emana ta zabal zazu
Universidad del País Vasco
Euskal Herriko Unibertsitatea
HEZKUNTZA ETA KIROL FAKULTATEA
FACULTAD DE EDUCACIÓN Y DEPORTE

Pilot study of the effects of the pacing strategy of the cycling section on the running section of a sprint triathlon

Author: Moreno Sánchez, Inés
Director: Fernández Peña, Eneko

JARDUERA FISIKOAREN ETA KIROLAREN ZIENTZIETAKO GRADUA
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TABLE OF CONTENTS

TABLE OF CONTENTS OF TABLES

1. ABSTRACT

Objectives: To investigate the effect of two cycling intensities on a subsequent 3000m running performance in four well trained triathletes; both of them beginners and the other two experienced triathletes.

Methods: Four triathletes completed a maximal cycling test, a maximal isolated 3000m running test and two cycle-run succession sessions. Running sections were the same in both cycle-run tests, 3000m, but the cycling section was different in each one; one of them was composed by 18km cycling at 90% of its maximum intensity, and the other 18km at 75%.

Results: A significant effect of previous cycling exercise on continuous running was found both when maintained at 90% during the cycling sector and when maintained at 75%. The negative effects were similar in both veterans and novices when maintained at 90%; and the negative effects were heavier in novices when maintained at 75%. Conclusions: The results confirm the alteration in running performance completed after the cycling event compared with the isolated run. Moreover it could be suggested that these alterations depend on the intensity maintained during the cycling section and also on the experience of each triathlete.

2. INTRODUCTION

SPRINT TRIATHLON

Triathlon is a resistance multi-sport event that comprises three disciplines: swimming, cycling and running, always following that order and without any stops, just short transitional times between them (Cejuela Anta, 2007). There are many different and versatile events in triathlon, ranging from short distances ones, such as sprint modality which is composed by a 0,750km swimming, 21km cycling and 5km running, through to ironman events which parts are 3,86km swimming, 180km cycling and 42km running. (Santana-Cabrera & Santana-Martín, 2015).

Success is quite defined by the ability of an athlete to overcome difficulties in the change from one discipline to another. This requires a large amount of training for each modality, and also for each transition. There are lot of ways to practice triathlon depending on the aim of each triathlete. It is also different the way of training depending on the distance of the race you are preparing for.

During the last decade, numerous studies have investigated the effects of the cycle-run transition on subsequent running adaptation in triathletes. In these studies it can be observed that an isolated run compared with a running post cycling, is always performed in a better way, not only the rhythm but also other aspects such as the stride or the position of the body. Moreover, the first few minutes of triathlon running have been reported to induce an increase in oxygen uptake and heart rate. Furthermore, an alteration in ventilatory efficiency and haemodynamic modifications such as: changes in muscle blood flow. Furthermore, changes in running pattern have been observed after cycling, such as an increase in stride rate and modifications in trunk gradient, knee angle in the non-support phase, and knee extension during the stance phase. These changes are generally related to the appearance of leg muscle fatigue characterised by perturbation of electromyography activity of different muscle groups.7
In the same way, in some studies it has been shown that trained triathletes are more used to high intensities and to transitions, and this is helpful in order to be able to maintain a high intensity during cycling without having bad consequences in the following running part..

That is why in this study it is going to be analysed by doing 4 maximal effort tests performed by 4 triathletes, how the bike sector can affect in the continuous running race. Not only in general, but also depending on the intensity maintained in the bike sector. In the same way, in order to try to find out if these effects are more detrimental for novice triathletes, two of the participants have only one year of practice in this sport; and the other two, more than three. This way and comparing them with each other, the goal is to know how important is the intensity during the bike sector due to its consequent negative effects during the running sector; and if these effects are heavier in the novice triathletes or not.

About the utility and the practicality of this study some different facts must be explained. Every person who has being cycling knows that it is always better to go after another person than to go the first one. So as, in any sprint triathlon if you have the possibility of going in a bunch, even if in this study we got to know that it is better to maintain a lower intensity, it would be always better to follow the bunch than going alone in order to maintain the optimum intensity. Because as many authors have mentioned, cycling behind one or more people reduces the energetic cost, and therefore the possibility of fatigue.
But looking for a good bunch in every race is not always possible, so this experiment could be so useful for those triathletes who are alone in the race, and don’t know if it is

better to do their best during the cycling part or to save energy to the following 5 km leg running. Moreover, it also exists a type of race its name is individual time trial, where a group of triathletes will have to do their best without opponents, just against the clock. And when designing the strategy, this study could be so helpful. Because knowing which is the optimum intensity our athletes have to maintain during the cycling part not to have a huge damage during the running part could be awesome.

In the same way and looking ahead this experiment could be also done with the aim of being helpful for longer distances triathlons. Because the more long they are it is more common to go alone. The reason is that if you are cycling the 180km of an ironman, and instead of cycling maintaining the intensity you are used to do it, you try to follow a bunch which velocity is higher, you will maybe not be able to finish the race. This is why doing this experiment and knowing which intensity is the best for not affecting the 42 km leg run, could be a great advantage for those triathletes that are preparing an ironman. But, first I will designed this experiment focussing in the sprint triathlons.

But the most important reason is that nowadays and due to the world pandemic, in most of the triathlons that are being done it is forbidden to pedal behind another person, because it is mandatory to maintain a distance of 10 meters between participants. That is why each participant has to do the race on his own, as doing a time trial. And it is for these cases, where it is essential to know what is the optimal intensity to maintain during the cycling sector in order to be able to face the running race in a correct way.

