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Roberto Cejuela & Sergio Migliorini

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LACTATIC INTENSITY OF COMPETITION IN SPRINT DISTANCE TRIATHLON

Alberto Ferriz , +Roberto Cejuela , Alejandro Imbernón , Jose G Villa-Vicente[2], Irene López , Jorge Rivas

Departmental Section of Physical Education and Sports, University of Alicante (Spain)

[2] Department of Physical Education and Sports, University of León (Spain)

+Address for correspondence:

Roberto Cejuela Anta,

Departmental Section of Physical Education and Sports, University of Alicante (Spain)

Facultad de Educación, Campus de San Vicente del Raspeig.

03540. San Vicente del Raspeig (Alicante). Spain

Tel: +34.965903721 Fax : +34.965903721

Email: roberto.cejuela@ua.es

Keyword

Performance, physiological factors, anaerobic threshold.

Summary

El triatlón, en su modalidad Sprint (750-20-5), tiene rasgos o características únicas dentro de las distintas modalidades que clasifican este deporte como puede ser las altas intensidades de carrera o la estrategia de la misma. El objeto del siguiente estudio es conocer y analizar estas características y relacionarlas con los valores medidos de uno de los factores fisiológicos como es el nivel de lactato en sangre que generan los triatletas (masculinos y femeninos) al finalizar la competición. Además, se contrastará con la literatura existente y que hace referencia a este factor fisiológico con el fin de poder

discutir y sacar conclusiones para optimizar los entrenamientos entorno a estas exigencias fisiológicas para la modalidad de Triatlón Sprint.

Triathlon, in its Sprint's discipline (750-20-5), has unique traits or characteristics within different disciplines which classified this sport, as for example high running intensities or its strategy. The aim of this study is to determine and analyze these characteristics and related them with measured values of one of the physiological factors which is blood lactate concentration generated by triathletes (males and females) at the end of the competition. In addition, the study will be contrasted with existing literature which refers to this physiological factor in order to discuss and draw conclusions to optimize trainings around these physiological requirements of Sprint Triathlon.

Introduction

Knowing competition's intensities is fundamental to improve and optimize the performance of athletes in whatever athletic discipline. Sprint Triathlon (750m-swimming; 20km-cycling; 5km-foot race); is a combined of resistance, transitions (T1 and T2) serve to connect the segments and they cause the change of the position of the triahtlete and their subsequent muscles, what can cause alterations in blood lactate concentrations (Cejuela et al. 2007).

One of the restrictions of the performance is the aforementioned blood lactate (Ribas, 2006). Lactate is the result of change or transition which is produced in energy systems when intensity changes from aerobic to anaerobic (Chicharro, 1995).

The study aims to determine blood lactate concentrations generated by triathletes in competition in order to optimize trainings around these physiological demands.

Material & methods

20 triathletes were selected, 9 males (22.3±3.3 years old) and 11 females (22.81±2.82 years old) who took part in University Triathlon Spanish Championship 2010 which was celebrated in Alicante. Based on their performance, subjects were divided in two categories: Elite (4 men and 3 women who belong to High Performance National Centre) and Development (5 men and 8 women, who belong to Regional Development Centre). All of them follow a planned and organized training.

5 μl samples of blood were collected by the protocol which is defined by analyzer system called Lactate Pro, validated by Pyne et al. (2000), immediately after the end of the competition.

A test of normality and variable homogeneity was done initially using the Statistical Program Package for Social Sciences (SPSS) v.15.0. Following this, descriptive statistics were generated and finally the student's test for independent samples was applied. Pearson correlation coefficients were computed between the values of blood lactate concentration (Mmol L^{-1}) and the final rank results. The alpha level for a significant p was set at ≤ 0.05.

Results

In Table 1 are reflected value data obtained from men and women in their blood lactate concentration immediately after the end of the competition.

Table 1.

	Blood Lactate Concentration (Mmol L-1)	
	MALES	FEMALES
Subject 1	15,4	14,6
Subject2	7,4	7,7
Subject 3	17,6	8,9
Subject 4	11,1	11,9
Subject 5	9,1	8,8
Subject 6	7	10,6
Subject 7	18,2	8,1
Subject 8	12,1	4
Subject 9	11,1	6,5
Subject 10	-	9,6
Subject 11	-	7,7
AVERAGE	12,11 ± 4,14	8,94 ± 2,79

Table 1. Values of blood lactate concentration (Mmol L-1) of men and women at the end the Sprint Triathlon.

There are gender differences in lactate values (12.11±4.14 Mmol·L^{-1} men, 8.94 ± 2.79 Mmol·L^{-1} women) founded at the end of the test, Table 1.

In men group, there are no significant differences in blood lactate values found among the elite group (12.88±5.65Mmol·L^{-1}) and development group (12.10± 4.16 Mmol·L^{-1}). By contrast, there is a significant difference between female elite group (10.40±3.68 Mmol·L^{-1}) and development group (7.43 ± 2.45 Mmol·L^{-1}). Figure 1.

Figure 1

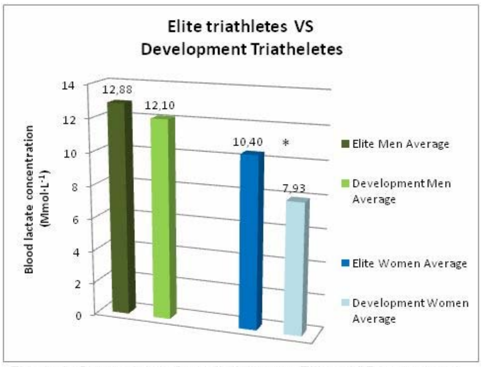

Figure 1. Comparison of results between Elite and Devolopment triathletes men and Elite and Development triathletes women of Blood lactate concentration (Mmol•L-1).

Have not been obtained positive correlations in blood lactate values found between men and women and their respective positions in the competition's general classification ($p \leq 0.05$).

Discussion

There is little literature that shows relevant and comparable values of reliable value data, on account of difficulty of drawing blood to the athletes during competition. Bluche and Cols, 1989, obtained values of 6.85±1.83 Mmol·L^{-1} at the end of an Olympic triathlon. These values are significantly lower than ours, what can explain that a Sprint's triathlete can tolerate higher blood lactate's levels due to duration of the competition is shorter (≈ 60 min. vs ≈ 120 min.) and intensity is higher compared with Olympic triathlon.

Studies made out of the competition have shown that drafting in the second swimming's segment benefits triathlete who follows in the wake of the previous swimmer, either behind and beside it, who shows levels of blood lactate lower and who improves his performance in cycling's segment (Delextrat and Cols, 2003; Bentley and Cols, 2007). In the same way, it has been reported that drafting's use during 20km of cycling compared with the same cycling alone, improved performance in subsequent foot race by 4% (Hausswirth and Cols, 1999).

Triathlon is one of the sports in which race strategy, especially in Sprint's and Olympic triathlon (with drafting allowed), plays an important role in the performance (Cejuela, 2008) and the intensity of the effort is not consistently maintained.

Lactate concentrations measured during simulations of the second transition (cycling-foot race) ranging between 3 and 4 Mmol·L^{-1} (Hue and Cols., 2000; Hue, Galy et al., 2001; Hue, 2003). Taking as reference this data and Berbalk and Cols, 1997, ones in the simulation of the conditions of a Sprint Triathlon, we think that the levels of value data measured in our study can make what happened in the last 2km of the competition.

Between groups there are no differences in the measured values between men, but there are differences between genders and level's women groups (elite vs development). These differences may be due to the state of fatigue in which muscle fibers are and their ability to run the same force with higher energy expenditure, what can explain lower lactate concentrations and lower running economy in the worst-performing groups (development) and in women (Guezennec, 1996).

As for the correlation between lactate values and final classification obtained, nor in the study of Bluche and Cols, 1989, of an Olympic triathlon, there is a significant correlation (0.34). Probably, this is because it depends on the level of competition and the strategy implemented during the competition.

Conclusions

With these references we can deduce that the intensity of the competition will set the strategy to be developed during the meeting. For the sprint distance triathlete, the performance will be conditioned for its capacity to clear lactate accumulated in race attacks and return to MSL (Maximum sustained lactate, which represent the highest intensity that can be sustained without a progressive increase in the concentration of blood lactic acid) which depends on the type of the exercise.

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TRIATHLON IN SCHOOL-BASED PHYSICAL EDUCATION

Victoria E. Machota Blas .PhD. Head of Physical Education Department

Academic Institution: Secondary School "Antonio Hellín Costa". Puerto de Mazarrón. Murcia. Spain

Corresponding author: Victoria E. Machota Blas

C/ Pedro López Meca 50

Bloque 1, Escalera C, 2º 28

Bolnuevo (Mazarrón). Murcia. Spain

Email: vmictoriaeugen6@gmail.com

Telephone: (34) 968150865

(34) 630563196

Fax: 968 33 20 74

Summary and Keywords

The aim of this poster is to describe the implementation of Triathlon in the school-based Physical Education. A teaching unit of triathlon of 12 lessons was designed to become part of the Physical Education syllabus with the aim to work on the technique and tactic of each of the three disciplines and the different transitions and sum up with a competition. Students became aware of the sport of Triathlon demonstrating outcomes and motivation to future practise of triathlon in order to increase their levels of physical activity. This unit shows that appropriate modifications allow this sport to be adapted and included in the framework of school-based Physical Education.

Keywords: Teaching unit. Secondary School. Individual Sports.

El objetivo de este póster es describir la implementación del deporte de Triatlón en la Educación Física Escolar. Para ello, se diseñó una unidad didáctica de Triatlón integrada por 12 sesiones incluida en la Programación Docente del Departamento de Educación Física cuyo objetivo era trabajar la técnica y táctica de cada una de las tres disciplinas y las diferentes transiciones culminando con una competición. Los alumnos conocieron el Triatlón demostrando los aprendizajes y la motivación necesaria para su futura práctica y con el fin de incrementar sus niveles de actividad física. Esta unidad demuestra que con las modificaciones apropiadas, este deporte puede incluirse en el marco de la Educación Física Escolar.

Palabras clave: Unidad didáctica. Educación Secundaria. Deportes Individuales.

Introduction

In the recents years, Triathlon has become an extremely popular sport in Spain and worldwide. The Spanish Sport Authority (1) is promoting its practice in collaboration with The Spanish Triathlon Federation (2) which has modified rules and regulations to match the skill levels and needs for young people (age, ability and mature level). Given the positive benefits of the practice of triathlon and the need to increase adolescents physical activity according to national data (3), the aim of this poster is to present the implementation of triathlon within the school-based Physical Education.

Method

A teaching unit of triathlon (4) was designed to become part of the physical education syllabus. The main objectives were:

- To introduce students to the sport of Triathlon and its other two disciplines (Duathlon: running and cycling; Aquathlon: swimming and running).
- To develop student´s knowledge and skills enabling them to practise and participate in the interschool sports competitions.
- To make students aware of the positive benefits of practise and participation in triathlon.
- To promote growth and development throughout triathlon practise.
- To support the implementation of Triathlon in school-based physical education.

The unit was buit up of 12 lessons, 50 minutes each which were developed on a theoretical and practical basis following the scheme of an introduction-warming up, the development of the main contents of the session and a review-reflection about the work done and an introduction to the next session. The unit was conducted with a total of 98 (57 boys; 41 girls) 14-15 year-old students at a Secondary School (5) during the 3rd. school term (2010) taking advantage of the good weather. The students worked on the technique and tactic of each of the three disciplines (swimming, cycling and running) and the different transitions. The unit also included contents of water and road safety, how to train different modalities and distances and how to deal with competitions. To sum it up, the students took part in an inter-school aquathlon competition held by the local council. Regarding the facilites and equipment, most of the lessons took place in the school´s physical education sports facilities (classrooms, sports court and pavilion) adapting these and only requiring the use of a 25 m. outdoor council swimming-pool in 4 ocasions. In the same way, the students and the teacher contributed to the unit with their own bikes in order to teach cycling and transitions with the celebration of a local ride with the support of the local police officers.

Results

Students have become aware of the sport of Triathlon demonstrating outcomes on knowledge and understanding and basic skills related to this sport. This unit has provided them with the opportunities to learn about this sport contributing to the motivation and future practise of triathlon beyond this school-based physical education unit.

Conclusion

Triathlon is a sport which may be practised by adolescents in order to increase their levels of physical activity. Its initial development may seem conditioned upon location (facilities) and characteristics of very specific material. However, appropriate modifications allow this sport to be adapted and included in the school-based Physical Education Syllabus so it may contribute to maintain healthy and physically active lifestyles. Research is needed in order to study the impact of Triathlon in school-based physical education.

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ANALYSIS OF INJURIES PRODUCED IN OLIMPIC TRIATHLON

Alejandro Imbernón , Roberto Cejuela , Zigor Montalvo ,

Irene López & Alberto Ferriz

Departmental Section of Physical Education and Sports, University of Alicante (Spain)

Spanish Triathlon Federation

SUMMARY

In triathlon, athletes and begginers are related to the tree disciplines that form part of this sport (swimming, cycling and race). Triathletes, over their sport career, suffer many injuries, which affect negatively their athletic performance. The aim of this study was linked together sport source, kind of injury and affected area in elite triathletes of olympic distance. Were analyzed 25 athletes (n = 25) with 8 ± 5 years of experience in triathlon. Triathletes, who come from swimming, are who take less time on sick leave (72.6 ± 85.5 days) and those from cycling are who take most time off (126 ± 108.6 days).

KEYWORDS: triathletes, permormance, elite, recovery, sport.

INTRODUCTION

To the formation and development of elite triathletes, there are factors of performance improvement in triathlon like anaerobic threshold, production – elimination of lactate, VO max, speed and accuracy doing transitions or swimming technique in open sea (Cejuela et al., 2007). Sometimes, we forget an important aspect of performance, the time triathletes leave because of injuries suffered.

The preparation of triathletes is a cross – training of the three sports while they are not practicing the other two. Sometimes, cross – training can be a reason of pathological symptoms or chronic sports injuries produced by triathlon (Galera et al., 2010).

Most triathletes come from one of the sports that structure triathlon (swimming, cycling and foot race). Other have formed as triathletes or come from other sport not related to triathlon.

There are numerous scientific articles about physiology, training, psychological or nutritional in triathlon (Díaz et al., 2009; Bentley et al., 2002 & Millet, G.P. et al., 2009). However, there are not too much concerning sport injuries produced in triathlon (Vleck y cols. 2010 & Show y cols. 2004).

The aim of this study was to find the relationship between the injuries in elite triathletes and their sport source before starting triathlon practice.

METHODS

25 international elite triathletes (n = 25), 8 women and 17 men answered the survey. The age mean was 26 ± 1.2 years and years of competing mean in triathlons is 8 ± 5 years.

As data collection tool was elaborated a questionnaire, divided in two parts:

The first part, consists of 6 items socio – demographic content (subject, country, year of birth, kind, years that triathletes had been competing in their sport source and sport source). In the second part, the items were determined based on 6 modified criteria of the study of Cameron et al. (2008), for determining the harshness of their injury. Items that have being used were the kind of injury, affected area, duration, time without exercise and the total time lost during the injury.

The questionnaires were sent by email to 25 triathletes who responded the questionnaire filled out anonymously. All questionnaires were supervised by spanish team doctor triathlon and all the participant signed a document about transfer personal data, approved by Alicante University´s ethics committee.

Statistical analyses

A descriptive study was conducted by performing a data analysis with the statistical software SPSS version 18.0. With this program, we calculate the mean, standard deviations, frequencies and percentages. To determine relationships between the design variables, we used bivariate correlation techniques applying Pearson and Spearman´s Rho linear correlation coefficient.

RESULTS

Total time out because of injury was 1980 days and the average time, an elite triathlete is injured is 103.2 ± 117 days.

The table 1 shows the results relating each sport source with the number of injuries, downtime (days), the most affected area and kind of injury.

Table 1. Relationship between sport source with the number of injuries, downtime, the affected area and the kind of injury.

SPORT SOURCE	N INJURIES	DAYS WITHOUT EXERCISE	AFFECTED AREA	KIND OF INJURY
SWIMMING	27	72.6 ± 85.5	Lower leg (14.8%) Foot (14.8%)	Muscles (33.3%) Bones (25%) Tendons (25%)
CYCLING	11	126 ± 108.6	Foot (36.4%)	Tendons (45.5%)
RACE	13	117.6 ± 99	Foot (23.1%)	Tendons (46.2%)
TRIATHLÓN	13	95.1 ± 55.5	Ankle (30.8%) Knee (23.1%)	Tendons (30.8%)
OTHER	15	124.5 ± 198	Hip (20%) Knee (20%) Foot (20%) Lower leg (13.3%)	Muscles (26.7%)

Triathletes who come from swimming have been less time off throughout their career with 72.6 ± 85.5 days and those who come from cycling have been the most time off with 126 ± 108.6 days.

