmers. The test protocols were 100 m and 2,000 m freestyle. The parameters calculated were VO<sub>2</sub> peak and the rate of maximal lactate accumulation. Between two programs, 2,000 m time performance, lactate and VO<sub>2</sub> peak increased following HIIT. On the other hand, no changes showed at the 100 m time. All these improvements were achieved with two hours less training than the high-volume training group (Sperlich et al., 2010).

D.A. Marinho et al. (2011) studied the relationship between anaerobic critical velocity and the ideal short distance that could be used in training for the four swimming techniques. The results revealed that short distances of 10, 15, 20 and 25 m could be a great indicator of anaerobic critical velocity in the distances of 50, 100 and 200 m. Thus, these distances probably describe the ideal distance that coaches could use in young swimmers for greater training stimuli.

## Interval

An important part in high-intensity training is the interval. Some studies examined HIIT's effects after different interval protocols. In two studies performed 15 × 40 m sprints and six 4 min work bouts respectively. The rest time was 120, 60, and 30 sec for 15 × 4 m between each sprint and 240, 120 and 60 sec for the six 4 min work bouts.

The results in both studies suggested that 120 sec was the most beneficial rest time between maximal repetitions of exercise (Balsom et al., 2005).

So, the purpose of this study was to determine if a 4-week swimming program, 4 times per week, with HIIT, two times per week, with two different passive interval protocols, it could improve children's swimming performance. Children, due to their physiological demands, needs less time to recover after an exercise in addition to adults (Tabata et al., 1997). Thus, it is great of interest in this study to examine if there will be any difference between the two resting protocols.

## Methods

### Participants

All tests were conducted according to the ethical guidelines of the Research Committee of Aristotle University of Thessaloniki. In the study participated 18 children (9 boys and 9 girls) aged  $11.6 \pm 1.5$ . The participants' swimming level was moderate. Height (H), weight (W) and body mass index (BMI) were measured (Table 1), while the participants were questioned if they were well on their health. Moreover, they were examined by a cardiologist before the study. All children's parents were informed about the procedures of this experiment and the possible improvements that this type of exercise could provide to their children's health. At the 16 exercise sessions, the attendance was  $12 \pm 3$  for HIIT 1 and  $13 \pm 2$  for HIIT 2.

**Table 1.** Age, height, weight and body mass index (BMI) of the participants

Parameters	HIIT 1 (10 s) n = 9	HIIT 2 (1min) n = 9
Age (years)	$11.5 \pm 1.7$	$11.7 \pm 1.2$
Height (cm)	$154.7 \pm 11.5$	$150.7 \pm 12.4$
Weight (kg)	$50.3 \pm 11.2$	$39.9 \pm 14.5$
BMI (kg/cm <sup>2</sup> )	$21 \pm 4$	$17 \pm 3.3$

### Study design

The study measured pre-post differences in a 4-week swimming program with training 4 times per week in which two programs were HIIT, in a 17.5 m pool. Premium school children took part in the study. The participants were informed about the protocols they would follow and the way they would have to answer about the rate of perceived exertion (RPE). Before training, the children's attendance was monitored and the training volume was calculated to find out if the training's frequency and volume were enough for performance adaptations.

### Procedures

The 18 boys and girls were divided into two equal groups depending on their swimming level. The first group was named HIIT 1 and included 5 girls and 4 boys, and the second group was named HIIT 2 and included 4 girls and 5 boys. The HIIT protocol for both groups included  $4 \times 17.5$  m freestyle and  $4 \times 17.5$  m freestyle kick with a kickboard in maximal intensity. The difference between HIIT 1 and 2 was the interval. The passive interval in the sets was

10 seconds for the first group and 1 minute for the second group. Between the freestyle swim and freestyle kick protocols, there was a 5-minute passive interval for both groups.

## Measures

To find out if there were any adaptations from the two HIIT programs the children were tested in two swimming protocols. The first protocol took place at the beginning (0 weeks) of the experiment and the other one at the end (4 weeks). These two protocols included 35 m freestyle and 2 min freestyle kick (Papadimitriou, Loupos, Tsalis, Manou, 2017) in maximal intensity, respectively. In the 35 m freestyle, the time (T), the number of strokes (SN) and the stroke length (SL) were measured. On the 2 min freestyle kick the covered distance was measured (D). Additionally, the heart rate (35F HR–2'FK HR) and the rate of perceived exertion (35F RPE–2'FK RPE) were measured for both tests. The HR parameters were estimated in 10 seconds (Nussinovitch et al., 2011) with the use of POLAR Electro.

