Barragán, R.; González-Ravé, J.M.; González-Mohíno, F.; Yustres, I.; Juárez Santos-García, D. (2020) Effects of Swimming Intensity on Triathlon Performance. Revista Internacional de Medicina y Ciencias de la Actividad Física y el Deporte vol. 20 (80) pp. 529-538 Http://cdeporte.rediris.es/revista/revista80/artefectos1208.htm
DOI: https://doi.org/10.15366/rimcafd2020.80.004

ORIGINAL

EFFECTS OF SWIMMING INTENSITY ON TRIATHLON PERFORMANCE

EFECTOS DE LA INTENSIDAD DE NADO EN EL RENDIMIENTO DEL TRIATLON

Barragán, R.[1]; González-Ravé, J.M.[1]; González-Mohíno, F.[1,2]; Yustres, I.[1]; Juárez Santos-García, D.[1]

[1] Laboratorio Entrenamiento Deportivo, Facultad Ciencias del Deporte, Universidad Castilla-La Mancha, Toledo (Spain) rubenbarragancastellanos@hotmail.com, josemaria.gonzalez@uclm.es, inmaculada.yustres@uclm.es, daniel.juarez@uclm.es.
[2] Facultad de Lenguas y Educación, Universidad Nebrija, Madrid (Spain) fgonzalezmohino@nebrija.es

Spanish-English translator: Inmaculada Yustres, inmaculada.yustres@uclm.es

Código UNESCO/UNESCO code: 2411 Fisiología del Ejercicio / Exercise Physiology.
Clasificación Consejo de Europa / Council of Europe Classification: 6. Fisología del Ejercicio / Exercise Physiology.

Recibido 15 de enero de 2019 **Received** January 15, 2019
Aceptado 25 marzo de 2019 **Accepted** March 25, 2019

ABSTRACT

Objective: To analyze the influence of different swimming intensities on the subsequent cycling and running sectors and overall sprint triathlon performance. Methods: Seven sub23 and senior triathletes (height 1.74 ± 0.04 m, weight 70.82 ± 6.76 kg, age 23.42 ± 3.25 years, VO_2 max 63.54 ± 5.23 ml • kg-1 • min-1) participated in this study. They carried out three complete triathlons at different swimming intensities (70%, 80% and 90% of a previous 750m test). Heart rate and lactate were measured at the end of each sector and after completing the whole triathlon. Results: The 90% swimming intensity obtained the best final performance. Lactate and heart rate in the swimming sector for this condition increased significantly, without differences in the following sectors. Conclusions: Based on the sample studied, the final performance in a sprint triathlon seems to be conditioned by the swim intensity, being 90% the best intensity observed in moderately trained triathletes.

KEYWORDS: endurance, performance, training.

RESUMEN

Objetivo: Analizar la influencia de diferentes intensidades de nado en los sectores de ciclismo y carrera a pie y en el rendimiento final del triatlón sprint. Métodos: Siete triatletas sub23 y Absolutos (altura de 1,74 ± 0,04 m, peso de 70,82 ± 6,76 kg, edad de 23,42 ± 3,25 años, VO_2 max de 63,54 ± 5,23 $ml \cdot kg^{-1} \cdot min^{-1}$) participaron en este estudio. Realizaron tres triatlones completos a intensidades de nado diferentes (70%, 80% y 90% de un test de 750m previo). Se midió la frecuencia cardíaca y el lactato al finalizar cada sector y el triatlón completo. Resultados: La intensidad de nado del 90% obtuvo el mejor rendimiento final. El lactato y frecuencia cardíaca en el sector de nado para esta condición incrementó significativamente, sin diferencias en los sectores siguientes. Conclusiones: Basándonos en la muestra estudiada, el rendimiento final en un triatlón sprint parece estar condicionado por la intensidad de nado, siendo el 90% la mejor intensidad observada en triatletas moderadamente entrenados.

PALABRAS CLAVE: resistencia, rendimiento, entrenamiento.

INTRODUCTION

Triathlon is a multidisciplinary sport that involves three successive disciplines: swimming, cycling and running. At the same time, the triathlon has different ways of competing, such as sprint, Olympic and long distance, which are characterized by different competition distances. Related to the research of this sport, the vast majority of performance studies in triathletes focus on the effects of the use of neoprene (1,2,3), the use of drafting in swimming (4,5,6,7, 8,9), drafting in cycling (16,17,18) and also in the effect of the cycling sector in the subsequent running race (10,11,12,13).