3. BACKGROUND

SPRINT TRIATHLON

Triathlon is a resistance multisport event that comprises three disciplines which are swimming, cycling and running, always following that order and without any stops, just short transitional times between them (Cejuela Anta, 2007). There are many different and versatile events in triathlon, ranging from short distances ones, such as Sprint distance and Olympic distance, to long distances which are Half Ironman and Ironman (Santana-Cabrera & Santana-Martín, 2015).

Sprint distance triathlons are the shortest ones according to the regulations and they are also the most common modality. It is composed by a 0,750 km swimming, 21 km cycling and 5 km running (Cejuela Anta, 2007).

Even if this sport is quite new it has become so popular, that there are a lot of questions about the physiological characteristics and mechanisms needed to success in this sport (Hausswirth et al., 1999). So as, since it started to be well known both physiological and psychological aspects have started to be investigated in order to get to know which are the most important ones (Hausswirth et al., 1999). The principal aims of these experiments are to develop training methods, racing strategies or race regulations (Hausswirth et al., 1999).

MOST IMPORTANT ASPECTS WHICH MUST BE DEVELOPED IN ORDER TO SUCCESS IN THIS MODALITY

Success is quite defined by the ability of each athlete to carry out the three sectors in a high velocity, without getting too fatigued in any of them for not influencing badly the other ones (Cuba Dorado & García-García, 2014). Succes in cyclic sports, such as running and cycling, depends on the technique, strength and endurance (García Manso y Cols., 1998). Furthermore, besides velocity, resistance, strength and technique, the tactic determinants are also important in both running and cycling sections (Cejuela, 2006).

STRENGTH

There are also different types of strength in this sport: the maximum force which is the maximum force that a person is able to do in an exact moment (González Badillo y cols., 1995); endurance strength, which is the one that allows a person to produce force during a long time (Bompa, 1999); and velocity strength, which allows the triathlete to do immediate anaerobic lactate resistance actions in the most important moments, such as the final sprint (Cejuela, 2006).

TECHNIQUE

Endurance and strength types in both running and cycling disciplines are the same, but technique is different in each sport. According to Cejuela (2006) the technique determinants during the cycling section are: the personal abilities (the chosen cadence, control of brakes, curves course, descend, ascend, position and hydration) and group abilities (drafting, relay, descend on group, and ascend on group). On the other hand, the ones during running section are: stride frequency, stride length and running technique which involves hip position, arm movement, footstep, knee movement, type of propulsion and trunk position (Cejuela, 2006).

ENDURANCE AND ENERGY SYSTEMS

Endurance is defined as the limit of time in which an athlete can keep working maintaining an exact intensity (Bompa, 1999). In sprint triathlons is determined by the aerobic and anaerobic capacity of each triathlete (Cejuela Anta, 2007).

This capacity depends on the energy systems, the ways of producing energy. Aerobic capacity is related with long term energy system, that produces energy through aerobic (with oxygen) pathways; and anaerobic capacity is related with short term and immediate energy systems.

Long term energy system is dominant at lower intensities and efforts lasting longer than 2 or 3 minutes (Coach, 2007). Conversely, short term or anaerobic lactic system (no oxygen, with lactic acid) begins to contribute in order to give more energy to fuel the muscles at maximum intensities, and its duration is no longer than 2 or 3 minutes. In the same way, immediate energy system or anaerobic alactic system is used for explosive or immediate movements and it only supplies energy for up to about 10 seconds (Coach, 2007).

As explained before, long term system produces ATP in the mitochondria of the muscles by using oxygen; short term system doesn't use oxygen in order to produce ATP, it produces from glucose and stored glycogen, and along with energy lactic acid is produced as a by product of the system; immediate system is fuelled by stores ATP and creatine phosphate (Coach, 2007).

These energy systems don't work independently, all operate simultaneously in different degrees depending on the energy demands. During sprint triathlons long term system is the dominant system (Cejuela Anta, 2007; Coach, 2007). But the immediate and short term systems are accessed when an athlete increases the intensity.

Focussing on the long term system, or aerobic system, aerobic capacity must be explained. This term refers to the ability of the heart and lungs to deliver oxygen to working muscles during continuous physical activity (Cheng et al., 2019). Maximal oxygen uptake (VO2max) has been regarded by majority of authors as the best indicator of aerobic capacity of an organism (Ranković et al., 2010). VO2max refers to the intensity of aerobic process, and actually represents the capacity of the organism to utilize at a certain moment the maximum amount of oxygen. In other words, the maximum amount of oxygen which the organism consumes per unit of time while performing the exercise of growing intensity, and which cannot be further increased with further rise of exercise intensity (Ranković et al., 2010). Therefore, triathletes must train their aerobic capacity in order to work aerobically as long as they can even if the intensity is increasing. In other words, triathletes must train their aerobic capacity in order to work aerobically as long as they can even if the intensity is increasing (Chavaren y cols., 1996).

But as said before this is not the unique capacity needed and even if the majority of the triathletes trainings will rely on the improvement of long term system, some trainings should make use of the immediate and short term energy systems. Because this type of balanced trainings will lead to improvement in maximum oxygen uptake and work efficiency. In other words, athletes will be able to work harder at less cost.