## Statistical analysis

For the statistical analysis the Shapiro-Wilk test of normality was used. Furthermore, to assess the effects of two HIIT resting protocols, before and after the intervention, in the parameters studied, there was used a two-way ANOVA with repeated measures (group × time). Moreover, a Pearson's - r correlation was conducted between the parameters that were studied. The analysis was performed using the SPSS Version 25.0 for Windows (SPSS Inc., Chicago, IL, USA). The level of statistical significance was set at  $\alpha = 0.05$ .

## Results

From the Shapiro-Wilk analysis there was found a normality in the parameters that studied ( $p > 0.05$ ). In two-way ANOVA with repeated measures analysis, there was found no significant differences between the two groups (HIIT 1 vs HIIT 2) in almost all parameters studied, except for HR in 2'FK test. On the other hand, statistically significant differences were found in combined groups (HIIT 1 + 2) between 0 and 4th weeks. Figures 1, 2, 3, 4, 5, 6 show the differences between measurements and groups. Figures 7 and 8 show the correlations between the parameters between 35F, 35F SN, 35F SL and 2'FK.

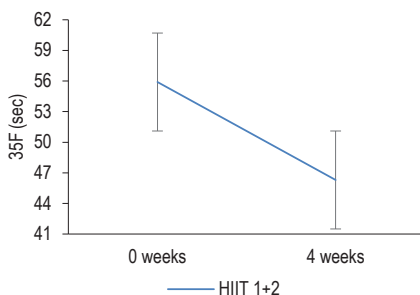
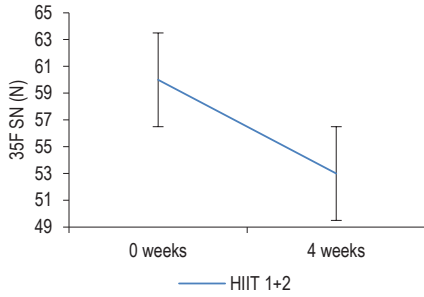


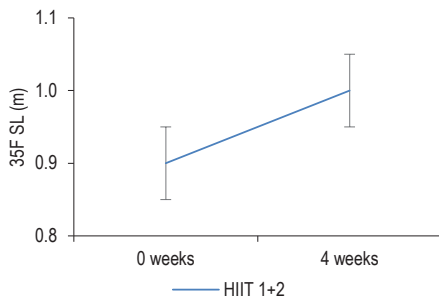
Figure 1. Performance at 35 m freestyle (35F)



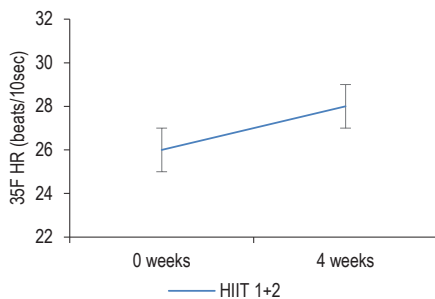
**Figure 2.** Stroke number at 35 m freestyle (35F SN)

From the results the 35F in HIIT 1 + 2 decreased and the difference was statistically significant. The decrease was from  $55.9 \pm 13.8$  to  $46.3 \pm 9.3$  sec ( $p = 0.01$ ) (Figure 1). The 35F SN decreased from  $60 \pm 16$  to  $53 \pm 15$  strokes ( $p = 0.01$ ) (Figure 2).

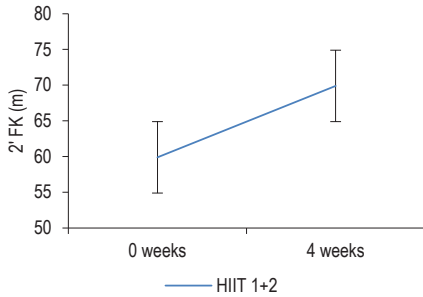
The 35F SL in HIIT 1 + 2 increased statistically significantly from  $0.9 \pm 0.3$  to  $1 \pm 0.3$  m ( $p = 0.01$ ) (Figure 3). Moreover, the 35F HR increased from  $27 \pm 2$  to  $28 \pm 2$  beats/10 sec ( $p = 0.01$ ) (Figure 4).