In triathlon, the discipline of swimming is important because the final result will be influenced by the performance of the triathletes in this sector. Landers et al. (14) found that the winners of different triathlons finished the swimming sector in the first group in 90% and 70% of the competitions in men and women, respectively. Cejuela et al. (15) showed that the swimming discipline corresponds to 16% of the total triathlon time. Also, the final order during the swimming discipline (14) correlates with the final position of the triathlon (r = 0.49 and 0.39, women and men, respectively). Therefore, we can assume that the swimming sector is very important for the final result of the triathlon, and, ultimately, analyzing the optimal rhythm of this sector can influence the final result.

However, Vleck et al. (16) found that low performance in this part, causes a higher effort in the cycling sector and, ultimately, influences the running race. In addition, Peeling and Landers (17) emphasize that the energy used and the final position during the swimming sector is important in determining the final success of the entire triathlon. In this sense, the intensity at which the swim is carried out has been little studied in the scientific literature. For example, Peeling et al. (18) carried out a study in which the triathletes performed three sprint triathlons under laboratory conditions at 80%, 90% and 100% intensities of a swim test of the same sprint distance (750m). These authors found that the 80% swimming intensity reduced the frequency of swimming cycles, the blood lactate and the total time of the triathlon was lower than the rest of the intensities.

Considering therefore the importance of optimizing the intensity at which the swimming sector is carried out for the final performance of a triathlon, the objective of this study is to analyze the influence of different swimming intensities (70%, 80% and 90% of the STT swim test) in the subsequent performance in the cycling, running and total triathlon sector.

MATERIAL AND METHODS

Subjects

Seven male triathletes of sub23 and Absolute, moderately trained categories (height of 1.74 ± 0.04 m, weight of 70.82 ± 6.76 kg, age of 23.42 ± 3.25 years, and VO2 max of 63, 54 ± 5.23 ml · kg-1 · min-1) participated in this study. Prior to the study, the subjects were informed of the tests to be performed, of the possible risks and had to sign an informed consent. The data were obtained and treated at the University of Castilla-La Mancha (Spain), between the months February-March 2018, anonymously, to protect the identity of each of the subjects evaluated. This study was carried out according to the principles of the Declaration of Helsinki.

Procedure

The research was carried out during five sessions involving an incremental test of VO2 max, a test of 750m (STT) and three sprint distance triathlons (TRI) separated by at least 72h of rest, and they were all carried out at the same time of the day. The subjects were informed that they should not perform intense exercise 24h before each test. All the swimming tests were carried out in an indoor pool with six lanes, 25m in length and under the same temperature conditions (27º). The incremental test of VO2 max and the cycling sector of each triathlon were performed in the Laboratory under the same conditions (550m altitude, 20-25º temperature and 35-40% relative humidity).

In the first session, an incremental test on a cycle ergometer (Lode Excalibur Sport, Groningen, The Netherlands) to determine VO2 max was performed. The test started with 5 minutes of heating at 75W and then the load was increased with 50W increments every minute until exhaustion, following the protocol of Craig et al. (19)

After 48 hours of recovery, in the second session, a 750m swim test (STT) was performed in the indoor pool after 200m of warm-up. Afterwards, the subjects were required to swim 750m as fast as possible. The total time, peak heart rate (Polar FT1, Polar Electro, Kempele, Finland), and blood lactate (Scout lactate analyzer, SensLab GmbH, Leipzig, Germany) were measured.

In the following sessions, three TRI were performed at different swimming intensities. A standard 200m warm-up was completed before the start of each swim section of each triathlon (750m at 70%, 80% and 90% of the STT test speed), in a random order. In order to properly control of the swimming rhythm, an aquatic metronome (Finis Tempo Trainer) was placed inside the swimming cap near the swimmer's ear.

After swimming, the subjects moved to the laboratory to perform the cycling sector (located 50m from the pool). The subjects pedaled on the cycle ergometer (SNT Medical CardiGroup, Bikemarc Sport Technology, Barcelona, Spain) a distance of 20km in the best possible time. The cadence and average power were measured. At the end of the cycling sector, the subjects ran outside the Laboratory a distance of 5km in the shortest possible time. The peak heart rate, blood lactate and time were measured after each sector, and at the end of the complete triathlon.