This is related with another term named as anaerobic threshold, one of the most specific and important factors. It is the exertion between aerobic and anaerobic training, in other words the highest intensity that an athlete can maintain before stopping to pick up oxygen (Svedahl & MacIntosh, 2003). So as, the concept of anaerobic threshold refers to the transition point or zone between aerobic metabolism and anaerobic metabolism. In other words, it is the transition zone between an intensity in which energy production is preponderantly aerobic and a higher exercise intensity in which energy production requires anaerobic lactic metabolism. Therefore, the anaerobic threshold can be defined as the intensity of exercise or physical work, above which the concentration of lactate in the blood begins to increase progressively, while ventilation also intensifies in a disproportionate manner with respect to the oxygen consumed (Lemme, 2004).

This fact is so important because in order to get them optimum performance they need to sustain very high intensities for as long as it possible but working aerobically in order not to accumulate lactate because this could lead to early fatigue (Cejuela Anta, 2007).

It has been shown that well trained triathlete's anaerobic threshold is at their 85% of their VO_2max (Billat et al., 1999; Galy et al., 2003). But it has been shown that the anaerobic threshold of each athlete is different not only in each of the three sports, but also when performing the three disciplines continuously (Billat et al., 1999; Galy et al., 2003; Sleivert & Wenger, 1993).

TACTIC DETERMINANTS:

PACE

However, besides velocity, resistance, strength and technique, the tactic determinants are also important in both running and cycling sections (Cejuela, 2006).

Different race pace types have been analysed due to its crucial importance, because race pace could be directly related with fatigue and accumulation of lactate and hydrogen ions (Wu et al., 2014). Moreover, for sprint distance triathlon the progressive reduction in pace is more associated with metabolic accumulation and accompanying neuromuscular fatigue than with accumulation of anaerobic metabolic. This is why authors recommend calculating intensity zones not only by heart rate but also by race pace. This way athletes will be able to know which is the race pace that they can sustain working aerobically, and without getting to fatigue(Wu et al., 2014).

The possible factors regulating pace includes exercise distance or duration, race dynamics (drafting conditions, influence of other competitors…), environment factors (wind velocities, topography…), transitions (cycle to run), age, sex, previous experience and cognitive capacity (Atkinson et al., 2007; Atkinson & Brunskill, 2000; T. Bernard et al., 2003; Etter et al., 2013; Christophe Hausswirth & Brisswalter, 2008; Tucker, 2009).

But understanding pacing is complex not only because all the previous factors must be taken into account, but also because athletes are required to distribute their effort over the entire event and also over each discipline (Wu et al., 2014).

Taking into account the factors named above, exercise duration appears to have the most significant influence on optimal pacing strategies (Atkinson et al., 2007). But even If the distance or duration is important various athletes adopt fast start strategies(Chris R. Abbiss et al., 2006; Vleck et al., 2008) . Moreover Baley et al (Bailey et al., 2011) compared the effect of a fast-start, even start and slow-start pacing strategy on 3 minutes cycling performance; and they found a superior performance with the fast start, %7 greater power output.

However, there is evidence to indicate that an even pacing strategy, achieved by maintaining a constant velocity despite varying external conditions (wind, topography, drafting…) may be ideal during endurance events such as sprint triathlons (C. R Abbiss & Laursen, 2008). This is because an increase in velocity requires a dramatic increase in energy expenditure to overcome the nonlinear increase, and could lead to premature fatigue (Skorski et al., 2014).

But this pacing strategy may not be physiologically optimal because external perturbation such as topography or wind must be required to maintain this pacing strategy (Wu et al., 2014). Because they produce large variations in power output when counteracting them. Therefore, depending on this perturbations variations in speed are necessary to maintain a relative distribution of power output and energetic resources for a more optimal strategy (Thomas et al., 2013; Wu et al., 2014).

DRAFTING

It is well known that air resistance is responsible for most of the metabolic cost of cycling section (Belloli et al., 2016). So that, in order to get an evolution in this sector they have investigated tactic factors for decreasing the metabolic cost, for example, drafting (Hausswirth et al., 1999). This term is defined by the practice in which individual's cycle following closely one behind the other or others to limit the air resistance force (Edwards & Byrnes, 2007). It has been shown that cycling behind another cyclist reduces this resistance force up to 44% comparing both the leading cyclist and the one behind him (Kyle, 1979). This is why drafting during the bike section not only lowers metabolic cost but also lowers the heart rate and the ventilation values (Hausswirth et al., 1999).
Depending on the race rules, athletes are often able to draft within a sheltered position behind another competitor (Christophe Hausswirth & Brisswalter, 2008), which provides an opportunity to conserve energy and plays considerable role in determining optimal selected pacing (Tucker, 2009). Drafting during cycling drastically reduces fluid resistance (aerodynamic drag) and, thus, its optimal to conserve energy (Brisswalter & Hausswirth, 2008; Christophe Hausswirth et al., 1999, 2000; Christophe Hausswirth &

Brisswalter, 2008). For example, in a simulated sprint triathlon Hausswirth et al (Christophe Hausswirth et al., 1999) observed a reduction on the oxygen uptake, heart rate and pulmonary ventilation when athletes were drafting 0,2.0,5 meters behind a lead cyclist, compared with non-drafting situation. Furthermore, the number of athletes present in the drafting pack may also influence the speed and energy utilization, which has a significant influence on the subsequent run (Christophe Hausswirth et al., 1999).