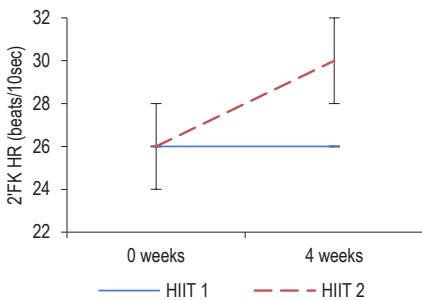
**Figure 3.** Stroke length at 35 m freestyle (35F SL)



**Figure 4.** Heart rate at 35 m freestyle (35F HR)



**Figure 5.** Distance covered at freestyle kick in 2' (2' FK)



**Figure 6.** Heart rate at freestyle kick in 2' (2' FK HR)

In 2'FK there was found a statistically significant increase in the distance covered from 0 to 4<sup>th</sup> week in HIIT 1 + 2. Specifically, swimmers from  $59.9 \pm 14.5$  m in the 0-week covered  $69.9 \pm 10$  m in the 4th week ( $p = 0.01$ ) (Figure 5). The only parameter which showed statistically significant difference between the two groups (HIIT 1 and HIIT 2) was 2'FK HR. The 2' FK HR in HIIT 2 group increased from  $26 \pm 2$  to  $30 \pm 3$  beats/10 sec ( $p = 0.05$ ), while HIIT 1 group increased the HR from  $26 \pm 2$  to  $28 \pm 3$  beats/ 10 sec ( $p = 0.04$ ) (Figure 6).

Statistically significant correlations were found between the parameters studied ( $p < 0.05$ ). The time at 35F which swimmers swam correlated with the 35F SN at the second test of the measurements ( $R^2 = 0.810$ ;  $p = 0.900$ ;  $p = 0.00$ ) (Figure 7a). The time at 35F B which swimmers swam also correlated with the 35F SL at the second test of the measurements ( $R^2 = 0.768$ ;  $p = -0.877$ ;  $p = 0.00$ ) (Figure 7b). One more statistically significant correlation was found between the time at 35F B and the 2'FK B at the second test of the measurements ( $R^2 = 0.396$ ;  $p = -0.626$ ;  $p = 0.05$ ) (Figure 8).

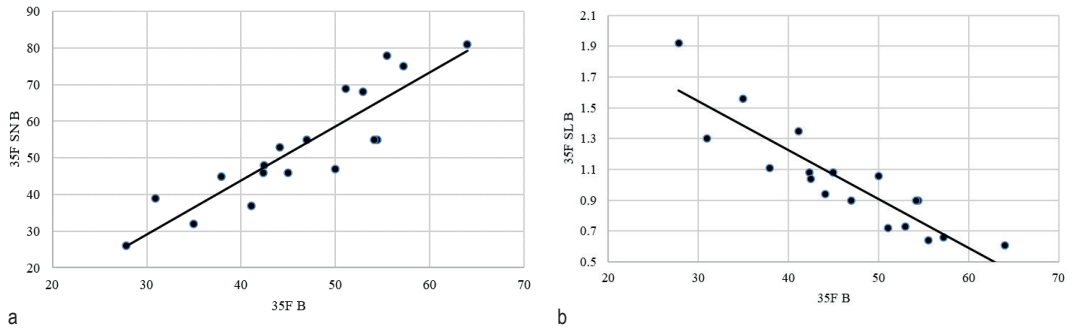


Figure 7. Correlations between 35 m freestyle (35F), stroke number (35F SN) and stroke length (35F SL)

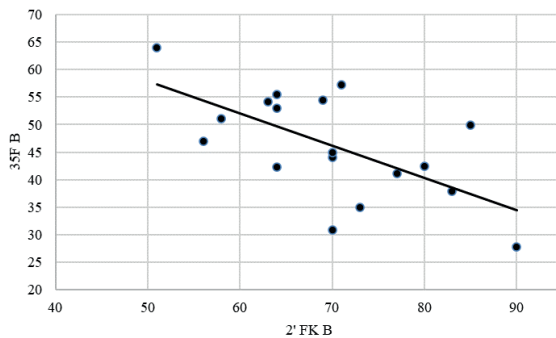


Figure 8. Correlation between 35m freestyle (35F) and 2' freestyle kick (2' FK)

## Discussion

In the study it was found that high intensity training in different intervals contributes positively in performance and in physiological parameters. These results were common with other studies in various sports (Helgerud et al., 2001; Laursen, Jenkins, 2002; Buchheit et al., 2008; Mosey, 2009; Laursen, 2010). Probably, the anaerobic pathway used in that kind of exercise helps the athlete's physiology in gaining a stronger stimulus.