In table 2 shows the results of the most common affected area and kind of injuries from 79 injuries picked (n =79).

The most affected area of all athletes tested is the foot (17.7%) and knee (13.9%). And the kind of injury that occurs with a high frequency is the tendon (31.6%) and muscle (25.3%).

It was established positive correlation as Pearson correlation and Spearman Rho between source sport, affected area (r = 0.77 and r = 0.81 respectively) and kind of injury (r = 0.93 and r = 0.9 respectively).

Table 2. Percentage of affected areas and most common kind of injury in elite triathletes.

N INJURIES	AFFECTED AREA	KIND OF INJURY
79	Foot (17.7%)	Tendons (31.6%)
	Knee (13.9%)	Muscles (25.3%)
	Lower leg (11.4%)	Bones (24.1%)
	Ankle (11.4%)	Ligaments (10.1%)
	Hip (11.4%)	Joints (8.9%)

DISCUSSION

Different studies denote that injuries appeared in triathlon because the excessive training, regular triathlon training, running during the week or even the type of footstep in running (Mc Hardy et al., 2006; Shaw et al., 2004; Vleck et al., 2010 & Gosling et al., 2008). In our study, we required the relationship between sport source and triathletes injuries.

Triathletes coming from swimming

Triathletes coming from swimming are the last of having injuries and the kind of injury most common is muscular. This result may be due because of the need of adaptation compared with other athletes from sports such as cycling or running. In swimmers, his muscles had been adapted to a low impact such as water to field for running. Other factors including technical implementation of the run (Vleck et al., 2010) and constant phase plantar flexion propulsion in water have caused a shortening of the calf and soleus, as well as Achilles tendon (McHardy et al., 2006).

Triathletes coming from cycling and running

This kind of triathletes are the ones who has been more time without training because injuries. The tendon injuries are the most common in this atlethes. It can be because during the race, the lower extremities suffer and also because of an incorrect position on the bike.

Triathletes coming from triathlon

Downtime of triathletes who have trained is low compared with other disciplines. One reason might be their entire upper body muscle adaptation to swimming and lower body muscle with cycling and running, making it very complete.

The injuries suffered are not prominence in any particular field even though the ankle is the most affected and tendon injury is the most problematic.

Triathletes coming from other sport

They have very reasonable injuries throughout their career. Therefore, there is not any highlight area affected and muscle injuries mainly predominant. It may be that constants change of sport leads to a non-specific adaptation of the muscles taking place muscle overload.

In the same way as the kind of injury, our data are in harmony with those of Vleck et al., 2010, being the main injury of elite triathlete who competes in olympic distance back injuries (17.9%), Achilles tendon (14.3%) and knee (14.2%).

CONCLUSION

Mostly triathletes coming from a sport linked to triathlon are connected with the kind of injury produced (0.9) and the area injury (0.8).

The most affected areas by elite triathletes are the lower leg and foot. The most common kind of injury are tendon and muscle, which are affected primarily by triathlete´s training and source sport.

This leads us to think about athletes training and sport source because many coaches will avoid several long – term injuries that can be counterproductive to his career.

So we have to introduce other training methods aimed at improvising these deficits in our triathletes as you go sport science as they apply neuromuscular training or new methods of teaching – learning the art of a particular discipline.

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THE VALIDATION OF A NEW METHOD THAT MEASURES CONTACT AND FLIGHT TIMES DURING TREADMILL RUNNING

Ana Ogueta Alday. Bachelor's degree in Sciences of Physical Activity and Sports. Faculty of Sciences of Physical Activity and Sports. Department of Physical Education and Sports. University of León

Juan Carlos Morante. PhD in Sciences of Physical Activity and Sports. Faculty of Physical Activity and Sports. Department of Physical Education and Sports. University of León

Raúl Lazo Vales. Master's degree in Sciences of Physical Activity and Sports. Faculty of Physical Activity and Sports. Department of Physical Education and Sports. University of León

Jose Antonio Rodriguez-Marroyo. PhD in Sciences of Physical Activity and Sports. Faculty of Physical Activity and Sports. Department of Physical Education and Sports. University of León

José Gerardo Villa. PhD in Sciences of Physical Activity and Sports. Faculty of Physical Activity and Sports. Department of Physical Education and Sports. University of León

Juan García López. PhD in Sciences of Physical Activity and Sports. Faculty of Physical Activity and Sports. Department of Physical Education and Sports. University of León

Corresponding author:

Ana Ogueta Alday

C/Madre Vedruna 18 6º I, 01008 Vitoria-Gasteiz (Spain)

aogueta@gmail.com

+34649355787

Summary

This study aims to adapt and validate a new low cost method that measures contact and flight times during treadmill running. 15 well-trained distance runners participated (25±1 years, 69.5±1.4 kg, 1.77±0.02 m). They completed 7 running trials (10-22 km/h) in a treadmill where the new method was installed (1.5 m laser contact mat, SportRunning). Stride parameters (contact and flight times, stride length and rate) were registered simultaneously with a high speed video camera (reference method) and with the new method (laser contact mat + software). Additionally, runners were classified at 18 km/h according to their foot stride pattern (Hasegawa et al., 2007): rearfoot and midfoot/forefoot strike. Contact time was longer ($F=249$ y $p<0.001$) and the flight time smaller ($F=105$ y $p<0.001$) with the new method comparing to the reference method. Correlation between both methods was very high ($r>0.994$ y $p<0.001$). The differences depended on treadmill velocity ($F=8.9$ y $p<0.001$) but not on runners foot stride pattern ($F=0.2$ y $p=0.64$), so an equation was obtained to correct values. Runners' foot stride pattern affected contact time ($F=5.13$ y $p<0.05$) and flight time ($F=19.42$ y $p<0.001$), as other studies have shown. Therefore, the new low cost method has been validated with great accuracy and sensitivity. Further studies could use it to clarify the influence of these biomechanical variables on running economy and performance.

Keywords: running biomechanics, sports technology, photoelectric mat

Resumen

El objetivo del trabajo es adaptar y validar un sistema optoeléctrico de bajo coste, capaz de registrar y analizar los parámetros biomecánicos básicos de la carrera en tapiz rodante. Participaron 15 corredores de fondo-medio fondo de nivel nacional (25±1 años, 69.5±1.4 kg, 1.77±0.02 m). Realizaron una prueba en tapiz rodante donde se registraron las variables biomecánicas básicas de la carrera (tiempos de apoyo y de vuelo, frecuencia y amplitud de zancada) a 7 velocidades diferentes

(10-22 km/h). Se tomaron simultáneamente registros mediante el software Sport-Bio-Running®, conectado a la plataforma de contacto láser y un sistema de vídeo de alta velocidad (método de referencia). Los corredores fueron clasificados a 18 km/h como talonadores o de planta entera-antepié (Hasegawa et al., 2007). El tiempo de contacto fue mayor ($F=249$ y $p<0.001$) y el de vuelo menor ($F=105$ y $p<0.001$) en la plataforma láser respecto al vídeo de alta velocidad, con correlación muy alta ($r>0.994$ y $p<0.001$) entre sistemas. Estas diferencias dependieron de la velocidad del ensayo ($F=8.9$ y $p<0.001$) y no del tipo de corredor ($F=0.2$ y $p=0.64$), por lo que se obtuvo una ecuación para corregir los valores. El tipo de corredor afectó al tiempo de contacto ($F=5.13$ y $p<0.05$) y de vuelo ($F=19.42$ y $p<0.001$), en consonancia con estudios previos. La nueva herramienta es válida y sensible, por lo que futuros estudios podrían utilizarla para el análisis biomecánico de la carrera y su relación con la economía.

Palabras clave: biomecánica de la carrera, innovación tecnológica, plataforma láser

Introduction

Running economy is an important factor in middle and long distance running performance and therefore in triathlon. Several researches have shown that after the second transition (cycle to run), running economy is modified compared to a control run (Millet and Vleck, 2000). However, running economy is influenced by different factors: physiology, training, environment, anthropometry and biomechanics (Saunders et al. 2004). The influence of running biomechanics (contact and flight times, stride length and stride rate) on running economy and performance is still unclear not only in running (Saunders et al. 2004) but also in triathlon (Millet and Vleck, 2000). This may be due to several problems: a-insufficient number of analyzed strides, b-the use of expensive methods, c-too time-expensive analysis, which difficult the feedback, etc. To solve these problems Viitasalo et al.

(1997) designed and validated the "Photocell Contact Mat" (track running). However, this system should be installed in a short testing area (insufficient number of strides) and requires adjusting the running velocity (no natural stride pattern). Recently, Gullstrand and Nilsson (2009) designed and validated the "IR40mat" (treadmill), solving some problems previously described. However, it has some disadvantages too (only one foot was registered, assuming bilateral symmetry, etc). This study aims to validate a new low cost method that measures for a long period of time contact and flight times during treadmill running.

Materials and methodology

15 well-trained distance runners participated in this study (25±1 years, 69.5 ± 1.4 kg and 1.77 ± 0.02 m). They completed 2 minutes trials (with 2-3 minutes recovery) at 7 different running velocities: 10, 12, 14, 16, 18, 20, 22 km/h in a treadmill (HP Cosmos Pulsar), where the new method was installed (SportRunning). It consists in 1.5 m laser contact mat, with an emitter and a receiver bar placed on both sides of the treadmill and laser beams 20mm separated from each other. Treadmill inclination was kept constant at 1% (instead of 0%) in an attempt to mimic the effects of air resistance on metabolic cost of flat outdoor running (Jones and Doust, 1996). Stride parameters (mean register of both feet) were registered during the last 10 s of each trial, enough time to get a steady-state in running velocity (Rodríguez-Marroyo et al., 2009). Records were performed simultaneously with a high speed video camera (reference method, 1200 Hz, Casio Exilim Pro EX-F1) and with the new method (laser contact mat, SportRunning + software, Sport-Bio-Running®). The software registered contact and flight times of both legs (although the representative value of the average of both legs was selected for analysis), and the coefficient of variation (CV). Stride time (ST) was obtained adding contact and flight times, and since it stride rate (SR) was calculated by the equation:

SR(Hz)=1·ST(s)$^{-1}$. In addition, introducing treadmill velocity in the equation: v(m·s^{-1})=SF(Hz)·SL(m), stride length (SL) is obtained. Images from high speed video camera were analyzed manually in Kinovea® software, analyzing a total of 10 supports (5 with each leg). As it has been explained before, stride time, stride rate and stride length were achieved from contact and flight times. Additionally, runners were classified at 18 km/h according to their foot stride pattern (Hasegawa et al., 2007): rearfoot strike (n=10) and midfoot/forefoot strike (n=5). ANOVA repeated measures were performed to compare both systems (reference method and photocell mat). One-way ANOVA was used to compare different running stride patterns. Post-hoc analysis was performed by using Kolmogorov-Smirnov test. Pearson coefficient of correlation was applied to analyze relationship between variables.

Results

Contact time was longer (IC95%=0.0040-0.0051 s, F=249 and p<0.001) and the flight time smaller (IC95%=0.0034-0.0051 s, F=105 and p<0.001) with the new method when comparing to the reference method, with no significant differences in stride length and stride rate. Correlation between both methods was very high (r>0.994 and p<0.001). These differences depended on treadmill velocity (F=8.9 y p<0.001), but not on runners' foot stride pattern (F=0.2 and p=0.64), so an equation was obtained to correct values. Applying the equation, the differences between contact and flight time disappear. Interval of confidence of the differences between systems at 95% (IC95%) was approximately 1 ms (contact time=between -0.0003 and 0.0006 s; flight time=between -0.0007 and 0.0009 s). Correlation between both methods in contact and flight times still very high once values have been corrected. Contact time decreased (F=513 and p<0.001) and flight time increased (F=29.4 and p<0.001) as treadmill velocity was higher. Contact time was longer (F=5.13 and p<0.05) and flight time shorter (F=19.42 y p<0.001) in rearfoot strike runners than midfoot/forefoot strike runners (F=5.13 and p<0.05).

Discussion and conclusions

The differences in both contact and flight times agree with those obtained by Viitasalo et al. (1997), but contrary to Gullstrand and Nilsson (2009). An equation was obtained to correct them according to treadmill velocity, and they disappear (IC95% ~1ms). Probably runners' foot strike pattern did not affect contact and flight time due to the low height of the laser beams (0,7 cm) (Viitasalo et al., 1997). Gullstrand and Nilsson's (2009) study showed more variability (IC95% ~33ms, between -0.028 and 0.005 s), possibly due to the mechanical sensor which was used to validate "IR40 mat". Differences between the two groups of runners (rearfoot vs midfoot/forefoot) are coincident with Hasegawa's et al. (2007) study. Therefore, the new low cost method that measures contact and flight times during treadmill running has been validated. Its accuracy and sensitivity are greater than those obtained in previous studies. It allows recording a sufficient number of steps with both feet, during a long period of time. Runners should not adjust the running velocity, so the movement pattern is more natural. Further studies could use it to clarify the influence of these biomechanical variables on running economy and performance, clarify what happens with stride parameters after cycle to run transition in triathlon and to study the symmetry during running.

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ANTHROPOMETRIC AND PHYSIOLOGICAL PROFILE OF YOUNG MALE ATHLETES OF OLYMPIC TRIATHLON

Antonio Gianfelici[1,2], Roberto Tamburri[2], Mario Miglio[2], Alessandro Bottoni[2], Alessandro Bomprezzi[2] e Marcello Faina[1]

[1]Sport Medicine and Science Institute, Italian National Olympic Committee. [2]Italian Triathlon Federation, Roma, Italy.

Corresponding author: Antonio Gianfelici, c/o Sport Medicine and Science Institute "A. Venerando" CONI - L.go Piero Gabrielli, 1 - 00197 Roma (Italy);E-mail: antonio.gianfelici@tin.it; Mobile +39.393.3323890.

Summary

The Triathlon is an endurance sport event consisting of swimming, biking and running; these events are placed back-to-back in immediate sequence and a competitor's official time includes the time required to "transition". The purpose of the present study was to determine the anthropometric and physiological profile of young triathletes (OTA)(19-23 years) compared to a group of elite OTA, and to evaluate the profiles' differences in order to establish if the younger group already has such qualities to succeed. Therefore, 7 male OTA, selected among the best Italian ranking between the age of 19 and 23, volunteered to participate into the study. Anthropometric measurements included body weight, height, and bioelectrical impedance measurements; physiological measurements included aerobic and anaerobic test. The results showed (age 21,7±1,28 years; height 177,9±5,76 cm; body mass (BM) 69,6±3,1 kg; body fat mass 6,0±1,97 %; fat free mass 65,3±1,99 kg) the $V'O_2$peak was 71,4±3,96 $mlO_2*kg^{-1}*min^{-1}$, 70,3±6,65 $mlO_2*kg^{-1}*min^{-1}$ and 67,6±10,83 $mlO_2*kg^{-1}*min^{-1}$, respectively on cyclergometer, on treadmill and on swimming flume. The peak power (PP) on Win30 test was 804,4±83,88 Watt (11,5±1,36 Watt/kg BM). This study shows that the young triathletes had similar body structures, similar aerobic data and similar anaerobic values compared with the elite Italian OTA and elite Portuguese triathletes.

*El Triatlón es un deporte de resistencia que consiste en eventos de natación, ciclismo y correr; estos eventos se vuelven a colocar en forma consecutiva en la secuencia inmediata y la hora oficial de la competencia incluye el tiempo necesario para la "transición". El propósito del presente estudio fue determinar el perfil antropométrico y fisiológico de los triatletas jóvenes (OTA) (19-23 años) en comparación con un grupo de élite de la OTA, y valorar las diferencias de los perfiles con el fin de establecer si el grupo más joven ya tiene cualidades para tener éxito. Por lo tanto, 7 hombres OTA, seleccionados entre los mejores clasificación italiana entre la edad de 19 y 23, se ofreció a participar en el estudio. Las mediciones antropométricas incluyeron el peso corporal, altura, y lasbioimpedancia bioeléctrica; mediciones fisiológicas incluyen la prueba aeróbica y anaeróbica. Los resultados mostraron (edad 21,7 ± 1,28 años; altura de 177,9 ± 5,76 cm; masa corporal (BM) 69,6 ± 3,1 kg, la masa grasa corporal 6,0 ± 1,97%; masa libre de grasa 65,3 ± 1,99 kg) la V'O2peak fue 71,4 ± 3,96 kg * mlO2-1 * min-1, 70,3 ± 6,65 kg * mlO2-1 * min-1 y 67,6 ± 10,83 kg * mlO2-1 * min-1, respectivamente, en cicloergómetro, en la cinta rodante y en canal de natación. La potencia pico (PP) en la prueba de Win30 fue 804,4 ± 83,88 W (11,5 ± 1,36 W / kg BM). Este estudio muestra que los triatletas jóvenes tenían estructuras corporales similares, datos similares aeróbica y anaeróbica valores similares en comparación con la élite OTA italiano y triatletas de élite portuguesa.*

Keywords: endurance, bioelectrical impedance, Maximal Oxygen uptake, cyclergometer, treadmill, swimming flume.