Therefore, optimal strategy during bike section is said to be difficult to estimate because pacing during this section could be highly variable and out of individuals control depending on the drafting and race dynamics (Wu et al., 2014). For instance, three studied (Vleck et al., 2008) that have analysed the pacing of elite athletes in draft legal races have collectively reported that these athletes typically adopt a positive pace during swimming, a variable pace during cycling (characterized by fluctuations in speed) and a reserve pace during the run (fast start, followed by a reduction in speed and subsequent increase in speed toward the end of the run) (C. R Abbiss & Laursen, 2008).

But in non-draft legal events, athletes required to maintain a specific distance behind the next competitor, and are given a specific time to pass front athletes when overtaking This difference in drafting ruling could significantly affect pacing during triathlon, as cycling during non-draft legal events are more similar to an individual time trial. Because during them power output maintains stable, without fluctuations in speed (Chris R. Abbiss et al., 2006). Under such conditions, race dynamics are likely to have less of an influence on cycling performance and, thus, athletes are likely to have a greater reliance on intrinsic control over pacing (Wu et al., 2014).

TRANSITION

The cycle before the run can negatively impact physiological stress and performance. These negative effects of preceding cycling section on running performance are well known (Millet & Vleck, 2000). They have been attributed to an increase in oxygen cohort, glycogen depletion, decreased pulmonary compliance, exercise induced hypoxemia, muscle fatigue and redistribution of muscle blood flow (C. Hausswirth et al., 1997).

Moreover, novice athletes reportedly experiences loss of coordination (Millet & Vleck, 2000), associated with changes in gait frequency and transition from a predominantly non-weight bearing activity (cycling) to one bearing two to three times of body mass (running) (Thierry Bernard et al., 2010). Furthermore, transition from a primarily concentric to stretch-shortening sport type to concentric and eccentric contractions in running (Thierry Bernard et al., 2010). So as, the level of how well and how much is trained an athlete is directly related with the fatigue or depletion, in this case the effect that cycling can have on the running section is also higher for those athletes that are less trained (Hue et al., 1997). For example comparing different experiments it can be said that depending on the level of the triathletes who have done the experiments, the differences between their isolated running performances and the ones done after an exhausted cycling session are different (Guezennec, 1996; Hausswirth et al., 2000; Zapico et al., 2009). In other words, the energy cost of high level triathletes is similar when running with a previous fatigue and when running without it (Zapico et al., 2009), but, the energy cost of amateur triathletes increases when they run after a previous fatigue (Guezennec, 1996; Hausswirth et al., 2000).

Therefore, it appears that careful pacing manipulation during the cycle discipline could benefit subsequent running performance. Indeed, it has been suggested that athletes may be able to alter power output and cadence during cycling in order to maintain constant intensity and maximize subsequent run (Thierry Bernard et al., 2007). For example, Bernand et al (Thierry Bernard et al., 2007) investigated the effect of pacing during a 20 km time-trial on subsequent 5 km run and they reported a significantly faster running performance after a constant intensity cycle bouts. Moreover, they demonstrated that an increase in power output during the final stages of a 20 km cycling is detrimental to subsequent 5 km running. Moreover, Le Meur et al (Le Meur et al., 2009) observed a significant decrease in power output in both elite males and females during a World Cups from the first lap to the last lap, presumably this was an attempt to minimize fatigue and maximize subsequent running performance.

Taking above ideas together Wu et al (Wu et al., 2014) suggested that depending on the drafting nature and distance of the race, different combinations of pacing for specific disciplines od the triathlon are requires for optimal performance. However, they suggest that a reduced intensity in prior cycling could result beneficial for a faster subsequent running performance.

4. METHODS

PARTICIPANTS

Four highly motivated participants took part in this experiment. The four of them are part of the same club; therefore, they share both trainer and training plan. They train every day of the week and some days they double their training sessions. On Mondays they usually swim and cycle; Tuesdays they run and cycle or do a strength training; Wednesdays cycling and swimming; Thursdays running and strength training or cycling; Fridays swimming and running or cycling; Saturdays cycling and running, sometimes in transition and sometimes separately; and Sundays cycling and swimming. Some of these workouts are short and very intense, others are both medium duration and medium intensity, and others are long and low intensity, also called regenerative. The four of them do all the workouts following the planning properly, except for the days that due to any major reason they can't (illness, work...).

Regarding each of them, two of them have been practicing this sport for less than one year, and the other two have been doing it for more than three years. One of them, called in this experiment as subject number 1, has been practicing this sport for less than a year, he was born in 1999, male, height 1,75m and weight 56kg. Subject number two has been practicing this sport for less than one year, born in 2000, male, height 1,78m and weight 66,1kg. Subject number three has been practicing this sport for more than three years, male, born in 1996, height 1,81m and weight 69kg. And finally, subject number four, has also been practicing this sport for more than three years, male, born in the year 1995, height 1,88m and weight 72kg.

In order for these participants to be able to perform the experiments, the Ethics Committee of the university reviewed and accepted the conditions of the experiment, and then gave its consent for approval. The four participants, as explained below, performed four maximal effort tests, for which they had to go four different days to the sports centre of the Public University of the Basque Country located in the Faculty of Physical Activity and Sport Sciences.