The time and the distance covered at the 35F and in 2' FK decreased and increased respectively in both of groups. Thus, HIIT independently of the interval rest between the sets helped the swimmers to improve. Probably, in both of HIIT sets, swimmers' physiology in childhood uses mainly the aerobic energy pathway. The rest of 10 sec gives an anaerobic pathway energy contribution. On the other hand, 1 min rest ensures a greater aerobic contribution. These hypotheses could be made only if the try was at its maximal intensity. The Borg's scale and HR in both of 35F and 2' KF tests in both of groups proves that swimmers swam in maximal intensity during the tests.

Why Borg's scale did not elevate in measurements after the 4-week period probably has two explanations. The swimmers' low skill level attenuated their ability to reach higher fatigue levels. Moreover, the performance

enhancement contributed to finding the test easier after the 4-week intervention. This hypothesis is supported by the HR parameter which increased at the second measurement in both groups and tests.

Usually, after a long intervention of exercise, athletes gain the ability of lowering their heart rate in the phase of rest after set (especially elite athletes). The explanation is that cardiac sympathetic excitation outlasting causes bradycardia with enhanced sympathetic activity in athletes (Furlan et al., 1993). In the study, immediately after the tests of 35F and 2' KF, the young swimmers were found to increase their HR by 10 seconds comparing the 0 and 4<sup>th</sup> week in both groups. The probable explanation is that the children in these ages fulfill their body demands of oxygen by increasing their HR. Young children, when involved in an aerobic exercise program, showed progressive increases in left ventricular posterior wall thickness and left ventricular mass and no changes in left-ventricular end-diastolic dimension, shortening fraction or resting heart rate (Geenen, Gilliam, Crowley, Moorehead-Steffens, Rosenthal, 1982). Thus, the swimmers' heart should pump more blood to the body to respond to the exercise demands.

Another finding in the study was that the HIIT 2 protocol, which had more resting time than HIIT 1, in 2'FK test, was found to have increased the HR response. In that case, possibly, the greater resting time in HIIT 2 caused higher anaerobic contribution and greater HR stimuli, therefore higher heart rate demands among the young swimmers. Contrary to the lower resting time, which had the HIIT 1 protocol, the energy contribution was probably more aerobic; therefore, the heart rate demands were lower. From the unique study which examined the HIIT effects in young swimmers (Sperlich et al., 2010) it was concluded that HIIT enhances VO<sub>2</sub> peak, the rate of maximal lactate accumulation and 2,000 m freestyle performance. The common finding is that in both studies HIIT improves aerobic and anaerobic contribution. On the other hand, an unclear field, which B. Sperlich did not analyze, is the interval which was used at HIIT period.

In the study it was found that, independently, in terms of the interval between HIIT's reps (10 sec or 1 min), the young swimmers improved their performance. P.D. Balsom et al. (Balsom, Seger, Sjödin, Ekblom, 1992) and S. Seiler and K.J. Hetlelid (2005) in their studies found that the optimal rest period for maximal repetition tries is 120 sec. Thus, greater distances need higher interval periods. Moreover, the main difference between our study, P.D. Balsom's et al. (1992) and S. Seiler and K.J. Hetlelid's (2005) is that their participants' age was higher than ours. So, the interval in children does not affect the aerobic or anaerobic stimulus.

Another aspect of performance which improved from the 4-week intervention program was the stroke length (SL) and the stroke number (SN). These parameters indicate that, probably, the improvement in technique contributed to the better performance, which both groups showed. The improved efficiency in the water was probably caused by technique exercises combined with the HIIT program. Thus, this combination affected the neuromuscular coordination and facilitation as well. Moreover, in correlation analysis the contribution of SN and SL with 35F makes the hypothesis about the importance of these parameters in performance stronger.

## Conclusion

The study is a novel which examines different rest protocols between HIIT sets on children. From the results it can be seen that the resting period does not differentiate the performance enhancement in young swimmers. Thus, the coaches do not need to pressure the young swimmers with exhausting sets in low intervals. On the other hand, perhaps the swimmers' skill level affects the training adaptations. Therefore, more research is needed in this field to avoid the exhausting training which many coaches prefer to use on children.



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