Introduction

The sport of triathlon comprises a sequential swim, cycle, and run over a variety of distances. The Triathlon has evolved considerably since its inception in the late 1970s, with the most significant change being the introduction of draft-legal races for the elite. Of these, Olympic (OT) distance consisting of 1.5 km of swim, 40 km bike and 10 km run; these events are placed back-to-back in immediate sequence and a competitor's official time includes the time required to "transition" between the individual legs of the race, including any time necessary for changing clothes and shoes. Several investigators (Farber, 1991; Kohrt, 1987; O'Toole, Douglas, 1995; Sleivert, Rowlands 1996; Zhou, 1997) have indicated that the main requisites for successful triathlon performance are high maximal oxygen uptake (V ’O_2peak), lactate threshold and other physiological parameters. The relation between these variables measured separately in each discipline and triathlon performance is not as high, however, as seen in the respective single sports. The ability to link the three triathlon disciplines in an optimal manner is an important determinant of success. (Miller, Vleck 2000). Also, in endurance sport, many Authors showed that are many factors that influence performance. A variety of anthropometric variables have been shown to have an effect on endurance performance: body mass (Bale, 1986; Sharwood 2002), body mass index (BMI), body fat (Hagan 1987), height, (Landers, 2000, Maldonato, 2002). Anthropometric properties and their effect on exercise performance have previously been investigated during short and middle distance running and marathons, (Legaz, Eston, 2005).

The purpose of the present study was to determine the anthropometric and physiological profile of young triathletes (OTA)(19-23 years) compared to a group of elite OTA, and to evaluate the profiles' differences in order to establish if the younger group already has such qualities to succeed.

Materials and Methodologies

The sample consisted of 7 elite young triathletes (all males) selected among the best Italian ranking between the age of 19 and 23. The subjects was enrolled voluntary to participate into the study. Testing was performed at the Sport Medicine and Science Institute "Antonio Venerando" of Italian Olympic National Comitee of Rome (Italy), in a thermally controlled room (20–22°C ambient temperature and 55–60% relative humidity). To ensure normohydration, subjects were advised to drink at least 2 liters of water per day during the week preceding the measurements. They were instructed to refrain from alcohol and physical exercise for 48 h and to refrain from smoking or drinking coffee on the day of the test. First, data for anthropometry and bioelectrical impedance (BIA) were obtained. After a 5-min break, during which subjects where expected to walk leisurely to equilibrate any fluid shifts caused by lying supine. Body mass was measured barefoot, after voiding, in minimal clothes on a calibrated electronic digital scale to the nearest 100 g. (TBF-310GS, Tanita, Illinois, USA). Standing height was measured barefoot to the nearest 0.1 cm using a stadiometer (MPS, Kern & Sohn GmbH, Balingen-Frommern, Germany). Body fat mass was derived from body mass and fat-free mass (FFM), which was estimated using the dat of bioelectrical impedance(BIA 101, Akern, Pontassieve, Italy). The physiological measurements was collected in laboratory, at morning, in four different days, intercalated by 1 day of recovery, between a test day and another. The athletes was divided in two different group that have been tested in cross-over design. Exercise testing was performed using three different ergometer: on the treadmill (HP Cosmos, Nussdorf-Traunstein, Germany), on the aerodinamic-braked cycloergometer (Frugeri, Padova, Italy) and in the swimming flume; in all times, the gas analysis was measured by metabolimeter (Quark PFT, Cosmed, Roma, Italy). Serial $V'O_2$ values were obtained during the exercise test by calculating the average of all breaths taken during each 15-second period. Athletes started at different workloads depending on their own preferences and need for a warm up period. All test protocols for athletes then increased: 1 km/h per 60s on treadmill; with 30W per 60s on cicloergometer; 0,1 m/s per 60s in the swimming flume. Protocols were chosen to yield exercise duration of ~8-12 min. The test continued until exhaustion or until the test subjects could not keep an even pace. was defined as the highest value reached at the end of exercise. Anaerobic power output was measured by Wingate Anaerobic Test (WIN30) as described by Bar-Or (1987) was performed on a calibrated electromagnetic braked cycle ergometer (Excalibur sport; Lode, Groningen, The Netherlands). External resistance was controlled, the power output was measured, and mean mechanical anaerobic power and peak mechanical anaerobic power (PP) were calculated from the exercise results using the Lode Wingate software package (Lode). The seat height was adjusted to the athletes' leg length (comfortable cycling height). The external load (torque; in Nm) was determined by body weight (at 0.9 × body weight). The athletes were instructed to exercise for 1 minute on the cycle ergometer with an external load of 100 Watt at 80–90 revolutions per minute. Thereafter the sprint protocol started. The patients were instructed to cycle as fast as possible for 30 seconds. Power output during the WIN30 was corrected for the inertia of the mass of the flywheel (23.11 kg/m^2). Measured variables were mean power and peak power. Mean power represents the average power output over the 30-second sprint. Peak power is the highest recorded power output achieved in any 3-second period during the 30-second sprint and represents the explosive characteristics of a person's muscle power.

Results

The mean ± SD age of the triathletes was 21,7±1,28 years with a range of 19–23 years. Detailed subject characteristics have been published elsewhere. The mean ± SD body mass of the patients was 69,6 ± 3,1 kg (range 66,0–75,0 kg), the mean ± SD height was 177,9 ± 5,76 centimeters (range 168 – 184 cm), and mean ± SD Body Mass Index (BMI) was 22,0 ± 1,6 kg/m^2 (range 20,6 - 24,8 kg/m^2). The mean ± SD body fat mass was 6,0±1,97 % (range 3,58–9,07 %), than mean ± SD fat free mass was 65,3±1,99 kg (range 61,6–68,0 kg). The aerobic profiles of triathletes was characterized by average ± SD $V'O_2peak$ 71,4±3,96 $mlO_2*kg^{-1}*min^{-1}$ (range 66,5 – 76,00 $mlO_2*kg^{-1}*min^{-1}$) when measured on aerodynamic brake cycloergometer, 70,3±6,65 $mlO_2*kg^{-1}*min^{-1}$ (range 61,0 – 82,0 $mlO_2*kg^{-1}*min^{-1}$) when measured on treadmill and 67,6±10,83 $mlO_2*kg^{-1}*min^{-1}$ range (47,2 – 83,20 $mlO_2*kg^{-1}*min^{-1}$) when measured on swimming flume. The mean ± SD Peak Power (PP) on Win30 test was 804,4±83,88 Watt (range 691 - 892 Watt) corresponding at 11,5±1,36 Watt/kg BM (range 10,3 - 13,6Watt/kg).

Discussion/Conclusion

The primary finding of the present investigation is that amongst competitive young triathletes have more muscle mass and less body fat than elite runners. In fact, when compared with the profiles of elite runners, performed 10000 m like the Olympic distance, the triathletes showed a percent of body fat less. The runners in study of Bale (Bale, 1986) had similar anthropometric profiles to other distance runners measured by Costill, McGowan, Pollock, Reilly and Foreman and the better runners have both anthropometric and training profiles very similar to those of elite runners in the above studies. When the triathletes was compared with the highest ranked elite open-water Brazilian swimmers, they showed the same height, same weight but lower fat mass lower and lighter (Castro, 2009).

We compared the results of measures of young triathletes with actual four elite Italian triathletes (data non published) (average height 179,5±6,56 cm; average weight 69,3±7,24 kg; average fat body 6,8±1,3%). No difference was noted.

Then, we compared all the results, anthropometric and physiological profiles, with the data of Portuguese and Italian triathletes. The Italian triathlon group, in this case was composed by triathletes that perfromed the test during 1996-1998. The data was reported on Dal Monte and Faina (2000). We had chosen the Portuguese group because it had a know tradition in sport long distance events: these group was composed by 12 male triathletes with high training level (Martins, 2006). The height, the body mass and body fat (30±6.8 yrs; 70.2±6.4 kg; 177.5±5.4 cm; 6.7±1.9% fat and 5.2±0.5 yrs of specific training) of Portuguese athletes (Martins-POR) were similar to other group. Portuguese athletes showed a lower maximal power, evaluated by the Wingate Test, when compared to Italian triathletes participating at this study. (10.2±0.9 W/Kg vs 11.5± 1.36 W/kg).

The V'O_2 max, obtained in treadmill, on Italian group, for both Dal Monte (DM-ITA) and actual (Gianf-ITA) groups, was higher that Portuguese group (DM-ITA 70,9±0,9; Gianf-ITA 70,3±6,65 vs Martins-POR 64.2±7.7 ml/kg/min).

This study shows that the young triathletes had similar body structures (height, weight, body fat), similar aerobic data and similar anaerobic values compared with the elite Italian OTA (Dal Monte, 2000) and even better than elite Portuguese triathletes (Martins, 2006). It could be concluded that anthropometric and physiological profile of young athletes (20 years old), who participate into Olympic triathlon, are similar to that of high level athletes. Therefore the lower performance capability should depends on other physiological or biomechanical quality as energetic cost of running or efficiency of cycling.

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RACE PACE ANALYSIS IN TRIATHLON SWIMMING: LOOKING FOR SPECIFIC TRAINNING ZONES

Rivas Feal, A.

High Level Triathlon and Swimming Coach, Master in High Sport Performance, Computer Science Engineering

Faculty of Sport and Physical Education. University of A Coruña. Spain

c/ Viñas de Babilonia 15, 3º C, 15179. Santa Cruz. Oleiros. A Coruña

antonio@udc.es

647802685

RESUMEN

El análisis de los parámetros de competición forma la base sobre la que se sustenta la preparación deportiva durante el trabajo diario de los entrenamientos. Definir las zonas de entrenamiento claves y conseguir preparar un buen plan de trabajo son el requisito previo a cualquier competición importante. El triatlón es un deporte nuevo en este sentido. Durante algunos años este deporte se ha ido nutriendo de participantes provenientes de otras disciplinas y es ahora cuando podemos empezar a ver los frutos de las primeras escuelas con lo que es de esperar que se den bastantes cambios en cuanto al planteamiento físico y táctico de los planes de trabajo y las competiciones.

La combinación de varias disciplinas genera la necesidad de estudiar diferentes posibilidades de preparación. Este trabajo pretende profundizar en el estudio de las intensidades de nado en el primer segmento en el que se plantea el primer filtro con respecto al grupo de deportistas que se disputarán el triunfo final. Diferentes condicionantes hacen que este segmento se dispute bajo unas condiciones bastante particulares desde el punto de vista metabólico y es necesario algún sistema de medida que arroje luz al planteamiento de los periodos de entrenamiento generales y específicos que definen la preparación de los deportistas.

PALABRAS CLAVE

Frecuencia de ciclo, lactato, ritmo de nado

SUMMARY

The analysis of race parameters is the base for sport training in daily training. Defining clue training zones and preparing an adequate working plan are the main goal before a relevant competition. Triathlon is a new sport in this sense. During the last few years most of triathletes were coming form another sports and now is the moment to begin to see first results about triathlon schools. So some changes are expected both tactical and physical training plans and competitions.

Combination of different sports makes necessary the study of different possibilities for initial education and training. This work tries to study the intensities of swimming in the first part of a triathlon race. This is the moment for filtering the group of people who have chance to win. Many conditions make this segment as an unusual race, most of all from a metabolic point of view and it is necessary a measurement system that allows to define a pattern to build preparation periods (general and specific) as well as a tool for training sessions.

KEYWORDS
Stroke Rate, Lactate, Swimming pace

INTRODUCTION

Swimming, as the first part of a triathlon race, has been considered as very important stage in order to reach a position inside the group. Depending on this result a triathlete could race for winning, for being one of the top places at the end or only for trying to get the best position as possible. Last races seems to show how the role of swimming is changing in terms of making groups that have enough influence in final results. Improving swimming level of swimmers, new race tactics or differences in measuring out the effort can be the reasons to see a long human chain going for bike in T1 and a lot of people into the peloton.

Many conditions are presents to make triathlon swimming as a special race: Type of course, number of laps, distance from the start line to the first buoy, waves and so on. On the other hand we don´t have the opportunity to measure any split time for reference and other data like power or biomechanical information are unavailable during the race and most times also during training sessions.

Anyway triathletes competitive behavior must be thoroughly analyzed in order to establish a race pattern as well as appropriate references for training. This is the purpose of the present study.

MATERIALS AND METHODOLOGY

This research is based on stroke rates measured from Athens Olympic Games in 2004 until now. Besides, the data have been "translated" into physiological variables (lactate values) by simulating the same stroke rate conditions in a swimming pool in order to can measure triathlete conditions in unavailable time points during the race (after one minute, 3 minutes, seven minutes and so on).

Stroke rate has been commonly used by swimming coaches as an indicator for swimming intensity. Certainly we can say that "stroke rate=lactate" what means that values makes enough good correlation.

Stroke rate is an indicator quite easy to get even with data from web information. Video recording and a stopwatch with strokemeter is the simplest system to obtain this value even with far images. Usually time in three cycles is measured and we can calculate the stroke rate in cycles per minute. So different stroke rate values can be measured in different moments in a race in which number or position of buoys or laps are not obligatory.

Accelerometer technology is a recent way to get stroke rate. With this new method we can obtain a value for each stroke. Analysis is now more exhaustive and we can see easily a graphic line of stroke rate evolution for a triathlete

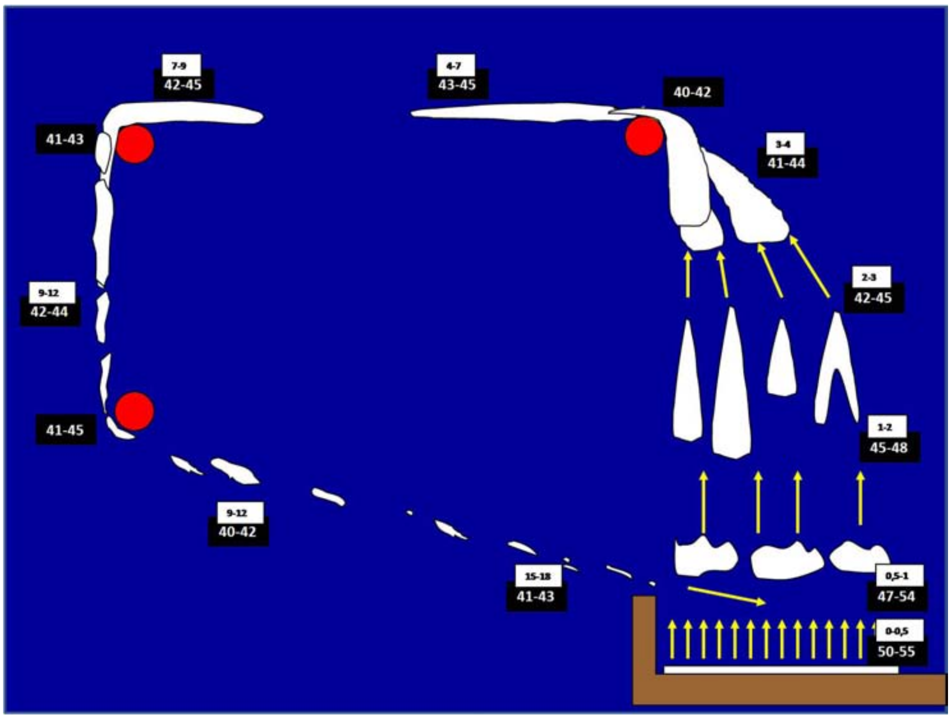
Another reason to use stroke rate to "measure" swimming performance in triathlon are related to the fact that it is quite influenced by waves, orientation, turns, other swimmers what makes this parameter as an specific indicator in open water swimming.