Statistical analysis

The results are expressed as mean and standard deviation. The Shapiro-Wilk test was used to check the homogeneity of each variable ($p > 0.05$). An analysis of repeated measures (ANOVA) was initially performed to identify the differences in the study variables. The effect size (ES) was calculated to evaluate the magnitude of the changes, which was interpreted as small (<0.3), moderate (≥0.3 and <0.5) and large (≥0.5). The analysis was performed using SPSS (version 21.0, IBM Corp, New York, NY, USA) for Windows. Statistical significance was established at $p < 0.05$.

RESULTS

The results are expressed as mean ± SD and are shown in Table 1. In turn, the contribution percentage of each of the sectors is shown with respect to the total time in Figure 1.

Table 1. Results of the variables analyzed according to the swimming intensity

	% Swimming intensity discipline				
Variables	70% (mean ± SD)	80% (mean ± SD)	90% (mean ± SD)	Sig.	ES
Triathlon total time (seconds)	4364.14 ± 253.52	4290.57 ± 241.92	4179.85 ± 226.17	0.045*	0.403
Swimming time (seconds)	953.14 ± 170.46	849.28 ± 124.29	744.28 ± 117.57	0.0001**	0.896
Cycling time (seconds)	2227.71 ± 132.69	2246.71 ± 136.70	2192.57 ± 149.55	0.56	0.092
Running time (seconds)	1185.14 ± 66.56	1194.85 ± 87.84	1225.42 ± 65.39	0.115	0.303
Swimming lactate (mmol l^{-1})	2.21 ± 0.59	3.22 ± 0.72	5.44 ± 1.97	0.0001**	0.742
Cycling lactate (mmol l^{-1})	5.88 ± 3.95	5.12 ± 2.57	4.85 ± 3.07	0.725	0.052
Running lactate (mmol l^{-1})	8.04 ± 4.21	7.38 ± 2.57	6.12 ± 2.40	0.07	0.357
Swimming heart rate (beats/min)	144.85 ± 13.32	120.14 ± 16.64	132.28 ± 25.95	0.046*	0.401
Cycling heart rate (beats/min)	155.71 ± 23.31	161.42 ± 21.61	152.57 ± 19.87	0.222	0.222
Running heart rate (beats/min)	165.28 ± 13.05	154.71 ± 17.65	160.14 ± 17.47	0.287	0.18
Power (watts)	171.71 ± 24.87	165.28 ± 23.69	171.71 ± 28.65	0.784	0.04
Cadence (rpm)	98.71 ± 8.77	99.57 ± 2.93	99.43 ± 3.60	0.947	0.009

* Significant differences for p< 0.05; ** Significant differences for p< 0.01; ES, effect size (d Cohen)

Total time of the triathlons

The average time of the triathlons at 70%, 80% and 90% of the STT was 4364.14 ± 253.52, 4290.57 ± 241.92 and 4179.85 ± 226.17 seconds. The time spent in performing the triathlon in the 90% STT swim condition was lower compared to 70% and 80% STT ($p < 0.05$).

Swimming sector

The total time of this sector for the three triathlons was 953.14 ± 170.46, 849.28 ± 124.29 and 744.28 ± 117.57 seconds, in the conditions of 70%, 80% and 90% STT, respectively. The blood lactate after carrying out this sector was 2.21 ± 0.59, 3.22 ± 0.72 and 5.44 ± 1.97 mmol l^{-1}, under conditions of 70%, 80% and 90% STT, respectively, being superior in 90% STT ($p < 0.001$) compared to 70% and 80% STT. With regard to heart rate, this was significantly higher ($p < 0.05$) in the 90% STT condition (144.85 ± 13.32, 120.14 ± 16.64 and 132.28 ± 25.95 beats per minute) compared to 70% and 80% STT, respectively.

Cycling sector

The total time of this sector for the three triathlons was 2227.71 ± 132.69, 2246.71 ± 136.70 and 2192.57 ± 149.55 seconds, in the conditions of 70%, 80% and 90% STT, respectively, without showing differences between groups. The blood lactate remained without significant differences between conditions (5.88 ± 3.95, 5.12 ± 2.57 and 4.85 ± 3.07, mmol l^{-1} respectively). In relation to heart rate, it remained unchanged in the three conditions (155.71 ± 23.31, 161.42 ± 21.61 and 152.57 ± 19.87 beats per minute, 70%, 80% and 90% STT, respectively). Regarding the parameters of power and cadence in this sector, they remained without differences between conditions.