MAXIMAL RUNNING TEST

The first of the four days during which the different tests were conducted subjects performed a maximal 3 km running test to determine their optimal pace and stride. This test was carried out on a 143 meters long track, on which they had to complete 21 laps

to complete the 3 km. Pace was controlled each lap and the first stride of laps number 1, 5, 10 and 15 were recorded.
This session began with a warm up. This warm up was the same that they practice in their running trainings, which is composed by 700 m easy run, 700 m easy to intense progressive run and 350 m medium to high intensity progressive run. After finishing it they did the 3 km running test, and after it a 5 minutes easy running warm down.

FTP TEST

The second test was a maximum cycling test. This test, called Functional Power Threshold, is a maximal test of 20 minutes, defined as the maximum average power that an athlete can develop over a given period of time. Therefore, cyclists had to pedal for 20 minutes while maintaining as much intensity as they could but trying not to raise or slow down, just maintaining a constant intensity and pace. The test was carried out using the Tacx Flow Smart smart cycling roller, because this roller is able to link to the computer, and this way it allows to perform the test using the Zwift program, which after performing the test calculates on its own the average intensity and the functional power threshold.

So as, this session began with the warm up, which was composed by 7 minutes easy ride followed by 5 repetitions of 1 minute intense ride and 1 minute of rest. After finishing it, they completed the 20 minutes test, and finally they did the warm down, that was a 5 minutes easy ride.

SPECIFIC TESTS: 18 KM CYCLING+ 3KM RUNNING

Triathletes completed two specific tests which were composed by 18 km cycling followed by 3km running. But the intensity maintained during the cycling part was different in each of them. In one of the two tests the triathletes had to pedal while maintaining an intensity of 75% of their maximum threshold; and in the other test they pedalled while staying at 90% of their FTP.

These two tests were done in the same place where they did the previous two running and cycling maximal tests and using the same material. Therefore, there were not environmental or material changes. Because the circuit where they did the 3000m test after having done the 18km bike, was the same that was used for the first 3000m running test without previous fatigue. In the same way, the 18km of cycling were done using exactly the same material that they used when they did the FTP test, and the location of the material was also the same as the one used for the first FTP test

So as, they did the 90% test and last day they did the %75 test. Both days sessions began with the warm up, which was composed by 7 minutes easy ride followed by 5 repetitions of 1 minute intense ride and 1 minute of rest. After finishing it, they completed specific test, and finally they did the warm down, that was a 5 minutes easy run.

5. RESULTS

3000 m PERFORMANCES vs RUNNING POST CYCLING

As explained above in the methods section, the triathletes performed a 3000m run test without previous fatigue for which they had to run 21 laps of the circuit. In this test, the total time required for each triathlete to complete the 3000km, the time for each km, and the time for each lap were measured.
In the same way, in the two 3000m tests performed after the cycling sector, the total time, the time of each km and the time of each lap were also measured.

Regarding the results of each participant, subject number one obtained a time of 10 minutes 9 seconds and 7 hundredths to complete the 3000m run without previous fatigue; being the first km performed the fastest with a time of 3 minutes 12 seconds and 42 hundredths; followed by the second km in 3 minutes 25 seconds and 35 hundredths; and finishing the last km at 3 minutes 31 seconds and 29 hundredths. So in this first 3000 without previous fatigue, his pace was regressive. On the other hand, the 3000 after having cycled 18 km at 90% of his maximum intensity, he completed it in a time of 10 minutes 43 seconds and 15 hundredths. In this 3000 the fastest km was the third one with a time of 3 minutes 29 seconds and 15 hundredths; the first one did it in 3 minutes 36 seconds and 3 hundredths, and the second one in 3 minutes 37 seconds and 62 hundredths, thus achieving a regressive pace and a difference of 34 seconds and 8 hundredths between the 3000 without fatigue and the 3000 after the 18km of cycling at 90%.

Table 1 subject 1 isolated 3000					
Lap	Minutes	Seconds	Hundredths	Σ time (s)	Lap time (s)
1	0	25	13	25,13	25.13
7	3	12	43	192.43	28.79
14	6	37	78	397.78	29.82
21	10	9	7	609.07	29.56

Table 2 subject 1 3000m post 90%					
Lap	Minutes	Seconds	Hundredths	Σ time (s)	Lap time (s)
1	0	29	43	29.43	29.43
7	3	36	3	216.3	30.97
14	7	13	65	433.65	30.54
21	10	43	15	643.15	29.08

On the other hand, subject number two, obtained a time of 10 minutes 44 seconds and 23 hundredths in the first 3000 performed without previous fatigue. In this first test the first km was done in a time of 3 minutes 39 seconds and 3 hundredths, the second in 3 minutes 37 seconds and 25 hundredths and the third in 3 minutes 39 seconds and 3 hundredths, thus achieving a regressive pace, since the first km was the fastest. In the 3000 test performed after 18km of cycling at 75%, he achieved a time of 11 minutes 8 seconds and 3 hundredths; performing the first km in 3 minutes 40 seconds and 49 hundredths, the second in 3 minutes 43 hundredths and 66 seconds and the third in 3 minutes 43 seconds and 88 hundredths. Being the difference between the 3000 without fatigue and the one done after the 18km of cycling at 75% of 23.28 seconds. In the 3000 test performed after 18km of cycling at 90%, he achieved a time of 11 minutes 27 seconds and 26 hundredths; performing the first km in 3 minutes 54 seconds and 92 hundredths, the second in 3 minutes 52 seconds and 7 hundredths and the third in 3 minutes 43 seconds and 88 hundredths. Being the difference between the 3000 without fatigue and the one done after the 18km of cycling at 90% of 43, 03 seconds.