On the other hand the data have been "translated" into physiological variables (lactate values) by simulating the same stroke rate conditions in a swimming pool in order to can measure triathlete conditions in unavailable time points during the race (after one minute, 3 minutes, seven minutes and so on). Total distance (1500 meters) has been divided into five parts with the same stroke rate conditions than in competition: 100 meters, 100 + 200 meters, 100+200+300 meters, 100+200+300+400 meters and finally 100+200+300+400+500 meters. Each part was performed separately with more than 24 hours resting. After an execution lactate values were measured in 1, 3, 5 and 7 minutes and the maximum was annotated. Twelve male people, 20-25 years old take part in the study: 8 triathletes and 4 swimmers.

RESULTS

Data from Olympic Games in Athens (2004) (women race) are shown in figure 1. As we can see there is a great difference between stroke rate values at the beginning of the race and after 7-8 minutes. Probably high values at start and the placement of first buoy were the reason for making so many groups at the end of swimming.

FIGURE 1



Figures 2 and 3 show graphical evolution for stroke rate in women and men races. There are no many differences between. Stroke rate pattern is almost the same. High values at the beginning and relatively low values after 7-8 minutes. Maximum and minimum values are what leader group (after 4 minutes of race) was performing during the race.

FIGURE 2

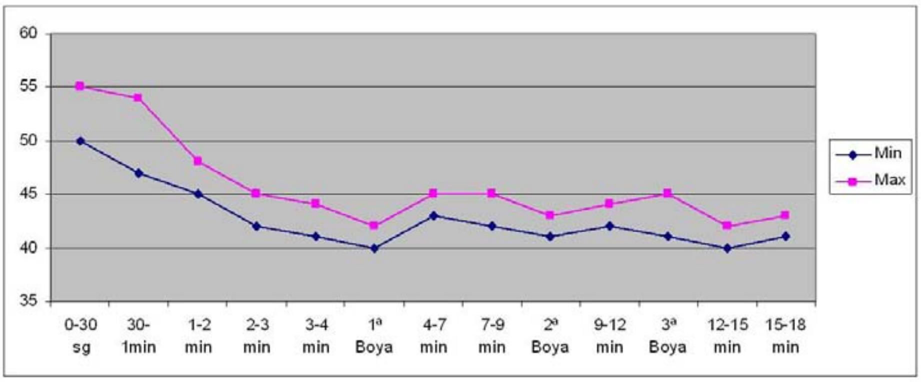
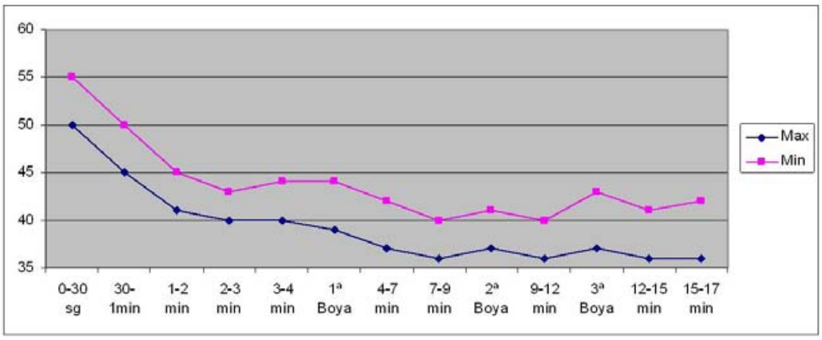


FIGURE 3



Besides, data from Beijing 2008 Olympic Games have been studied but only in the first part of the race and in the middle to see any difference about tactical planning. Table 1 shows this information comparing with some competitions in 2009 and nowadays (2010).

TABLE 1

	Budapest 2010		London 2010		Madrid 2010		Hamburg 2009		Beijing 2008	
	T 3 cycles	Stroke Rate	T 3 cycles	Stroke Rate	T 3 cycles	Stroke Rate	T 3 cycles	Stroke Rate	T 3 cycles	Stroke Rate
0-30 sec	3,65	49,3	3,62	49,7	3,51	51,3	3,87	46,5	3,73	48,3
1-2 min							4,05	44,4	4	45,0
4 min									4,6	39,1
6 min										
8-9 min	3,9	46,2	4,07	44,2	4,3	41,9			4,7	38,3
10-11 min							4,3	41,9	4,7	38,3
16 min									4,9	36,7

Stroke rate is decreasing along the first quarter of the race in all competitions since 2004 [1](from 55 cycles/minute to 36) and stroke rate values are significantly lower at the beginning of the race in the last four years (53-55 cycles/minute in 2004, 46-48 cycles/min in 2008 and 48-50 cycles/minute in 2010).

Simulations of competitive conditions in the pool with lactate measurements are showed in figure 4. Higher values were obtained by swimmers and lower were performed by the triathletes.

FIGURE 4

DISCUSSION AND CONCLUSIONS

Swimming in triathlon race has a pattern completely different to a 1500 meters in a pool. The need to reach good position after first buoy, turns and the presence of other swimmers may be the reason to perform high intensity pace at the beginning. This pace goes down in a progressive way and place each swimmer into a individual position in the group depending on biomechanical factors and lactate tolerance training.

Different reasons can explain the results along last years: In a young sport like triathlon we can expect some initial evolutions to ensure an improvement of final performance. Average level of swimming capabilities is going better so it is difficult to make winner groups during swimming stage. On the other hand the values of lactate we could find six years ago after 2 minutes of race were extremely high [2]. Probably many triathletes have decided to use another tactic in which they can place good position in the group with better physiological conditions.

Probably the best way to get adequate performance is to start with enough high stroke rate to ensure good position but enough low to allow a maintenance at least 8-9 minutes. Triathletes can evaluate their rivals and decide to one or another strategy.

If swimming in triathlon race is a combination of intensities (from fast to slow, from high to low) it can be useful to plan specific training session combining this intensities. Both for tapering series simulation and for segments of complete race (start and 4 minutes, form 2 minutes to 8-9 minutes,…).

Stroke rate seems to be good reference to be used in training session for measurement and controlling specific work. Even when the session are performed into open water.
Table 2 shows an approach to training zones extracted form results obtained before.

TABLE 2

General Period	Specific Period	Competitive Period
Aerobic zones	Combination of trainning zones	Race Simulation series
Non lactate zones	Lactate to aerobic	Lactate to Aerobic
Basic Strenght and Aerobic Endurance Strenght	Anaerobic to aerobic Endurance Strenght	
Skills Learning	Skills with fatigue	Skills into race conditions

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EFFECT OF TWO LACTATE CONCENTRATIONS (3 mMol·L^{-1} vs. 5 mMol·L^{-1}) ON SUBSEQUENT RUNNING IN TRAINED TRIATHLETES.

[1] Carlos Castellar Otín, [2] Jesús Montero Marín, [1] Francisco Pradas de la Fuente, [2] José Antonio Casajús Mallén.

[1] Faculty of Human and Education Sciences. University of Zaragoza (Spain).

[2] Faculty of Sciences of Health and Sports. University of Zaragoza (Spain).

Corresponding author: Carlos Castellar Otín. (C/ Valentín Carderera, 4. 22071. Huesca (España). +0034974239341. castella@unizar.es).

Summary

Different aspects concerning the second transition in the triathlon have been investigated. One of them is the change in cycling intensity to check its influence in the subsequent running. The aim of this study was to assess the influence of two lactate concentrations achieved during 30 min cycling (3 mMol·L^{-1} vs. 5 mMol·L^{-1}) on the subsequent running measured in a group of male trained triathletes. We had analysed heart rate and lactate (in effort and during recovery), length step, frequency step and rating of perceived exertion. We have found statistical differences in the first minute heart rate recovery and in length step in the first running metres immediately after cycling. To sum up, cycling intensities studied have little impact on the subsequent running in this group of triathletes.

La segunda transición en el triatlón (ciclismo – carrera a pie) ha sido estudiada desde múltiples perspectivas. Una de ellas es de la modificación en la intensidad sobre la bicicleta para comprobar su influencia en la carrera a pie posterior. El objetivo de nuestro estudio ha sido analizar el impacto que produce un esfuerzo sobre la bicicleta de 30 minutos de duración a una intensidad de 3 y de 5 mMol·L^{-1} respectivamente, en el desarrollo de la carrera a pie posterior en una muestra de triatletas entrenados.

Se han analizado las variables: frecuencia cardíaca y lactacidemia (en esfuerzo y en la recuperación), velocidad, longitud de paso y frecuencia de paso, así como índice de percepción del esfuerzo. Sólo se han hallado diferencias significativas en la recuperación de la frecuencia cardíaca en el primer minuto y en la longitud de paso de los primeros de carrera tras el ciclismo. Por tanto, no podemos concluir que la diferencia de intensidades sobre la bicicleta haya sido un criterio suficiente de cambio en esta muestra de triatletas.

Keywords

Triathlon, Cycling-Running Transition, Performance.

Introduction

The effect of chained effort in triathlon has been studied for several perspectives. There are studies that analyse the transition triathlon performance involvement with the race distance, as *Ironman* distance (Lepers, 2008; Neubauer, Köning & Wagner, 2008), Olympic distance (1.5 km swimming, 40 km cycling and 10 km running) (Miura, Kitagawa & Ishiko, 1997; Vleck, Bentley, Millet & Bürgi, 2008), short or sprint distance (0.750 – 20 – 5 km) (Cejuela, Pérez, Gerardo, Cortell & Rodríguez, 2007), or comparing short distance versus long distance specialists triathletes (Millet, Dreano & Bentley, 2003). The purpose of this work was to check the second transition influence (cycle-run) in triathletes with two different cycling intensities (3 mMol·L^{-1} vs. 5 mMol·L^{-1}) and after the same running field protocol.

Materials and methodology

Sixteen triathletes (Tables 1 & 2) involved: a maximal cycling laboratory test (cycloergometer Ergoline® Variobike 550, Germany) for determinate the maximal power output (W_{max}), the maximal oxygen consumption (VO_{2max}) with the analyzer Medgraphics® CPX Express (Medical Graphics Corporation, USA), and lactate threshold (LT) by means of variables exponential correlation in each load. Also an incremental and submaximal run field protocol (R) (5 x 1200 m / 1 min) where last load was at 100 % individual maximal lactate steady state (MLSS), and the length step (LS) and frequency step (FS) by means of filming with a digital video camera (Sony® TRV-17, USA), speed (V), heart rate (HR), lactate concentration (LA) and the ratings of perceived exertion (RPE). Furthermore the triathletes performed two combined field tests cycling-running, with two differents lactate concentrations of 3 vs. 5 $mMol·L^{-1}$ (3 C-R and 5 C-R respectively) on bicycle during thirty minutes and immediately finished this effort, the triathletes performed the same run field test.

Table 1: General characteristics of the subjects

Weight	Height	Age	IBM	T. E
71.56±7.92	178.55±7.15	27.30±6.47	22.41±1.53	5.34±2.94

Weight (kg), Height (cm), Age (years), T.E: Triathlon competitive experience (years), IBM: Index Body Mass.

Table 2: Psycho-Physiological characteristics of the subjects during a maximal cycling test

W_{max}	VO_{2max}	HR_{max}	LA_{max}	W 2 $mMol·L^{-1}$	W 4 $mMol·L^{-1}$	RPE
403±61.93	66.77±10.94	182±11.47	10.42±2.35	184±43.65	273±49.19	8.81±1.42

Watios (W), Oxygen Consumption Uptake (VO_{2max}, $mL·kg^{-1}·min^{-1}$), HR_{max} (Maximal Heart Rate, $beats·min^{-1}$), Blood lactate concentration ($mMol·L^{-1}$), RPE (Rating Perceived Exertion).

Normally distributed data (Kolmogorov-Smirnov Test and Shapiro-Wilk) were statistically analyzed using ANOVA test, and when differences were found, t-Test for *post-hoc* comparisons ($p<0.05$) was applied. Subsequently, when were found statistically differences in HR was applied ANCOVA test to control the probably age effect.

Results

No significant differences were found in the applied test (R vs. 3 C-R, R vs. 5 C-R & 3 C-R vs. 5 C-R) neither in the HR_{max} nor LA (maximal and the recovery), and those variables show in the table 3. Also, in the table 4 its show the HR and V at 4, 5 & 6 $mMol \cdot L^{-1}$ lactate concentrations, and neither have been found statistical differences.

Table 3: Maximal and recovery heart rate and blood lactate concentration

	R					3 C-R					5 C-R				
	Max	Rec. 1´	Rec. 3´	Rec. 5´	Rec. 7´	Máx	Rec. 1´	Rec. 3´	Rec. 5´	Rec. 7´	Máx	Rec. 1´	Rec. 3´	Rec. 5´	Rec. 7´
HR	186 ± 9.3	139 ± 14	111 ± 11	106 ± 12	101 ± 12	186 ± 8.8	147 ±12.9	116±10.1	111±11.1	105±12.6	186 ± 8.2	151±14.7	116±10.7	108±11.0	102±9.5
Lac	7.7 ± 1.9	8.0 ± 2.0	7.3 ± 1.8	7.2 ± 1.8	6.8 ± 1.8	7.7 ± 2.2	7.7 ± 1.7	7.6 ± 1.8	7.4 ± 1.8	6.7 ± 1.8	7.7 ± 2.2	7.2 ± 2.5	7.1 ± 1.8	7.0 ± 2.4	6.8 ± 2.2

HR (Heart Rate, $beats \cdot min^{-1}$); Lac (Blood lactate, $mMol \cdot L^{-1}$). Rec. (Recovery).

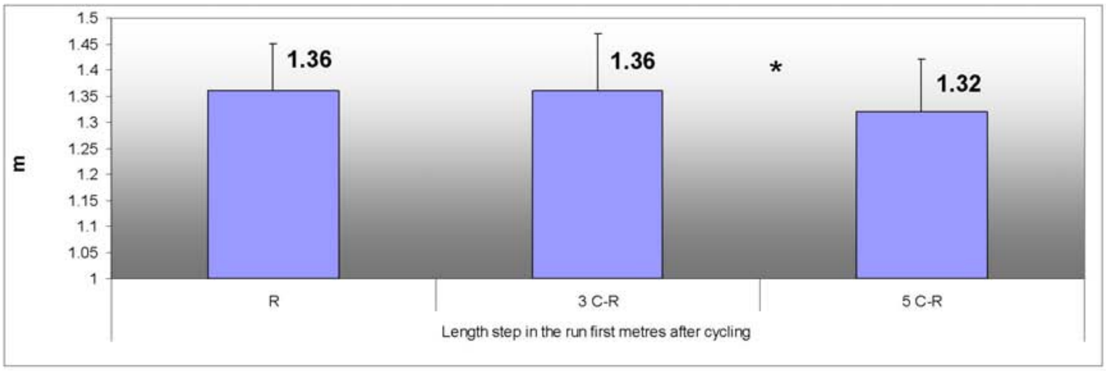
Table 4: Heart Rate and speed on a blood lactate concentration of 4 – 5 – 6 $mMol \cdot L^{-1}$

	R			3 C-R			5 C-R		
	4 $mMol \cdot L^{-1}$	5 $mMol \cdot L^{-1}$	6 $mMol \cdot L^{-1}$	4 $mMol \cdot L^{-1}$	5 $mMol \cdot L^{-1}$	6 $mMol \cdot L^{-1}$	4 $mMol \cdot L^{-1}$	5 $mMol \cdot L^{-1}$	6 $mMol \cdot L^{-1}$
HR	170 ± 9.1	176 ± 8.9	181 ± 9.0	173 ± 7.7	179 ± 7.8	184 ± 8.3	171±9.1	178±9.2	184±9.6
V	15.0±1.5	15.8±1.4	16.5±1.4	15.2±1.8	16.1±2.0	16.9±2.1	14.8±2.3	16.0±2.4	17.0±2.5

HR (Heart Rate, $beats \cdot min^{-1}$); Lac (Blood lactate, $mMol \cdot L^{-1}$). V (Speed, $km \cdot h^{-1}$ kilometres·hr).

Significant differences between cycle-run tests (3 C-R vs. 5 C-R) were recorded in LS in the first running metres (Figure 1) immediately after cycling (1.36 vs. 1.32 m), in the first minute heart rate recovery ($HR_{rec\ 1'}$) (39 vs. 35 bmp) and in the RPE after cycling (2.8 vs. 5.0). There were significant differences between the 5 C-R and the R protocols in LS (1.59 vs. 1.64 m) when the last load was at MLSS. Significant differences between the combined tests (3 C-R and 5 C-R) and the R protocol were also recorded in the $HR_{rec\ 1'}$ (39 vs. 47 bpm and 35 vs. 47 bmp) and in the RPE at the end of run effort (7.2 vs. 7.8 & 7.2 vs. 8.1, respectively). No significant differences between the two experimental groups were recorded in the FS.