Running sector

The total time of this sector was 1185.14 ± 66.56, 1194.85 ± 87.84 and 1225.42 ± 65.39 seconds, under the conditions of 70%, 80% and 90% STT, respectively, without showing differences between groups. With regard to blood lactate (8.04 ± 4.21, 7.38 ± 2.57 and 6.12 ± 2.40 mmol l^{-1}, under the conditions of 70%, 80% and 90% STT, respectively) no significant differences were found (p = 0.07), but a small effect size (ES = 0.35) was found. Finally, the heart rate remained unchanged in the three experimental conditions (165.28 ± 13.05, 154.71 ± 17.65 and 160.14 ± 17.47 beats per minute, under the conditions of 70%, 80 % and 90% STT, respectively).

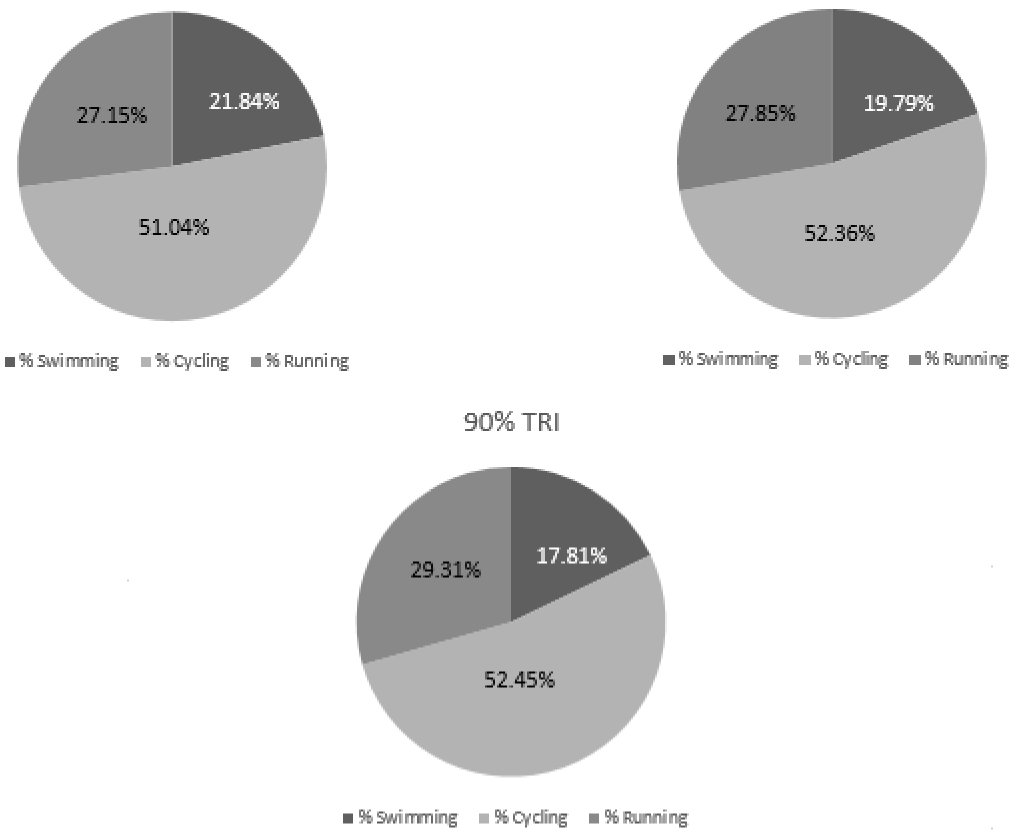

Figure 1. Contribution of each discipline relative to the total time of the triathlon according to each swimming intensity.

DISCUSSION

The objective of this study was to analyze the influence of different swimming intensities on the subsequent performance of cycling, running and the total time of a sprint triathlon, as well as its effect on heart rate and blood lactate. The most outstanding result was that the 90% STT swim intensity was the best result obtained in the total time to complete the triathlon. Our result differs from the results found by Peeling et al. (18), whose authors found that the intensity of 80% STT was the one that obtained the best final performance. These discrepancies may be due to the level of the sample (highly trained vs moderately trained as in our study). Unlike other studies, this study analyzes lower intensities that have not been previously shown by Peeling et al. (19) and Vleck et al. (16), as is the intensity of 70% of a swim distance test in a sprint triathlon (750m).