Table 3 subject 2 isolated 3000m

Lap	Minutes	Seconds	Hundredths	Σ time (s)	Lap time (s)
1	0	27	52	27.52	27.52
7	3	27	95	207.95	30.42
14	7	5	20	425.2	31.51
21	10	44	23	644.23	30.19

Table 4 subject 2 3000m post 75%

Lap	Minutes	Seconds	Hundredths	Σ time (s)	Lap time (s)
1	0	29	83	29.83	29.83
7	3	40	49	220.49	31.67
14	7	24	15	444.15	32.15
21	11	8	3	668.3	31.03

Table 5 subject 2 3000m post 90%

Lap	Minutes	Seconds	Hundredths	Σ time (s)	Lap time (s)
1	0	31	0	31	31
7	3	44	92	224.92	32.29
14	7	36	99	456.99	32.78
21	11	27	26	687.26	32.68

The third subject obtained a time of 9 minutes 42 seconds and 28 hundredths in the first 3000 performed without previous fatigue; performing the first km in 3 minutes 4 seconds and 32 hundredths, the second in 3 minutes 15 seconds and 13 hundredths and the third in 3 minutes 22 seconds and 83 hundredths, thus achieving a regressive pace. In the following test, the 3000 test performed after the 18km of cycling at 75%, the time obtained was 9 minutes and 52 seconds; in this test the first km was completed in 3 minutes 22 seconds and 74 hundredths, the second in 3 minutes 18 seconds and 39 hundredths and the third in 3 minutes 12 seconds and 87 hundredths, progressive rhythm. Finally the 3000 performed after 18km of cycling at 90% was completed in 10 minutes 12 seconds and 15 hundredths, with a time of 3 minutes 28 seconds and 89 hundredths in the first km, 3 minutes 24 seconds and 28 hundredths in the second and 3 minutes 18 seconds and 98 hundredths in the third. Taking these times into account, the 3000 without fatigue was the fastest, taking 9 seconds and 72 hundredths more in the test performed after the 18 km at 75%, and 29 seconds and 87 hundredths more in the test after the 18 km of cycling at 90%.

Table 6 subject 3 isolated 3000m

Lap	Minutes	Seconds	Hundredths	Σ time (s)	Lap time (s)
1	0	25	14	25.14	25.14
7	3	4	32	184.32	26.94
14	6	19	45	379.45	28.53
21	9	42	28	582.28	29.09

Table 7 subject 3 3000m post 75%

Lap	Minutes	Seconds	Hundredths	Σ time (s)	Lap time (s)
1	0	28	29	28.49	28.49
7	3	22	74	202.74	28.05
14	6	40	13	400.13	27.38
21	9	50	0	592	26.99

Table 8 subject 3 3000m post 90%

Lap	Minutes	Seconds	Hundredths	Σ time (s)	Lap time (s)
1	0	29	41	29.41	29.41
7	3	28	89	208.89	29.4
14	6	53	17	413.17	29.05
21	10	12	15	612.15	27.66

The fourth subject obtained a time of 10 minutes 56 seconds and 17 hundredths in the first 3000 performed without previous fatigue; performing the first km in 3 minutes 26 seconds and 0 hundredths, the second in 3 minutes 42 seconds and 95 hundredths and the third in 3 minutes 47 seconds and 22 hundredths, thus achieving a regressive pace. In the next 3000 test performed after the 18km of cycling at 75% he completed it in 10 minutes 57 seconds and 17 hundredths, with a time of 3 minutes 33 seconds and 15 hundredths in the first km, 3 minutes 41 seconds and 54 hundredths in the second and 3 minutes 42 seconds and 48 hundredths in the third. In the last test, the 3000 test performed after the 18km of cycling at 90%, the time obtained was 11 minutes 10 seconds and 18 hundredths; in this test the first km was completed in 3 minutes 41 seconds and 43 hundredths, the second in 3 minutes 46 seconds and 62 hundredths and the third in 3 minutes 42 seconds and 13 hundredths, progressive pace. Taking these times into account, the 3000 without fatigue was the fastest, taking 9 seconds and 72 hundredths more in the test performed after the 18 km at 75%, and 29 seconds and 87 hundredths more in the test after the 18 km of cycling at 90%.

Table 9 subject 4 isolated 3000m

Lap	Minutes	Seconds	Hundredths	Σ time (s)	Lap time (s)
1	0	26	86	26.86	26.86
7	3	26	0	206	31.26
14	7	8	95	428.95	32.24
21	10	56	17	656.17	31.66

Table 10 subject 4 3000m post 75%

Lap	Minutes	Seconds	Hundredths	Σ time (s)	Lap time (s)
1	0	28	72	28.72	28.72
7	3	33	15	213.15	30.91
14	7	14	69	434.69	31.84
21	10	57	17	657.17	30.73

Table 11 subject 4 3000m post 90%

Lap	Minutes	Seconds	Hundredths	Σ time (s)	Lap time (s)
1	0	29	94	29.94	29.94
7	3	41	43	221.43	32.19
14	7	28	5	448.05	32.08
21	11	10	18	670.18	29.75

6. DISCUSSION

EFFECTS OF THE PACING STRATEGY OS THE CYCLING ON THE SUBSEQUENT RUNNING PACE

Many studies have shown that the previous cycling sector in a triathlon has negative effects on the continuous running. In this experiment we have been able to observe and confirm that statement, because the four participants obtained a better time in the 3000m running test performed without previous fatigue, compared with both the 3000m run after the 18km cycling at 75% and the 3000m run after having done the 18km cycling at 90%. This shows that even if these participants train all three sports on a weekly basis, even if they train all three disciplines continuously, the cycling sector still has a negative effect on the continuous running.