Figure 1: Comparative of length step in the run first metres after cycling in tests R, 3 C-R and 5 C-R.



(p=0.043). m (metres) R (Run test). 3 C-R (30 minutes cycling to 3 m·Mol^{-1} and Run test). 5 C-R (30 minutes cycling to 5 m·Mol^{-1} and Run test).

Discussion and conclusions

There were statistical differences between 3 C-R & 5 C-R in the HR first minute during recovery (39 vs. 35 bmp). This fact reveals a higher cardiovascular impact in the triathletes in the 5 C-R protocol. However, this fact was not found in others parameters, as HR_{max} (185±9.2 vs. 184±7.7 bmp) or LA_{max} (7.7±2.2 vs. 7.2±2.2 mMol·L^{-1}). Probably had been insufficient cycling intensities to be enough significant differences in run effort, but could to sense changes in submaximal parameters. For example, we had found speed lower in 4 $mMol·L^{-1}$ lactate concentration (15.2±1.8 vs. 14.8±2.3 $km·h^{-1}$), and HR decrease in 4 $mMol·L^{-1}$ lactate concentration (173±7.7 vs. 171±9.1 bmp), although any parameters described have been found statistical differences. The parameters observed show similar results others studies (Hue, Le Gallais, Chollet, Boussana & Préfaut, 1998), where to check similar decreases in HR and VO_2 during 10 running kilometres just immediately to finish 40 cycling kilometres, respect to run control protocol.

The only cinematic parameter, between the 3 C-R and 5 C-R protocols, where we had found statistical differences was the LS in the first metres (400 m) just started the first run load (1.36±0.1 vs. 1.32±0.1 m respectively). The success of other studies where has been analysed similar cinematic parameters respect our study (Goottschall & Palmer, 2000) observed a significant decrease in LS at the beginning of the run (run race of 5000 m) after thirty cycling minutes in a high intensity. Others authors (Marino & Goegan, 1993) have been found similar parameters also. One of the probably reasons for decrease in LS could be the continuous fatigue of quadriceps muscle during cycling effort, and prevented the necessary force in the run step for compare the same run step in the isolated run protocol.

The significant reduction in LS in the first metres recorded during the 5 C-R test, as well as the significant differences observed in the first minute heart rate recovery, suggest that those variables are the main parameters that may change when increasing the intensity of cycling. However, the two intensities of cycling evaluated in this study were not crucial for inducing a greater impact on the other parameters tested in this group of triathletes during the subsequent running.

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Running technique analysis in triathletes

CARLOS MARTÍN CARO[1]

[1]*Degree in Sport and Physical Activity Sciences. Optimal Endurance Training, Madrid, Spain.*

Corresponding author: Carlos Martín Caro

C/Pintor el Greco 23, 2ºB

28933 Móstoles, Madrid, Spain

carlos@optimalendurancetraining.com

Tel:0034656667397

Abstract

English

Stride frequency and length has been widely studied in speed running, but insufficiently in endurance running. The aim of our study is to assess relationship between the kinematic running variables in duathlon competition. The work was conducted with 17 triathletes (14 men and 3 women) of age group competitive level in Sprint and Olympic distance. The kinematic parameters were obtained from an analysis in two dimensions, calculating joint angles and distances. We found significant correlations between speed and stride length (r = 0.96), the maximum knees separation and speed (r = 0.89), maximum knee flexion in support and knee angle landing (r = 0.82), the strength index and the recovery leg knee angle (r = 0.78), anterior thigh angle to the vertical at the time of knees maximum separation and speed (r = 0.70), P <0.05. Triathletes with high values of knee angle at the time of first contact with the ground, show also high values in maximum knee flexion angle in support. The most correlated variables with running speed in Duathlon competition are stride length and maximum knee separation.

Spanish

La frecuencia y la amplitud de zancada han sido ampliamente estudiadas en carrera de velocidad, pero de forma insuficiente en carrera de resistencia. El objetivo de nuestro estudio es evaluar la relación entre las variables cinemáticas de la carrera en la competición de Duatlón. El estudio se realizó con 17 triatletas (14 hombres y 3 mujeres) que compiten en grupos de edad en distancia sprint y olímpica. Los parámetros cinemáticos se obtuvieron de un análisis en 2 dimensiones, calculando ángulos de articulaciones y distancias. Se encontraron correlaciones significativas entre la velocidad y la longitud de zancada (r = 0.96), la separación máxima de rodillas y la velocidad(r = 0.89), la máxima flexión de rodilla durante el contacto con el suelo y el ángulo de la rodilla en el aterrizaje (r = 0.82), el índice de fuerza y el ángulo de rodilla de la pierna de recobro (r = 0.78), ángulo anterior del muslo con respecto a la vertical en el momento de máxima separación de rodillas y la velocidad (r = 0.70), P <0.05. Los triatletas con altos valores de ángulo de rodilla en el momento del primer contacto con el suelo, presentan también altos valores de máxima flexión de rodilla durante el apoyo. Las variables más correlacionadas con la velocidad de carrera en un Duatlón son la longitud de zancada y la máxima separación de rodillas.

Keywords: Stride Length, endurance performance, Duathlon.

Introduction

Stride frequency and length has been widely studied in speed running(1), but insufficiently in endurance running. The available evidence also suggests that triathletes have poorer running economy than comparable elite runners(2). There is many biomechanical variables appear to affect running performance and economy(3). Runners has the best economy with a freely chosen stride frequency and length(4), also economy has been associated with less vertical oscillation(3), reduced support time associated with greater power(5), reduced plantar flexion at higher speeds during foot removal(6), increased forward lean of the trunk(6), increased shank angle relative to the ground at foot strike(6) and lower peak ground reaction forces(3). Performance in endurance running has been correlated with low support time(7), high minimum knee angle during the stance phase(8).

Correct Knee angle in foot strike, the stride frequency and length dynamic and their relations with competition speed has not been completely studied in endurance running.

The aim of our study is to assess relationship between the kinematic running variables in duathlon competition.

Materials and methodology

Participants

Measurements were performed during the Madrid Duathlon Championship 2010. In the Madrid Duathlon Championship 17 triathletes (14 men and 3 women) of age group competitive level in

Sprint and Olympic distance (age 35.0 ± 5.3 years; best 5 km time 20 min 3 s ± 58.2 s; height 1.75 ± 0.01 m; body mass 72.3 ± 7.2 kg) were investigated during the Duatlon pre transition running segment, video recorded for comparing kinematic parameters.

Data collection

The competition recording were held at the middle of the Duatlon pre transition running segment in a sagittal plane with a Canon digital camera (FS10) operating at 25 frames per second. The cameras were positioned on the same level than the race surface at 15 m from de triathletes sagittal plane and camera height was fixed at 87 cm. Horizontal position and space were calibrated using a 4 points reference system.

Data Analysis

To obtain the kinematic parameters was used the Dartfish Connect 5.5 software (Dartfish, Fribourg, Switzerland), which allows make an analysis in two dimensions, calculating several variables relating to joint angles and distances.

The kinematic parameters were calculated in 5 key positions following the standards of Leskinen researches (8) and our own standard (Table 1): Touchdown(TD), Midstance(M), Toe-off(TO), Maximum knees separation (MKS) and landing (L). To minimize errors introduced by the operators, all trials were digitized by a single operator. We used the mechanical model of the human body of 14 segments(9) , but using only the segments of trunk, thigh, leg and foot. The segments were calculated from the digitization of the points of shoulder, hip, knee, ankle, heel and tiptoe.

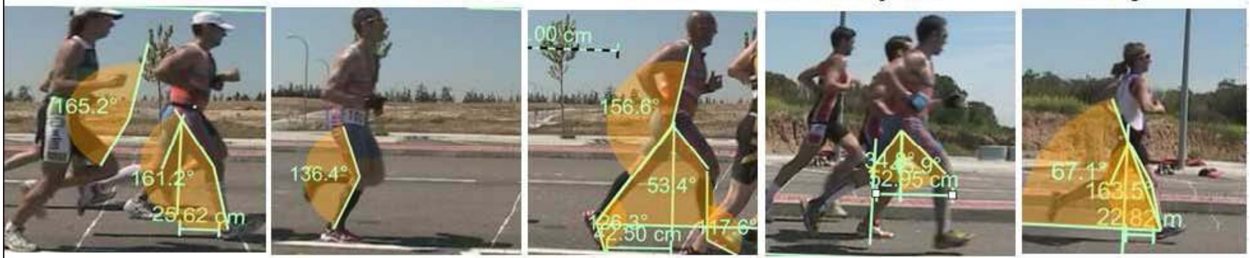
Variables description

Variables calculated in each key position are described in table 1. Running speed (RS) was calculated from the stride frequency (SF) and stride length (SL). RS was considered as a performance indicator. SF was calculated using the inverse of time spent in making a stride cycle through the temporal relationship of each frame (25 frames / second). A stride cycle (SC) runs from the moment the athlete is supporting a foot on the ground until it returns to support the same foot in the next stride. Vertical oscilation (VO) is the vertical displacement between the lower and the higher position of a SC. Strength Index (SI), SI=1-(PD/(SL - LD)). Hip Arc (HArc) is the hip arc angle during the support, Harc=180-TOA-LA. Maximun knee flexion after landing (MKF) is the diference in grades between KA_L and KA_M.

Table 1

Table 1: Running key positions and variables calculated in each key positions

Touchdown	Midstance	Toe-off	Max. knees separation	Landing



Touchdown	Midstance	Toe-off	Max. knees separation	Landing
TA_TD RecA_TD	KA_M	TTA_TO AA_TO RecAA_TO PD TOA	KS ATA PTA TA_MKS	LD KA_L LA

TA_TD=Angle between thighs in TD, RecKA_TD= Recovery Knee angle in TD, KA_M= Knee angle in M, TTA_TO=Trunk-porterior thight angle in TO, AA_TO=Propulsive Leg ankle angle in TO, RecAA_TO=Recovery Leg ankle angle in TO, PD=distance between hip vertical proyection and propulsive foot tiptoe in TO(propulsive distance), KS=knee separation in MKS, ATA=Anterior thigh angle with hip vertical proyection in MKS, PTA= Posterior thigh angle with hip vertical proyection in MKS, TA_MKS= ATA+PTA, LD=distance between hip vertical proyection and front foot heel(landing distance),KA_L=knee angle of Leg landing, TOA= hip-ankle segment angle of rear leg with horizontal in TO, LA=hip-ankle segment angle of front leg in L.

Statistical analysis

After checking the sample normality, the kurtosis and the asymmetry, Pearson correlations were performed between each variable obtained from each triathlete, the significance level was set at $\alpha = 0.05$.

Results

Results are showed in table 2. Significant correlations were found between Speed and SL (r = 0.96, P <0.05), the KS and Speed (r = 0.89, P <0.05), so that the higher speed the greater SL and KS. MKF correlated with KA_L (r = 0.82), so that the greater the MKF, the greater KA_L, triathletes that land with the knee extended flex more the leg during the stance phase. Harc correlated with TA_TD(r=0.75, P <0.05) and Speed and ATA (r = 0.70, P <0.05).

Significant inverse correlations were found between the strength index and the RecKA_TD (r = -0.78, P <0.05), so triathletes which less contribition of PD in his SL has lower RecKA_TD, also La correlated with TA_TD (r = -0.72, P <0.05), so triatletes that have a low LA have their thighs very separated in TD.

Table 2

Table 2: Pearson correlations between running variables

	SF	SL	Speed	VO	TA_TD	RecKA_TD	KA_M	TTA_TO	AA_TO	RecAA_TO	PD	KS	PTA	ATA	TA_MKS	LD	KA_L	MKF	TOA	LA	SI	Harc	
SF	1,00	0,21	0,48	-0,34	-0,02	-0,34	-0,28	0,01	-0,20	0,32	-0,13	0,21	0,19	0,31	0,32	-0,09	-0,43	-0,28	-0,05	-0,18	0,34	0,14	**SF**
SL		1,00	0,96**	-0,07	0,23	-0,60*	0,22	-0,02	0,11	0,46*	0,38	0,93**	0,53	0,68*	0,77**	0,32	-0,36	-0,52*	-0,01	-0,25	0,66*	0,17	**SL**
Speed			1,00	-0,16	0,20	-0,64*	0,12	0,00	0,05	0,50*	0,29	0,89**	0,51*	0,70*	0,78**	0,28	-0,44	-0,55*	-0,02	-0,29	0,69*	0,20	**Speed**
VO				1,00	-0,26	0,05	-0,19	0,17	-0,16	0,17	-0,16	-0,07	0,17	-0,39	-0,18	-0,12	0,26	0,39	0,32	0,41	0,13	-0,42	**VO**
TA_TD					1,00	0,46	-0,17	0,20	0,26	0,11	0,51*	0,35	0,47*	0,18	0,38	0,64*	-0,45	-0,37	-0,60*	-0,72*	-0,32	0,75**	**TA_TD**
RecKA_TD						1,00	0,00	0,20	0,08	-0,25	0,12	-0,55*	-0,07	-0,72*	-0,55*	0,31	0,23	0,24	-0,38	-0,24	-0,78**	0,34	**RecKA_TD**
KA_M							1,00	-0,01	-0,15	-0,07	-0,12	0,01	-0,39	-0,03	-0,23	0,24	0,40	-0,19	0,28	0,17	0,20	-0,24	**KA_M**
TTA_TO								1,00	-0,08	-0,34	-0,25	-0,17	-0,08	-0,16	-0,16	0,47	-0,15	-0,15	-0,05	-0,27	0,05	0,20	**TTA_TO**
AA_TO									1,00	-0,35	0,70*	0,22	0,20	0,14	0,21	0,29	-0,34	-0,27	-0,13	-0,42	-0,47	0,33	**AA_TO**
RecAA_TO										1,00	0,05	0,47	0,66*	0,30	0,57*	-0,20	-0,08	-0,04	-0,02	0,10	0,48	-0,05	**RecAA_TO**
PD											1,00	0,53*	0,46	0,11	0,33	0,29	-0,48	-0,44	-0,35	-0,37	-0,41	0,40	**PD**
KS												1,00	0,61	0,71	0,84	0,31	-0,55	-0,60*	-0,10	-0,31	0,49	0,25	**KS**
PTA													1,00	0,24	0,72	0,15	-0,28	-0,06	-0,40	-0,35	0,19	0,41	**PTA**
ATA														1,00	0,85	0,05	-0,52*	-0,55*	0,04	-0,21	0,56*	0,11	**ATA**
TA_MKS															1,00	0,12	-0,53	-0,42	-0,19	-0,34	0,50*	0,31	**TA_MKS**
LD																1,00	-0,27	-0,44	-0,32	-0,79	-0,14	0,66	**LD**
KA_L																	1,00	0,82**	0,13	0,44	0,06	-0,34	**KA_L**
MKF																		1,00	-0,03	0,36	-0,06	-0,22	**MKF**
TOA																			1,00	0,59	0,28	-0,85	**TOA**
LA																				1,00	0,21	-0,92	**LA**
SI																					1,00	-0,27	**SI**
Harc																						1,00	**Harc**

* relevant and significant correlations, p<0,05

** relevant and significant correlations higher than 0.75

Discussion and conclusions

The most correlated variables with speed are SL and MKS. This results could suggest that triathletes must train fot getting longer stride to improve performance, but a running technique that get shorter stride can improve anaerobic threshold speed (10), so this is not clear.

Triathletes with high values of KA_L, show also high values in MKF, this last caracteristic is not good performance indicator because good runners flex less the knee in stance phase(8) .

In conclusion, the most correlated variable with running speed in Duathlon competition is stride length.

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Physiological correlates of simulated sprint-distance triathlon

Daniel Taylor[1], Mark. F. Smith[1] and Veronica E. Vleck[2]

[1]School of Sports, Coaching and Exercise Science, University of Lincoln, Lincoln, LN6 7TS, United Kingdom.

[2]CIPER. Faculty of Human Kinetics, Technical University of Lisbon, Cruz Quebrada-Dafundo 1499-002 Portugal.