On the other hand, according to the conclusions of Peeling et al. (19), a low swimming intensity would influence a better subsequent performance in the cycling and running sector, although in our study the same thing did not happen. We did not find significant differences between conditions in the total times of the cycling and running sectors. In turn, the conclusions of Peeling et al. (17, 18) differ from those found by Vleck et al. (16). According to this author, it seems that a lower performance in swimming, can result in a great physical effort at the beginning of the cycling sector, and could influence the subsequent running sector. In spite of this, in our study we did not find significant differences in time and blood lactate in the race, although the moderate effect size (ES = 0.303 and 0.357, respectively) in these variables indicates a tendency that, at higher intensity of swim, the triathlete is not able to deploy his best performance in that sector. Perhaps with a greater number of subjects, this tendency would have been significant. Our results showed a direct relationship between the time in the running race sector and the resulting blood lactate, since the subjects when swimming at a lower intensity (70% TRI), were able to run the sector faster on foot, and, therefore, blood lactate was higher, although not significant (ES = 0.357), showing this tendency.

In relation to the results during the swimming sector, significant differences were found in blood lactate and heart rate. The 90% TRI condition reached a higher value in blood lactate and heart rate. Previous studies have shown a high correlation between blood lactate and heart rate, showing that, at a higher intensity, lactate and heart rate increase in the same proportion (20,21).
Our results show that the final time in the triathlon is improved when the swimming sector is faster (90% TRI), conversely to the results found by Kreider et al. (22) and Peeling et al. (18), who showed that a low relative intensity in the swimming sector could imply an increase in the performance of the cycling and running sectors. Other authors have shown how not only the intensity of the swim influences the final performance of the triathlon, but also the swim strategy used, with the positive strategy being the one that best performs at the end (23). However, in our study we did not find significant differences between swimming intensity conditions in the cycling and running sectors, although the average time of the 90% TRI condition in the running sector was slightly higher compared to 70% and 80% TRI, but without being significant (p = 0.115). The moderate effect size (ES = 0.303) may show a tendency that a higher intensity in the swimming sector could reduce the performance in the race sector. Taking this into account, the time gained in the swimming sector when performed at a higher intensity (90% STT), is sufficient to obtain a better total triathlon time, despite the loss of time in the running race sector for moderately trained triathletes. In this way, in trained triathletes, the optimal swimming intensity would be between 80-90%, according to our results and those previously shown by Peeling et al. (18)

CONCLUSIONS

The present study concludes that the swimming intensity is determinant for the final performance of a sprint distance triathlon in the studied sample. However, additional studies with a larger sample and in triathletes of a higher performance level are recommended.