Furthermore, observing the different paces maintained during the different km of these 3000 tests, it can be seen that all of them maintained a regressive pace in the 3000 performed without previous fatigue, and on the contrary, three of the four participants obtained a progressive pace in the 3000 tests performed after the cycling sectors. That is to say, without fatigue the first km is the fastest for all of them, and on the other hand with previous fatigue the first km is always the slowest and the last the fastest. Therefore, it could be considered that the cycling sector has greater negative effects on the first km of running, and that gradually the negative effects disappear, and triathletes can return to running while maintaining their optimal pace.

DIFFERENCES IN THE SUBSEQUENT RUNNING PERFORMANCES POST PREVIOUS FATIGUE

In this experiment it has been confirmed that the previous cycling sector in triathlons has negative effects on the subsequent running. Furthermore, it has been investigated if the intensity maintained during this cycling section influences these negative effects. In other words, we have tried to investigate whether a higher intensity during the cycling sector has worse consequences on the continuous running or whether, on the contrary, the consequences are the same and do not depend on the intensity. The objective being to know what would be the optimal pace during the cycling sector in triathlons without drafting, since nowadays due to the safety distance that must be kept by the Covid 19 this is the most used modality in competition. As explained above in triathlons with drafting the best strategy during the cycling sector is always based on not losing the peloton, however in the modality without drafting, where the pelotons are not legal, each triathlete has to plan his race and pace.

With this in mind the consequences that the intensity maintained during the cycling sector has on the continuous running race has been investigated, in order to know if nowadays in the non-drafting modality it is better to have a higher intensity during the cycling sector; or if on the contrary, a too high intensity can affect too much the running race and therefore not be a good strategy.

Looking at the results of the three 3000m running tests they performed, all the triathletes obtained the worst time in the 3000m running test performed after the bike sector at 90%. This is why it could be affirmed that the higher the intensity maintained during the cycling sector, the worse the consequences of the running race will be. Therefore, each triathlete should know the level of these consequences, and plan the strategy of the bike sector taking into account the negative effects that the intensity can have on the continuous running.

DIFFERENCES BETWEEN NOVICE AND VETERAN

On the other hand, through this experiment it has also been tried to observe if the consequences of the cycling sector affect more the new triathletes; or if on the contrary the consequences are the same for the triathletes who have been doing this sport for a longer time as well as for those who have not.

For this purpose, the times obtained by subjects one and two, who have been practicing this sport for less than a year, were compared with the times obtained by subjects three and four, who have been practicing this sport for more than three years.

Named above, the four obtained their worst result in the 3000 performed after the cycling sector at 90%. On the one hand, subject number three, one of the veterans, performed this 3000 13.12 seconds slower than the 3000 performed without previous fatigue; the fourth subject, another of the veterans, obtained a difference of 20.15 seconds. As for the novices, the first subject was unable to perform this test because, after falling in a competition, he was injured and had to rest. The other novice was able to perform the test and the difference between the 3000 performed without previous fatigue and the 3000 performed after the bike sector at 90% was 19.23 seconds. Therefore, according to these data, the high intensity maintained during the cycling sector was equally detrimental to both the veteran triathletes and the novice.

Even so, it is striking that although the difference comparing the two specific tests does not show a great difference between novice and veteran triathletes; comparing the 3000 test without previous fatigue with the 3000 test after having done the 18km bike at 75%, there is a big difference between novices and veterans. The difference in seconds gained in these two tests was much higher for the novice triathletes than for the veterans. Subject number one obtained a difference of 34.08 seconds and subject number two a difference of 23.80 seconds. In contrast, for the veterans, subject number three gained only 9.27 seconds and subject number four gained 1 second.

This suggests that the new triathletes have almost the same negative effects on the running race after cycling the 18km at 90% as after cycling it at 75%. In contrast, veterans have almost no negative effects after cycling at 75% compared to the 3000 test performed without prior fatigue. On the other hand, the negative effects increase when cycling at 90%.

Taking these data into account, it could be described as a conclusion that novices could proclaim as optimal pace a maximum or submaximal intensity during the cycling sector, since they have the same side effects while maintaining a low or high intensity. On the contrary, veterans, taking into account the great difference in the effects depending on the intensity, should perform more specific tests with intensities between 75% and %90 in order to be able to analyse when the negative effects start to increase; since at 75% they are almost null and at 95% they are quite noticeable.

7. CONCLUSION

All in all, it can be concluded by reaffirming that the cycling sector always has a negative effect on the subsequent running, but that this effect will depend both on the intensity and on the years of practice of this sport.

Therefore, the recommended strategy during the cycling portion of a sprint triathlon for new triathletes is to maintain a submaximal intensity during the cycling portion, as the effects on the subsequent run are similar after a medium or high intensity cycling portion.