Corresponding Author:

Daniel Taylor

School of Sports, Coaching and Exercise Science,

University of Lincoln,

Lincoln,

LN6 7TS

UK

Tel: 01522 886845

E-mail: dtaylor@lincoln.ac.uk

Summary

The purpose of this study was to examine the relationship between simulated triathlon performance and physiological variables measured during conventional laboratory tests. Seven non-elite, competitive male triathletes completed incremental cycling and running tests in a random order, in addition to a simulated sprint-distance triathlon trial (750 m swim, 500 kJ bike, 5 km run) using a 25 m pool, an electromagnetically braked cycle ergometer and motorised treadmill. There were no significant correlations between overall performance time and either running or cycling incremental tests, however significant correlations were found between triathlon run time and both running and cycling incremental tests ($V_{peak,}$ r = -.900, $p<0.05$; $V_{4mmol,}$ r = -.822, $p<0.05$; $W_{peak,}$ r = -.844, $p<0.05$). Total simulated triathlon time was highly correlated to cycle time (r = .930, $p<0.05$) and mean cycling power output (r = -.956, $p<0.05$), whilst there was no significant correlation between either swim time or run time and overall performance time. For non-elite, competitive male triathletes, a performance assessment which better reflects the demands of the cycle phase of triathlon (i.e. a time-trial protocol) may provide a better indication of simulated sprint-distance triathlon performance in comparison to commonly used incremental laboratory tests. Furthermore, cycling performance appears more important to overall performance in simulated sprint-distance triathlon than swimming or running.

Keywords: multisport, transition, constant-distance test, triathlete, incremental test

Resumen

El objetivo de este estudio fue examinar la relación entre el rendimiento en un triatlón simulado y las variables fisiológicas medidas durante pruebas convencionales de laboratorio. Siete triatletas hombres y entrenados realizaron en orden aleatorio pruebas incrementales en ciclismo y carrera. Además, realizaron una simulación de un triatlón sprint (750 m natación, 20 km ciclismo, 5 km carrera) utilizando una piscina de 25 m, un cicloergómetro de freno electromagnético y una cinta mecánica. No hubo correlaciones significativas entre el rendimiento (tiempo) global y las pruebas incrementales. Sin embargo, se encontró una correlación significativa entre el tiempo de carrera en el triatlón y ambas pruebas incrementales en ciclismo y carrera (V_{peak}, $r = -.900$, $p<0.05$; V_{4mmol}, $r = -.822$, $p<0.05$; W_{peak}, $r = -.844$, $p<0.05$). El tiempo total del triatlón simulado mostró una correlación alta con el tiempo ($r = .930$, $p<0.05$) y la potencia media en la fase ciclismo ($r = -.956$, $p<0.05$), mientras que no se encontraron correlaciones entre el rendimiento global y los tiempos en natación o en carrera. En comparación con las pruebas incrementales de laboratorio, una evaluación del rendimiento que refleje mejor las demandas de la fase de ciclismo durante el triatlón (por ejemplo una contrarreloj) puede proporcionar una mejor indicación del rendimiento en un triatlón sprint simulado en triatletas entrenados. Por lo tanto, el rendimiento en ciclismo parece ser más importante que la natación o la carrera para el rendimiento global en un triatlón sprint simulado

Palabras clave: Multideporte, transición, prueba de distancia constante, triatleta, prueba incremental

Introduction

The physiological demands of non-elite, sprint-distance triathlon are considered as unique compared to longer and/or elite event formats, due to differences in distances and tactical considerations (i.e. drafting vs. non-drafting on the bike) (Bentley et al., 2008; Bentley et al., 2002). However, examination of the relationship between triathlon performance and physiological variables measured during laboratory testing has primarily focused on longer events than the sprint-distance format (Schabort et al., 2000; Whyte et al., 2000; Zhou et al., 1997). Those studies which have examined sprint-distance triathlon in this context have only correlated physiological parameters with competitive field-based performance (Bailey et al., 2007; Van Schuylenbergh et al., 2004), with no research to date considering the relationship between simulated triathlon performance and physiological variables measured during conventional laboratory tests. The aim of this study therefore was to investigate the relationship between selected physiological variables and performance in simulated sprint-distance triathlon.

Materials and methodology

Seven non-elite, competitive male triathletes (mean ± SD: age 32.6 ± 6.2 yrs, body mass 76.9 ± 6.0 kg) completed two incremental exercise tests in a random order, either on an electromagnetically braked cycle ergometer (SRM, Germany) or motorised treadmill (LifeFitness 93T, USA). V,O_{2peak}, peak aerobic power (W_{peak}) and power output at a fixed blood lactate concentration of 4 mmol·L^{-1} (W_{4mmol}) were measured during cycling, whilst V,O_{2peak}, peak running velocity (V_{peak}) and speed at a fixed blood lactate concentration of 4 mmol·L^{-1} (V_{4mmol}) were measured during running. Within ten days of laboratory testing participants completed a simulated sprint-distance triathlon trial (750 m swim, 500 kJ bike, 5 km run), using a 25 m pool, cycle ergometer and motorised treadmill. In addition to overall performance time and sub-discipline splits, power output (W) was measured during the cycle phase.

Results

Physiological values obtained for the triathletes during incremental cycle ergometry and treadmill running are shown in Table 1. There were no significant correlations between total performance time (h, min and s) for simulated triathlon (01:18:15 ± 0:08:24) and either running or cycling incremental tests ($V_{peak,}$ $r = -.437$, $p = 0.327$; $V_{4mmol,}$ $r = -.417$, $p = 0.353$; $VO_{2peak\ (run),}$ $r = -.341$, $p<0.455$; $W_{peak,}$ $r = -.687$, $p = 0.08$; $W_{4mmol,}$ $r = .020$, $p = 0.966$; $VO_{2peak\ (cycle),}$ $r = -.082$, $p = 0.861$). Significant correlations were found between triathlon run time (0:21:59 ± 0:02:19) and both running and cycling incremental tests ($V_{peak,}$ $r = -.900$, $p<0.05$; $V_{4mmol,}$ $r = -.822$, $p<0.05$; $W_{peak,}$ $r = -.844$, $p<0.05$). Total performance time was highly correlated to cycle time (0:39:34 ± 0:04:54) ($r = .930$, $p<0.05$) and mean power output (212.8 ± 25.7 W) ($r = -.956$, $p<0.05$), whilst there was no significant correlation between either swim time (0:12:24 ± 0:01:22) ($r = 0.558$, $p = 0.193$) or run time ($r = 0.521$, $p = 0.230$) and overall performance time.

Table 1 Peak and submaximal physiological variables obtained from cycling and running tests.

Peak cycling values	
$\dot{V}O_{2peak}$ ($l \cdot min^{-1}$)	4.2 ± 0.4
$\dot{V}O_{2peak}$ ($ml \cdot min^{-1} kg^{-1}$)	54.1 ± 6.0
W_{peak} (W)	307.0 ± 19.5
W_{peak} ($W \cdot kg^{-1}$)	4.0 ± 0.4
W_{4mmol} (W)	241.0 ± 15.3
HR_{peak} ($b \cdot min^{-1}$)	175 ± 6
Peak running values	
$\dot{V}O_{2peak}$ ($l \cdot min^{-1}$)	4.3 ± 0.5
$\dot{V}O_{2peak}$ ($ml \cdot min^{-1} kg^{-1}$)	55.5 ± 3.9
V_{peak} ($km \cdot h^{-1}$)	15.9 ± 1.2
V_{4mmol} ($km \cdot h^{-1}$)	13.6 ± 1.0
HR_{peak} ($b \cdot min^{-1}$)	182 ± 6

Values are mean ± SD

Discussion and conclusions

To our knowledge this is the first study to have examined the relationship between simulated triathlon performance and physiological variables measured during conventional laboratory tests. The results suggest that using a performance assessment which reflects the demands of the cycle phase of triathlon (i.e. a time-trial protocol) may provide a better indication of simulated sprint-distance triathlon performance, in comparison to commonly used incremental laboratory tests. Furthermore for non-elite, competitive male triathletes, cycling performance appears more important to overall performance in simulated sprint-distance triathlon than swimming or running. Although performance intensities observed during simulated triathlon were comparable to higher calibre triathletes performing in similar sprint-distance performance tests (>80% $V,O_{2peak,}$ >70 % W_{peak}) (Hausswirth et al., 2001), it is important for future research to establish whether these findings are an artefact of the protocol used, or whether they reflect the genuine importance of the cycle phase to sprint-distance triathlon performance.

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Analysis of pacing strategy during duathlon and triathlon competitions in youth athletes

Comotto Stefania[1] (MS), Capranica Laura[1] (Full Professor), Piacentini Maria Francesca[1] (Associate Professor, Ph.D.)

[1]Department of Human Movement and Sport Science, University of Rome "Foro Italico", Rome, Italy

Corresponding author:

Prof. Maria Francesca Piacentini

Department of Human Movement and Sport Sciences

University of Rome "Foro Italico"

P.za L. De Bosis, 15

Rome, Italy

Phone +39 0636733245

Fax +39 0636733330

Email: mariafrancesca.piacentini@uniroma4.it

ABSTRACT

The aim of the present study was to investigate the swimming, cycling and running velocities during triathlon and duathlon competitions. Four Youth athletes (2 Male and 2 Female, mean age 16±1 yrs) participating in both duathlon and triathlon Italian championships took part in the present study. A wearable 15hrz GPS (SPY Pro, GPSSport, Canberra, Australia) was used to record individual velocities and distance covered. To evaluate pacing strategy, 25m, 100m, and 500m mean distance was considered for swimming, running and cycling, respectively.

Pacing strategy resulted positive for running phase in duathlon (-28%) and for swimming phase in triathlon (-21%). For both races, athletes adopted a negative pacing strategy for cycling phase (duathlon: +20%; triathlon: +12%). Finally, the last phase of both competitions seemed to have a different pacing strategy. In particular, in duathlon athletes adopted an even strategy, whereas in triathlon their velocity showed a 24% decrement.

Young athletes, as already seen for elite, start at a faster pace during both competitions and thereafter velocity decreases highlighting a positive strategy. Indeed, in the first phase of both competitions athletes start as quickly as possible, in order to have an advantage during the subsequent phases, independently of swimming or running. In fact, the importance of performing well the first transition and starting cycling with the first pack seems important also at this younger age and with the shorter distances as confirmed by the final ranking positions in both races.

KEYWORDS: competition, pacing strategy, youth athletes

INTRODUCTION

An individual's pacing strategy is defined as the distribution of work or energy expenditure that occurs throughout an exercise task (Abbiss & Laursen, 2008). It is well documented that during athletic competitions, well trained athletes must regulate their rate of work output in order to optimize overall performance (Foster et al., 2005; Abbiss & Laursen, 2008). The literature on pacing strategy in triathlon, that involves a sequence of swimming, cycling and running phase, have focused on analysis of World Cup races (Vleck et al., 2006, Vleck et al., 2008, Le Meur et al., 2009) and on laboratory tests (Hausswirth et al., 2010). A recent study conducted by Le Meur et al., (2009) demonstrated that during swimming triathletes adopted a positive pacing strategy, meaning a decrease in swimming velocity after peak velocity was reached. Moreover, Vleck et al., (2006) affirm that the ranking position at the end of the swimming phase seems to reflect the final ranking position. During the cycling phase elite triathletes decrease significantly cycling speeds between the initial and the final part (Le Meur et al., 2009). Finally, the analysis of the running phase in World Cup races show that triathletes tend to adopt a positive pacing (Vleck et al. 2006, Vleck et al. 2008, Le Meur et al. 2009). Races of younger age categories are much shorter, however, no study until now has analyzed their pacing strategy. Therefore, the aim of this study was to quantify the velocity during swimming, cycling and running phase, and analyze the pacing strategies adopted by athletes during duathlon (running, cycling and running) and triathlon competitions. In particular the hypotheses of this study were to find higher cycling velocities in triathlon compared to duathlon and to find a similar pacing strategy as elite athletes.

MATERIALS AND METHODOLOGY

Participants

Four Youth athletes (2 Male and 2 Female, mean age 16±1 yrs) regularly training (2h and 30min for 4 days a week) and participating in both duathlon and triathlon Italian championships were recruited for the present study. The official distances of duathlon and triathlon competitions are shown in table 1.

Table 1. Category, age and distance in triathlon and duathlon competitions

CATEGORY	AGE	TRIATHLON Swim (m)	TRIATHLON Bike (m)	TRIATHLON Run (m)	DUATHLON Run (m)	DUATHLON Bike (m)	DUATHLON Run (m)
Youth A	14 - 15	250	8000	2000	2000	8000	1000
Youth B	16 - 17	250	8000	2000	2000	8000	1000

Procedure

Every athletes wore a 15hrz wearable Global Positioning System (GPS, SPY Pro, GPSsport, Canberra, Australia) during both competitions. Distance covered and velocity in each phase was continuously recorded. The mean velocity was calculated every 50m (ms^{-1}) of the swimming phase, every 1000m (kmh^{-1}) during cycling, and every 200m (ms^{-1}) of the running phase. Moreover, the official timing system (Chip System) was used to evaluate the ranking of all participants in both races after each phase. Timing mats were situated at the start and at the end of both races, and at the beginning of each transition phase.

Data analysis

ANOVA for repeated measures ($P<0.05$) was used to evaluate the pacing strategy in each phase. A student paired T-test ($P<0.05$) was used to verify differences between cycling phases of duathlon and triathlon. A Pearson's correlation ($P<0.05$) was used to determine the relationship between overall race position and isolated positions associated with the performance achieved during swimming, cycling and running phases.

RESULTS

During the triathlon's swimming phase athletes showed a higher velocity ($P<0.005$) during the first 50m ($1.5\pm0.1 ms^{-1}$) and thereafter decreased by 21% during the last 50m ($1.2\pm0.2 ms^{-1}$), adopting a positive pacing strategy. During the first duathlon running phase the highest velocity was recorded after 200m ($5.7\pm0.6 ms^{-1}$) ($P<0.0001$). In particular, during this phase, athletes adopted a positive pacing strategy with a 28% velocity decrease ($P<0.0001$) during the last 200m ($4.4\pm0.4 ms^{-1}$).

Figure 1. Mean velocity and standard deviation of the first phase: (a) triathlon's swimming phase and (b) duathlon's running phase

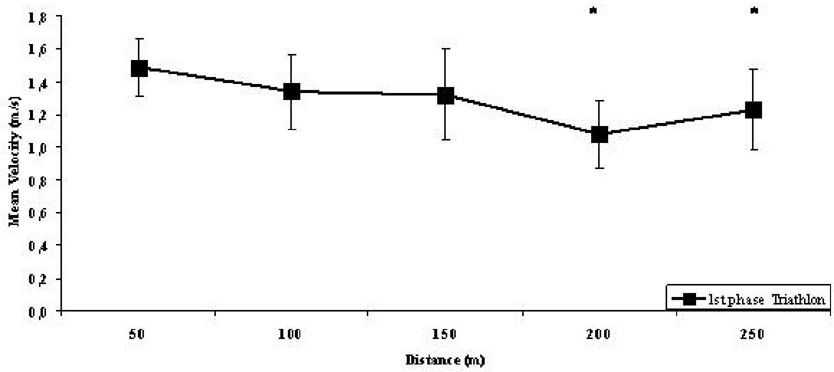


Figure 1a
* = significant differences from the first 50m (P<0.005)

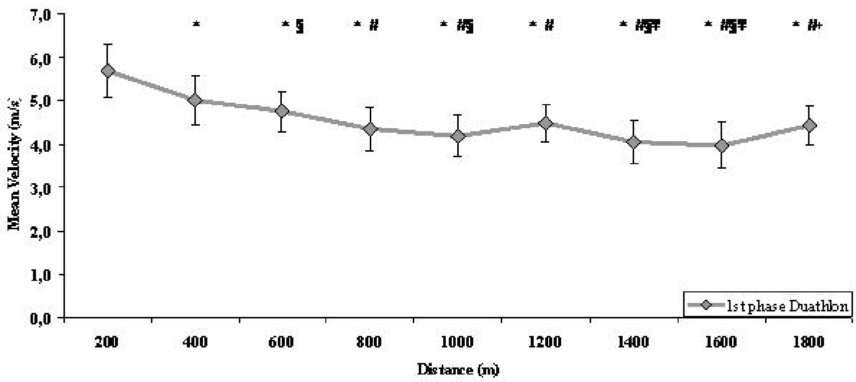
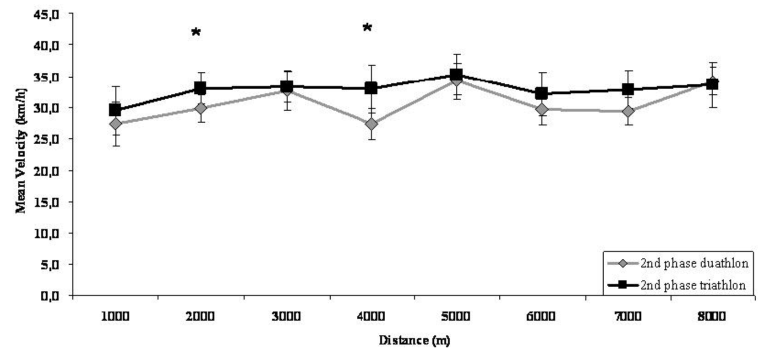


Figure 1b
* = significant differences from 200m (P<0.0001)
# = significant differences from 400m (P<0.0001)
§ = significant differences from 600m (P<0.0001)
¥ = significant differences from 1200m (P<0.0008)
+ = significant differences from 1600m (P<0.0007)

In triathlon and duathlon cycling phase athletes adopted a negative pacing strategy with a 12% and 20% velocity increase respectively (P<0.0001). Moreover, in both races the slowest velocity (P<0.0005) was recorded during the first 1000m (29.4±3.8kmh^{-1} in triathlon and 27.4±3.4kmh^{-1} in duathlon). Peak velocity (P<0.001) was reached at 5000m (35.3±3.3kmh^{-1} in triathlon and 34.2±2.8kmh^{-1} in duathlon) in both races compared to other cycling sections. Comparing the two cycling phases, the first kilometres during triathlon (33.0±2.6kmh^{-1} and 32.9±3.8kmh^{-1} in 2000m and 4000m, respectively) were faster (P<0.02) compared to duathlon (29.8±2.1kmh^{-1} and 27.3±2.5kmh^{-1} in 2000m and 4000m, respectively).