REFERENCES

1. Chatard JC, Senegas X, Selles M, Dreanot P, Geyssant A. Wet suit effect: a comparison between competitive swimmers and triathletes. Med Sci Sport Exer. 1995;27(4):580-586. https://doi.org/10.1249/00005768-199504000-00017
2. Cordain L, Kopriva R. Wetsuits, body density and swimming performance. Brit J Sport Med. 1991;25(1):31-33. https://doi.org/10.1136/bjsm.25.1.31
3. De Lucas RD, Balikian P, Neiva CM, Greco CC, Denadai BS. The effects of wet suits on physiological and biomechanical indices during swimming. J Sci Med Sport. 2000;3(1):1-8. https://doi.org/10.1016/S1440-2440(00)80042-0
4. Bassett Jr DR, Flohr J, Duey WJ, Howley ET, Pein RL. Metabolic responses to drafting during front crawl swimming. Med Sci Sport Exer. 1991;23(6):744-747. https://doi.org/10.1249/00005768-199106000-00015
5. Bassett DR, Howley ET. Limiting factors for maximum oxygen uptake and determinants of endurance performance. Med Sci Sport Exer. 2000;32(1):70-84. https://doi.org/10.1097/00005768-200001000-00012
6. Chatard JC, Chollet D, Millet G. Performance and drag during drafting swimming in highly trained triathletes. Med Sci Sport Exer. 1998;30(8):1276-1280. https://doi.org/10.1097/00005768-199808000-00015
7. Chollet D, Hue O, Auclair F, Millet G, Chatard JC. The effects of drafting on stroking variations during swimming in elite male triathletes. Eur J Appl Physiol. 2000;82(5-6):413-417. https://doi.org/10.1007/s004210000233
8. Delextrat A, Tricot V, Bernard T, Vercruyssen F, Hausswirth C, Brisswalter J. Modification of cycling biomechanics during a swim-to-cycle trial. J Appl Biomech. 2005;21(3):297-308. https://doi.org/10.1123/jab.21.3.297
9. Millet GP, Vleck VE. Physiological and biomechanical adaptations to the cycle to run transition in Olympic triathlon: review and practical recommendations for training. Brit J Sport Med. 2000;34(5):384-390. https://doi.org/10.1136/bjsm.34.5.384
10. Bonacci J, Blanch P, Chapman AR, Vicenzino B. Altered movement patterns but not muscle recruitment in moderately trained triathletes during running after cycling. J Sports Sci. 2010;28(13):1477-1487. https://doi.org/10.1080/02640414.2010.514279
11. Bonacci J, Saunders PU, Alexander M, Blanch P, Vicenzino B. Neuromuscular control and running economy is preserved in elite international triathletes after cycling. Sport Biomech. 2011;10(01):59-71. https://doi.org/10.1080/14763141.2010.547593
12. Etxebarria N, Anson JM, Pyne DB, Ferguson RA. Cycling attributes that enhance running performance after the cycle section in triathlon. Int J Sports Physiol Perform. 2013;8(5):502-509. https://doi.org/10.1123/ijspp.8.5.502
13. Vercruyssen F, Brisswalter J, Hausswirth C, Bernard T, Bernard O, Vallier JM. Influence of cycling cadence on subsequent running performance in triathletes. Med Sci Sport Exer. 2002;34(3):530-536. https://doi.org/10.1097/00005768-200203000-00022
14. Landers GJ, Blanksby BA, Ackland TR, Monson R. Swim Positioning and its Influence on Triathlon Outcome. Int J Exerc Sci. 2008;1(3):96-105.
15. Cejuela R, Cala A, Pérez-Turpin JA, Villa JG, Cortell JM, Chinchilla JJ. Temporal activity in particular segments and transitions in the olympic

triathlon. J Hum Kinet. 2013;36(1):87-95. https://doi.org/10.2478/hukin-2013-0009
16. Vleck VE, Bürgi A, Bentley DJ. The consequences of swim, cycle, and run performance on overall result in elite Olympic distance triathlon. Int J Sport Med. 2006;27(01):43-48. https://doi.org/10.1055/s-2005-837502
17. Peeling P, Landers G. Swimming intensity during triathlon: a review of current research and strategies to enhance race performance. J Sport Sci. 2009;27(10):1079-1085. https://doi.org/10.1080/02640410903081878
18. Peeling PD, Bishop DJ, Landers GJ. Effect of swimming intensity on subsequent cycling and overall triathlon performance. Brit J Sport Med. 2005;39(12):960-964. https://doi.org/10.1136/bjsm.2005.020370
19. Craig N, Walsh C, Martin DT, Woolford S, Bourdon P, Stanef T, Savage B. Protocols for the physiological assessment of high-performance track, road and mountain cyclists. Physiological tests for elite athletes/Australian Sports Commission. Champaign (IL): Human Kinetics, 2000:258-77.
20. Belcher CP, Pemberton CL. The Use of the Blood Lactate Curve to Develop Training Intensity Guidelines for the Sports of Track and Field and Cross-Country. Int J of Exerc Sci. 2012;5(2):148-159. https://doi.org/10.1123/jce.6.2.148
21. Lopes RF, Osiecki R, Rama LMPL. Heart rate and blood lactate concentration response after each segment of the Olympic Triathlon event. Rev Bra Med Esporte. 2012;18(3):158-160. https://doi.org/10.1590/S1517-86922012000300003
22. Kreider RB, Boone T, Thompson WR, Burkes S, Cortes CW. Cardiovascular and thermal responses of triathlon performance. Med Sci Sport Exer. 1988;20(4):385-390. https://doi.org/10.1249/00005768-198808000-00010
23. Wu SS, Peiffer JJ, Peeling P, Brisswalter J, Lau WY, Nosaka K, Abbiss CR. Improvement of sprint triathlon performance in trained athletes with positive swim pacing. Int J Sports Physiol Perform. 2016;11(8):1024-1028. https://doi.org/10.1123/ijspp.2015-0580

Number of total citations / Total references: 23 (100%)
Number of citations of the journal / Journal's own references: 0 (0%)