On the contrary, having found that veteran triathletes have medium intensities during the cycling sector after which they have almost no negative effects during the running race, we recommend performing the specific tests of this experiment at different intensities. In this way they will be able to know the highest intensity they can maintain without these effects still being noticeable during the run. In this way, you will not lose too many seconds in either the cycling or the running sector, thus achieving the perfect balance.

However, this study was conducted with only four participants, so studies with a larger number of subjects are needed to prove the statistical evidence of the conclusions.

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9. APPENDICES

Annex a: Ethics Committee consent

emen ta zabal zazu

Universidad del País Vasco | Euskal Herriko Unibertsitatea

NAZIOARTEKO BIKAINTASUN CAMPUSA
CAMPUS DE EXCELENCIA INTERNACIONAL

IKERKETA SAILEKO ERREKTOREORDETZA
VICERRECTORADO DE INVESTIGACIÓN

GIZAKIEKIN ETA HAUEN LAGIN ETA DATUEKIN EGINDAKO IKERKETEI BURUZKO ETIKA BATZORDEAREN (GIEB-UPV/EHU) TXOSTENA

Mª Jesús Marcos Muñoz andreak, Universidad del País Vasco/Euskal Herriko Unibertsitateko (UPV/EHU) GIEBeko idazkari gisa,

ZIURTATZEN DU

Ezen gizakiekin egindako ikerkuntzaren etika batzorde honek, GIEB-UPV/EHU, (2014/2/17ko 32. EHAA)
Balioetsi duela ondoko ikertzailearen proposamen hau:
Inés Moreno Sánchez andreak, M10_2020_289, honako ikerketa proiektu hau egiteko:
"A pilot study of the effects of the pacing strategy of the cycling section on the running section of a sprint triathlon"

Eta aintzat hartuta ezen

1. Ikerketa justifikatuta dago, bere helburuei esker jakintza areagotu eta gizarteari onura ekarriko baitio, ikerlanak lekartzakeen eragozpen eta arriskuak arrazoizko izanik.
2. Ikertzaile taldearen gaitasuna eta erabilgarri dituzten baliabideak aproposak dira proiektua gauzatzeko.
3. Ikerketaren planteamendua bat dator era honetako ikerkuntza egin ahal izateko baldintza metodologiko eta etikoekin, ikerkuntza zientifikoaren praktika egokien irizpideei jarraiki.
4. Indarreko arauak betetzen ditu, ikerketa egin ahal izateko baimenak, akordioak edo hitzarmenak barne.

Aldeko Txostena eman du 2021ko urtarrilaren 21ean egin duen bileran (134/2021akta) aipatutako ikerketa proiektua ondoko ikertzaileek osatutako taldeak egin dezan:

Inés Moreno Sánchez
Eneko Fernández Peña

INFORME DEL COMITÉ DE ÉTICA PARA LAS INVESTIGACIONES CON SERES HUMANOS, SUS MUESTRAS Y SUS DATOS (CEISH-UPV/EHU)

Mª Jesús Marcos Muñoz como Secretaria del CEISH de la Universidad del País Vasco/Euskal Herriko Unibertsitatea (UPV/EHU)

CERTIFICA

Que este Comité de Ética para la Investigación con Seres Humanos, CEISH-UPV/EHU, BOPV 32, 17/2/2014,
Ha evaluado la propuesta de la investigadora:
Dña. Inés Moreno Sánchez, M10_2020_289, para la realización del proyecto de investigación: *"A pilot study of the effects of the pacing strategy of the cycling section on the running section of a sprint triathlon"*

Y considerando que,

1. La investigación está justificada porque sus objetivos permitirán generar un aumento del conocimiento y un beneficio para la sociedad que hace asumibles las molestias y riesgos previsibles.
2. La capacidad del equipo investigador y los recursos disponibles son los adecuados para realizarla.
3. Se plantea según los requisitos metodológicos y éticos necesarios para su ejecución, según los criterios de buenas prácticas de la investigación científica.
4. Se cumple la normativa vigente, incluidas las autorizaciones, acuerdos o convenios necesarios para llevarla a cabo.

Ha emitido en la reunión celebrada el 21 de enero de 2021 (acta 134/2021), **INFORME FAVORABLE** a que dicho proyecto de investigación sea realizado, por el equipo investigador:

Inés Moreno Sánchez
Eneko Fernández Peña

MARIA JESUS MARCOS MUÑOZ

Firmado digitalmente por MARIA JESUS MARCOS MUÑOZ
Nombre de reconocimiento (DN): c=ES, o=UPV - EHU, ou=PAS, ou=Ziurtagiri onartua - Certificado reconocido, ou=Ziurtagiri korporatibo onartua - Cert. corporativo reconocido, ou=Condiciones de uso en www.izenpe.com nola erabili jakiteko, dnQualifier=dni 16038406T -cif Q4818001B, cn=MARIA JESUS MARCOS MUÑOZ, givenName=MARIA JESUS, sn=MARCOS, serialNumber=16038406T
Fecha: 2021.02.16 12:52:49 +01'00'

GIEB-UPV/EHUko idazkari teknikoa
Secretaria Técnica del CEISH-UPV/EHU

Lo que firmo en Leioa, a 16 de febrero de 2021

Eta halaxe sinatu du Leioan, 2021ko otsailaren 16an

susi.marcos@ehu.es
www.ehu.es/CEID

BIZKAIKO CAMPUSA
CAMPUS DE BIZKAIA
Sarriena Auzoa, z/g
48940 LEIOA