Figure 2. Mean velocity and standard deviation of the cycling phase during triathlon and duathlon competitions



* = significant differences between Duathlon and Triathlon competition (P<0.02)

During the last phase in triathlon no differences emerged for the first 800m, and the highest velocity was recorded at 600m (4.5±0.9ms^{-1}). After this point the velocity decreased by 24% until the end of the race (P<0.001), highlighting a variable pacing. During duathlon, athletes adopted an even strategy, with no differences in velocity between the first and the last section.

Figure 3. Mean velocity and standard deviation of the running phase: (a) triathlon and (b) duathlon's competitions

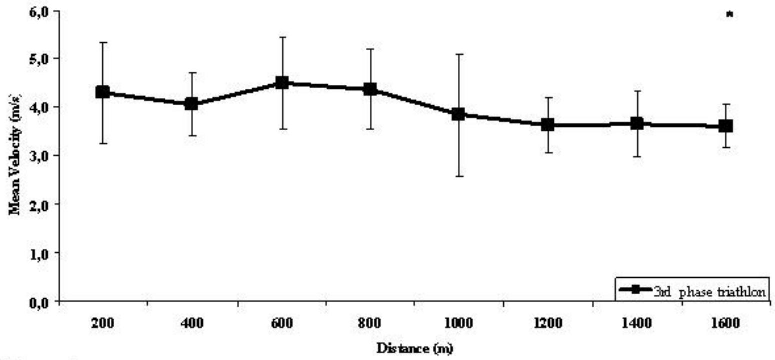


Figure 3a
* = significant differences from 600m (P<0.001)

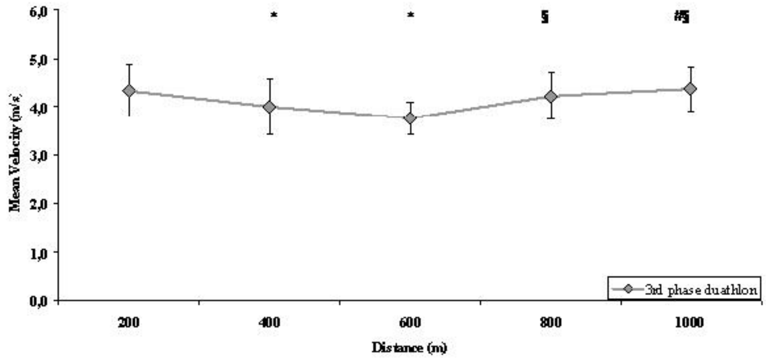


Figure 3b
* = significant differences from 200m (P<0.0008)
# = significant differences from 400m (P<0.0004)
§ = significant differences from 600m (P<0.0001)

Finally, a positive correlation (P<0.01) was found between overall race position and isolated positions after each phase. The data are represented in table 2.

Table 2. Correlation between the ranking for each phase considered individually and the final race position for overall triathlon and duathlon competition

PHASE	TRIATHLON	DUATHLON
First	0,819 *	0,923 *
Second	0,726 *	0,932 *
Third	0,692 *	0,896 *

* P<0.01

DISCUSSION AND CONCLUSIONS

To our knowledge, this is the first study to evaluate the pacing strategy during triathlon and duathlon competitions in young athletes. Literature on pacing strategy in triathlon has focused in term of tactics on elite athletes and none has been done on duathlon. Le Meur et al. (2009) has observed that triathletes start fast and pace decreases during the competition. Our study confirms that this strategy is adopted also by younger athletes, despite the shorter racing distance. In particular, pacing during the first phase for triathlon is similar to that adopted by elite athletes. This is necessary because athletes need to reach the first places of the pack, and to avoid congestion at the first turn-around buoy. In fact, it has been shown that weaker swimmers in the rear part of the group are disadvantaged (Vleck et al. 2006). Moreover, the same situation is evident for the first phase of duathlon, where athletes start as quickly as possible, in order to have an advantage during the subsequent phases. The second phase for both races seems to have a different pacing strategy from elite athletes. In fact, young athletes adopted a negative pacing strategy, whereas during cycling phase elite triathletes decrease significantly speed between the initial and the final part (Le Meur et al., 2009). This aspect can be explained by the shorter distance of the present event, only 8km compared to 40km in elite competitions. Despite the literature suggests to adopt a constant pace for long duration events (Abbiss & Laursen 2008), Vleck et al., (2006; 2008) show that most athletes, during the third phase, run faster over the first kilometres compared to other running sections, selecting a positive pacing strategy. Also young athletes adopt a similar pacing strategy during triathlon, whereas for duathlon the pace is even, probably due to the different distance covered by the athletes during this phase. Finally, as confirmed by Vleck et al. (2006) the position at the end of swimming in triathlon seems to reflect the position at the end of the race. In fact, the importance of performing well the first transition and starting cycling with the first pack seems important also at this younger age category as confirmed by the correlation between the final ranking positions and the position at the end of the first phase in both races.

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PROCEEDING

The other triathlon: the perceived psycho-social sphere of triathletes and coaches as a determinant of success. Germán Ruiz Tendero

- Academic title: Ph. D.
- Academia Institution: Complutense University of Madrid. Faculty of Education.

Correspondence:

E-mail: g.germanruiz@gmail.com

Postal address: Rector Royo Villanova St. Faculty of Education. Complutense University. 28040 – Madrid (Spain)

Summary:

Understanding sport as a complex system, this study focuses on the high level triathlon sphere to compare how the perceptions of the coaches and their athletes fluctuate when they evaluate positive and negative psychosocial factors affecting performance. Participants were surveyed: 48 Spanish high level active triathletes (19 females and 29 males) and their coaches (n=14, all men). Results: when identifying a number of factors as most critical in sport success, there is an agreement between coaches and triathletes on almost all positive factors. However, there is no agreement concerning the negative factors. It is noticeable a higher athletes´ sensitivity to their personal level (family, teammates, coach etc), while the coach tends to give more importance to technical and institutional aspects.

Keywords: coach, triathletes, success, environment, high level.

Introduction: it is not possible to understand the reality of sport, and more specifically, a high level sport system, without considering it as a body of elements which are interrelated, influenced and in constant change. In this universe of interactions, we understand that the whole person should be considered over his sport role, and these two dimensions (sportsman-person) would not be divisible during the sport career. Sport can be understood as a system from the General System Theory (GST) that arises from the mathematical field and extends to the most diverse scientific areas. The GST responds to new holistic problems regarding information society and technology. According to Bertalanffy (1) it is necessary to study not just isolated parts and processes, but also the problems resulting from the dynamic interaction of parts, whose behavior is different if studied in isolation or within a whole. The GST has been applied to gender-related issues in physical education and sport or coaching with success. Under this paradigm, high level triathlon can be considered as a specific complex system. In spite of its short history, the number of triathlon competitors (memberships) has considerably increased over the last ten years. It is known that, in triathlon competition is an inherent part of itself, so the number of memberships is a good indicator of the number of participants (2). In Spain this increase has risen from 4.036 memberships in 2000 to 15624 in 2010, that is, a rise of almost 400%. Thus, it is necessary to consider, beyond the sports, interests and motivations of this population, and in particular, the emerging performance groups, usually in High Performance Centers or Sport Technification Centers (3). We hardly find studies that tackle the psychosocial dimension of triathlon (4-5), and how this can underlie success or failure. (6-7). This research is aimed at the high level sport micro system, that is, the athlete's close environment, to compare how the perceptions of the coaches and their athletes fluctuate when they evaluate positive and negative psychosocial factors affecting performance.

Methods: the present study was developed using a descriptive and comparative design, based on the questionnaire as an instrument to collect qualitative and quantitative data. The questionnaire was designed for the purpose of this study, following previous sociodemographic models in high performance sport (8-9). It is composed mostly of multiple choice questions, and was previously reviewed and improved by two experts in sport systems to consolidate its validity. The final version of the questionnaire was divided into two sections: personal and sports details, and evaluation of 13 positive/negative factors affecting performance. Each factor was valued following a five-item Likert scale (1=unimportant; 2= of little importance; 3=moderately important; 4= important; 5= very important).

Participants: 48 Spanish high level active triathletes (19 females and 29 males) and their coaches (n=14, all men) were surveyed. The average age is 37 years (±7) for coaches and 25 years (±5) for triathletes. The requirements to select the sample were to be active in elite competition when the study was carried out, as well as to have been selected to compete at a major international competition (Olympic Games, World Championships, World Cup, European Championships).

Results:

Comparison of assessment (scale 1-5) that athletes and coaches make about positive influential factors on sports performance (*$p < ,05$):

- Dedication / Engagement*: triathletes = 4,60 (± 0,77); coaches= 4,892 (± 0,27).
- Volitional capacity: triathletes = 4,36 (± 0,89); coaches= 4,62 (± 0,50).
- Competitive success: triathletes = 4 (± 1,06); coaches= 3,92 (± 1,18).
- Competitive failure: triathletes = 3,11 (± 1,37); coaches= 2,69 (± 1,10).
- Economic incentives*: triathletes = 2,28 (± 1,22); coaches= 3,08 (± 0,95).
- Perseverance in training: triathletes = 4,59 (± 0,77); coaches= 4,85 (± 0,37).
- Training partners: triathletes = 3,19 (± 1,13); coaches= 3,15 (± 1,06).
- Training environment: triathletes = 3,17 (± 1,14); coaches= 3,62 (± 0,96).
- Scientific-technological: triathletes = 2,57 (± 1,21); coaches= 3,08 (± 1,11).
- Family support: triathletes = 4,51 (± 0,85); coaches= 4 (± 0,91).
- Institutional support*: triathletes = 2,34 (± 1,14); coaches= 3,15 (± 1,06).
- Medical support: triathletes = 2,81 (± 1,36); coaches= 3,46 (± 1,12).
- Coach: triathletes = 4,33 (± 0,64); coaches= 4,08 (± 0,64).

Discussion and conclusions: This study attempts to analyze variations in a performance microsystem, taking into account its two main protagonists: the coach and athlete. We find an excellent perceived treatment between triathletes and their coaches. Coach, parents and friends are decisive in the triathletes' beginning and continuation in their sport career. In other studies with elite young athletes in direct relation to the triathlon (swimming), 70% of the parents influenced positively in the beginning (10).When identifying a number of factors as more critical to sports success, there is agreement between coaches and triathletes on almost all positive factors. Not so in the negative factors. It is noticeable a higher athletes´ sensitivity to the personal level (family, teammates, coach etc), while the coach tends to give more importance to technical and institutional aspects. Ego orientation cannot be neglected, given the importance attached (6th place in the ranking) to the factor "competitive success". Nowadays we know that competitiveness and win orientation can predict high performance in sport, specially goal orientation can predict performance when we refer to endurance sports (11). Financial incentives is positioned as the most insignificant factor for the triathlete in terms of their influence on the path to sports success, while the most decisive factor for both, triathletes and coaches, is dedication and personal involvement. Success in this hard sport, requires voluntary athlete involvement day by day, and reinforces the importance of commitment, as Hilliard (12) pointed out in one of his pioneering studies on triathlon in the psychological realm. The most important factor adversely affecting performance would be injuries.

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PROCEEDING

High level triathlon coach: close environment and basic performance qualities

Germán Ruiz Tendero

- Academic title: Ph. D.
- Academia Institution: Complutense University of Madrid. Faculty of Education.

Correspondence:

E-mail: g.germanruiz@gmail.com

Postal address: Rector Royo Villanova St. Faculty of Education. Complutense University. 28040 – Madrid (Spain)

Summary:

Performance in high level sport is the result of interactions among coaches, athletes and the environment. The aim of this study is to analyze the triathlon coach sphere related to sport and personal environment. Another objective is to know what qualities can be attributed to a good high level coach (H.L.C.) in triathlon. The sample consisted of 14 Spanish H.L.C., all of them male (average age = 37.43 years old ±7.27). They were interviewed by means of a questionnaire. According to the coaches´ opinion, confidence in personal dialogue is the most valued quality.

Keywords: triathlon, performance, coach, environment.

Introduction:

The athlete's performance can hardly be seen as a purely personal achievement. It is possible to talk about teamwork even in individual sports. This performance is seen as the result of the interaction between the athlete, coach and training environment (1-2). Scientific literature about triathlon does not provide us with information about coaches, but magazine articles, which usually refer to personal interviews. On the one hand the aim of this study is to describe the near environment of the high-level coach (H.L.C.) regarding factors which are directly related to them in sport (athletes, federation, club, other partners) and personal fields (family, studies and job). On the other hand, to know what qualities they attribute to a good H.L.C. in triathlon.

Methodology: this research follows a descriptive design, based on a questionnaire as a measuring instrument. The questionnaire was designed for the purpose of this study, following previous sociodemographic models in high performance sport (3-6). It is composed mostly of multiple choice questions, and was previously reviewed and improved by two experts in sport systems to consolidate its validity. The final version of the questionnaire was divided into four sections: personal and sports details, studies and occupation, family sports history and evaluation of coach positive qualities shown in 12 closed items. Each item was valued following a five-item Likert scale (1=unimportant; 2= of little importance; 3=moderately important; 4= important; 5= very important).

SPSS version 15.0 was used for data analysis (descriptive and comparison tests). Participants: the population of Spanish H.L.C. consisted of 15, of whom only one was unable to participate in the study. Therefore, the final sample consisted of 14 coaches, all of them male (average age = 37.43 years old ±7.27). The requirement to be part of the sample, and therefore belong to the group H.L.C., was to be training, at the time of the study, at least one Spanish triathlete participating in international competitions (Olympic Games, World Championships, World Cups, European Championships).

Results: On average, each coach is training a total of 8 athletes (± 4.78), however, the average of athletes competing at international level trained by the same coach is 3.71 (± 3.04).

Treatment of the coaches with their triathletes: see figure 1.

Medium-term objectives: international objectives are the most important ones (77,8%).

Importance given to the different coach positive qualities: the confidence to personal dialogue stands as the most valued by coaches, followed by training knowledge and ability to motivate and encourage.

Education: 11 of the 14 H.L.C. have the Physical Activity and Sport Sciences degree.

Family environment: middle class (61.5%). Four of them have relatives who practice triathlon.

Discussion and conclusion: According to the coaches´ opinion, confidence in personal dialogue is the most valued quality. This overestimation of social sphere compared to the sports one, has been attributed to expert coaches, especially during learning periods (7-8). We can consider this aspect as positive, given the great influence of coaches on triathletes' sport continuation (9) . The Spanish H.L.C. environment is becoming expert performance, given its high involvement in a non-professionalized sport, which is also combining with another job. Finally, it is also concluded that, according to triathlon nature and coaches' environment investigated, the coach's personal presence in trainings and competitions is not a decisive factor influencing his athletes´ performance.

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Self-efficacy, anxiety and sport performance in triathlon

Guillermo Viguria Hellín

Degree in Psychology at Autonoma University of Madrid. Master´s degree in Psychology of Physical Activity and Sport at UAM – COE.

Oswaldo Rivera Rodriguez

Degree in Psychology at Del Valle University of Mexico. Master´s degree in Psychology of Physical Activity and Sport at UAM – COE.

Corresponding author:

Guillermo Viguria Hellín

Unidad de Psicología Aplicada al Deporte. Facultad de Psicología, Universidad Autónoma de Madrid. Campus Universitario Cantoblanco. Madrid.

Mail: guillermo.viguria@gmail.com

Telephone: +34 699 389 824

Summary

Triathlon performance is affected by the interaction of factors like the state anxiety. The purpose of the present study was to determinate the self-efficacy influence on triathletes performance and to confirm if high self-efficacy levels and low anxiety state are positive related with sport performance. Participants 25 with average age of 31.32 years (*SD* = 8.29) all athletes completed a self efficacy & anxiety questionnaires. The results showed that then the pre race self efficacy score was high the pre race anxiety state was lower; moreover self efficacy was related with the personal expectations to perform on a race. It is concluded that self efficacy can improve triathlon performance and may provide an effective personal resource against the negative anxiety effects in competition.

Resumen

El rendimiento deportivo en triatlón se ve afectado por la interacción de diversos factores como la ansiedad estado. El propósito del presente estudio fue determinar la influencia de la autoeficacia en el rendimiento de los triatletas, y confirmar si niveles elevados de autoeficacia acompañados por un bajo nivel de ansiedad estado se presentan en los deportistas que han tenido un rendimiento positivo. Participaran del estudio 25 triatletas con una edad media de 31,32 años (DE = 8.29), todos los atletas completaron un cuestionario de autoeficacia y ansiedad. Los resultados mostraron que una puntuación elevada de autoeficacia se presentó en los deportistas que presentaron los menores niveles de ansiedad estado antes de la competición, por otra parte la expectativa personal de obtener un resultado determinado tiene un relación positiva con los valores de autoeficacia del deportista. En conclusión la autoeficacia puede mejorar el rendimiento del triatlón y muestra como un recurso personal efectivo contra los efectos negativos de ansiedad durante la competición.

Keywords: anxiety, self-efficacy, triathlon, performance, personal expectations

Introduction

Triathlon is one of the most strict endurance sport physical and mentally for training and competition, which physical, technical, tactical and psychological factors interaction have a great influence on the athlete's performance. Anxiety has been one of the most studied psychological issues in sport [9]. State anxiety can generate responses of different intensity that can disrupt cognitive functions [7], high levels of competitive anxiety has been shown to reduce the efficiency of gaze behavior and poor performance in a variety of sporting tasks [3,6]. One anxiety mediator is self-efficacy-individual's beliefs about their capabilities, based on which organize and execute their acts, so that they can earn the desired performance [1]. Self efficacy also can affect the optimal triathlon performance [4]. Recent research showed a relationship between high levels of self-efficacy and positive subjective performance, there is also a negative relationship among self-efficacy and anxiety [5]. The purpose of the present study was to determinate the self-efficacy and anxiety influence on triathletes performance and to confirm if high self-efficacy levels and low anxiety state are positive related with sport performance.

Methods

Volunteered 25 triathletes with average age of 31.32 years (*SD* = 8.29). All participants completed the State-Trait Anxiety Inventory STAI [8] and the Self-efficacy questionnaire [2] during a Spanish Championship Race, furthermore all athletes were asked about their Performance Expectation one hour before the race and during the period of one week after the race participants were asked about their Performance related to previous.

Results

The results showed that performance related to personal performance was positive related with the previous competition results ($r = .514; p < 0.01$) and with the pre race self efficacy score (*r = .469; p*

< *0.05*). Moreover when the pre race self efficacy score was high the pre race anxiety state was lower (r = -.744; p > 0.001). Furthermore there were differences in the anxiety state values before (M = 20.76 SD = 7.92) and after (M = 14.52 SD = 7.97) the race (Z = -3.11; p< 0.01), these results could indicate that once the race is over the anxiety state decreases.

Discussion & Conclusion

The results suggest that high self efficacy levels are presented in those triathletes with the highest performance expectation moreover, these high self efficacy athletes present the less levels of pre race anxiety state, and these results are consistent with those obtained by Nicholls, Polman, Levi (2010). State anxiety decreased after the race regardless the triathlete's performance.

It is concluded that self efficacy can improve triathlon performance and may provide an effective personal resource against the negative anxiety effects in competition.

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Tracking mood states and on-going attentional focus in triathletes.

Guillermo Viguria[1], Miguel Quintana[2], Mª Esther Rincón [3], and Oswaldo Rivera[4].

[1]Ph. D. Candidate 2011 in Psychology at Autonoma University of Madrid; Master degree in Psychology of Physical Activity and Sport at UAM – COE. O3 Wellbeing Solutions Co. Ltd. at Madrid Scientific Park (Spain).

[2] Ph. D. Candidate 2011 in Psychology at Complutense University of Madrid (Spain).

Corporate Development Director for R+D+i in the Affective Psychotechnology Laboratory in O3Wellbeing Solutions Co. Ltd. at Madrid Scientific Park (Spain).

[3] PhD in Psychology at University of Seville (Spain). Responsible for R+D+i in the Affective Psychotechnology Laboratory in O3Wellbeing Solutions Co. Ltd.

[4] Master degree in Psychology of Physical Activity and Sport at UAM – COE. O3 Wellbeing Solutions Co. Ltd.

Corresponding author: Guillermo Viguria Hellín, O3 Wellbeing Solutions Co. Ltd. Psychotechnology R + D+ i Laboratory. Madrid Scientific Park. C/ Santiago Grisolía, 2, 28760, Tres Cantos (Madrid).

Mail: guillermo.viguria@o3wellbeing.com

Telephone: +34 699 389824

Fax: + (34) 91 803 1031

Summary:

Awareness and self-regulation of attentioncan be used as cognitive strategies may help to overcome factors that threaten optimal performance, such as negative mood. The state of mind is considered a key factor in triathlon performance because it is related to perceived effort, fatigue or self-confidence. Likewise, mind-body training techniques unfolded from a particular mindfulness-based state of mind have proved to yield positive mood states. A total of 18 Spanish triathletes were randomly assigned to one out of three experimental conditions: indoor cycling, treadmill or step. They exercised for 20 minutes at 60% of Maximum Heart Rate, while focusing their attention on counting their own breath. Mood state was measure pre-post session through two instruments: Profile of Mood State (POMS) and Two Dimensional Mood State (TMS). Statistical analysis showed a significant decrease pre-post session in tension and anger POMS subscales. Results from the TMS pointed out low scores in displeasure, whereas high scores in vitality, stability and pleasure. In short, preliminary data suggest that performing cyclical exercise disciplines while paying attention to one's own breath can improve mood states.

Key words: POMS, TMS, performance, mindfulness, triathlon.

Resumen:

La toma de conciencia y la auto-regulación de la atención se pueden emplear como estrategias cognitivas y pueden ayudar a superar factores que amenazan un rendimiento óptimo, tales como el estado de ánimo negativo. Debido a su relación con la percepción del esfuerzo, la fatiga o la auto-confianza, el estado de ánimo se considera un factor decisivo en el rendimiento en triatlón. Asimismo, las técnicas de ejercicio mente-cuerpo han demostrado su eficacia en la modulación de los estados de ánimo. Un total de 18 triatletas españoles fueron asignados al azar a una de las tres condiciones experimentales (bicicleta estática, cinta de correr y step) donde realizaban un ejercicio de 20 minutos de duración y una intensidad del 60% de su frecuencia cardíaca máxima, mientras focalizaban la atención en su propia respiración. El estado de ánimo fue evaluado (pre-post sesión) mediante la Escala del Perfil de los Estados de Ánimo (POMS) y la Escala Bidimensional del Estado de Ánimo (TMS). Los análisis estadísticos mostraron una reducción significativa pre-post sesión en dos de las subescalas medidas por el POMS: tensión y cólera. Los resultados obtenidos con el TMS determinaron puntuaciones reducidas en desagrado y elevadas en vitalidad, estabilidad y placer. Los datos preliminares de este estudio sugieren que el rendimiento en disciplinas deportivas de carácter cíclico, centrando la atención en su propia respiración, pueden mejorar el estado de ánimo.

Palabras clave: POMS, TMS, rendimiento, mindfulness, triatlón.

Introduction:

Triathlon is a highly demanding sport that encompasses physical endurance, technique and strategic aspects besides mental strength. Cognitive strategies comprise awareness and self-regulation of attention that can help to overcome optimal performance's threats such as negative mood (3, 9).

Thus, mood state is a key factor in triathlon performance due to its relationship with perceived effort, fatigue or self-confidence (5). The Profile of Mood State (POMS) has been used as a reliable scale to appraise sport related mood states in long distance disciplines such as biking, running or triathlon (7). The so called *iceberg profile* (6) derived from POMS has been associated with optimal performance in sport. Furthermore, mind-body exercise techniques yield positive mood states (10) unfolded from a particular mindfulness-based state of mind.

To be mindful of one's own breath can be an effective cognitive strategy that could improve the efficiency of athletes in training or competition (4). Despite of some studies on the effects of mindfulness-based techniques on long distance sports (2), further research is needed. Therefore, the purpose of this pilot study was to explore the mood state of elite triathletes exercising, while focusing their attention on their own breath, in laboratory settings.

Method:

A total of 18 Spanish elite triathletes took part in this study. They were randomly assigned to one of the three experimental conditions (indoor cycling, treadmill and step) during 20 minutes at 60% of Maximum Heart Rate while focusing their attention on counting their own breath. To record their focus of attention during the experimental task, they had to push the split button of a chronometer after every ten exhales during the whole duration of the session.

Mood state was measure pre-post session with two instruments: POMS 15-items (1) that measure five subscales (tension, depression, anger, vigor and fatigue) and the TMS (8) that measures vitality, stability, pleasure and displeasure through eight items.

Results:

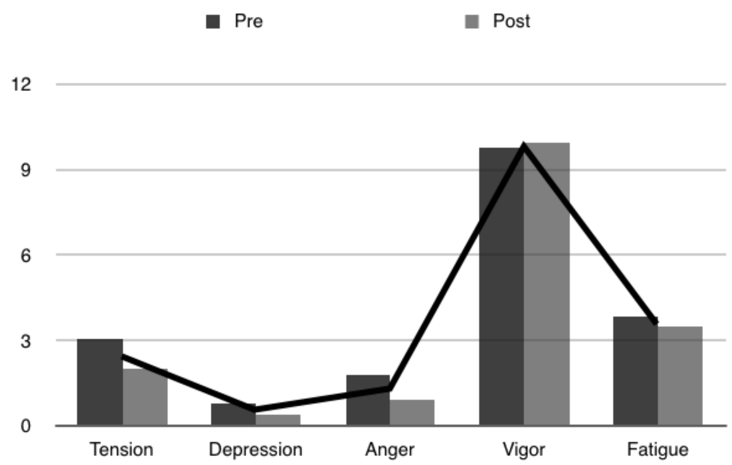
Wilcoxon analysis showed a significant statistical reduction pre-post session in tension ($p<.05$) and anger ($p<.01$) measure by POMS (see Table1).

Table 1. Pre-post scores comparison in POMS and TMS through Wilcoxon

	Triathletes (N=18)		Statistic	
	Pre-exercise *M* (SD)	Post-exercise *M* (SD)	*Z*	*p*
POMS				
Tension	3.06 (2.62)	2.00 (2.83)	-2.236	.025*
Depression	.78 (1.26)	.39 (.98)	-1.518	.129
Anger	1.78 (1.86)	.89 (1.41)	-2.676	.007**
Vigor	9.78 (2.51)	9.94 (1.70)	-.108	.914
Fatigue	3.83 (2.81)	3.50 (2.31)	-.893	.372
TMS				
Vitality	6.61 (3.73)	7.89 (1.60)	-1.980	.048*
Stability	5.83 (4.25)	6.11 (3.23)	-.746	.456
Pleasure	6.22 (3.06)	7.00 (2.07)	-1.456	.145
Displeasure	.39 (2.57)	1.00 (1.51)	-1.256	.209

Figure 1 shows the POMS's *iceberg profile*, characterized by low scores in the subscales of tension, depression, anger and fatigue and high scores in vigor. Results of the TMS illustrate low scores in displeasure and high scores in stability, pleasure and vitality which increased after the exercise ($p<.05$) (Figure 2).

Figure 1. Profile obtained from POMS and pre-post mean scores



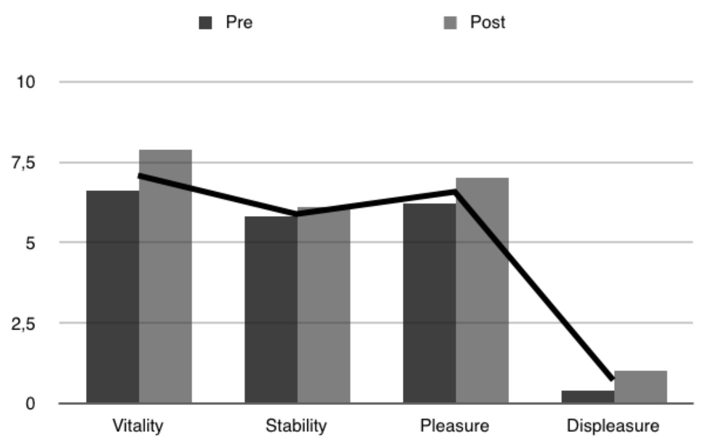


Figure 2. Profile obtained from TMS and pre-post mean scores.

Discussion/Conclusion:

Preliminary data of this study suggest that performing rhythmical and cyclical exercise disciplines while paying attention to one's own breath could improve mood state. Moreover, tracking on-going attentional focus may be a useful mental task to put aside disruptive thoughts or emotions while exercising. Further studies are necessary to better understand the interaction between mood state and cognitive strategies at different levels of exercise intensity; and its influence on other variables such as subjective perceived exertion, fatigue or pain. This study represents a first step for future research projects in order to develop psychometric tools to monitor mood states and train self-regulation of attention during exercise.

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CAN SWIMMING INTENSITY AFFECT THE ELASTIC EXPLOSIVE FORCE MANIFESTATION IN TRIATHLON?

Javier Mon Fernández[1,2], Ramón Maañón López[1], Silvia González Pereiró[1], Viana González Oscar[1].

1 University of A Coruña, Spain

2 Mexican Triathlon Federation. Research Department.

Corresponding author:

Javier Mon Fernández

Postal address: Av. Del conscripto S/N. Esq. Anillo Periférico. Col Lomas de Sotelo. Del. Miguel

Hidalgo. México DF. México

E-mail address: jmon@triatlon.com.mx

Phone: +5215541863388

Summary:

Triathletes have the ability to develop sudden pace changes in each triathlon leg, using both, elastic explosive force and elastic explosive-reactive force manifestations. The aim of this study is to assess the effects of prior swimming intensity on the elastic explosive force manifestation in well- trained triathletes. Sixteen international level triathletes, nine men and seven women, performed a counter movement jump (CMJ) after swimming at four different intensities: intense aerobic (IAE), anaerobic lactic (ALA), anaerobic alactic (AA)

and extensive aerobic (EAE) determined using %HRmax (aerobic intensities) and %Vmax (anaerobic intensities). HRmax and Vmax values were obtained within 400m and 25m crawl tests. Significant differences were found between CMJ in different situations ($p<0.05$). Higher height was found after IAE and lower height after EAE. Increasing kicking frequency in front crawl demands a higher nervous stimulus, which could influence the observed results. Perseveration could be a possible explanation for this difference in height after cyclic movements at different intensities which are not characterized by a long or short stretch-shortening cycle(SSC), nor by appearance of the myotatic reflex. Disorder in neuromuscular function due to different movement patterns could be another possible explanation for our results. These findings allow us to know more about possible positive, null or negative cross-transfer training effects between different activities and its use to achieve an increase triathlon performance.

Resumen:

Los triatletas tienen la habilidad de realizar cambios repentinos de ritmo en cada segmento, usando tanto la fuerza explosiva elástica como la fuerza explosiva elástica-reactiva. El objetivo de este estudio es conocer los efectos de la intensidad de la natación previa sobre la manifestación explosiva-elástica de la fuerza en triatletas bien entrenados. Dieciséis triatletas de nivel internacional, nueve hombres y siete mujeres, realizaron un salto con contramovimiento (CMJ) después de nadar a cuatro intensidades diferentes: aeróbico intenso (AEI), anaeróbico láctico (ALA), anaeróbico aláctico (AA) y aeróbico extensivo (AE), intensidades obtenidas usando el %FCmax (intensidades aeróbicas) y el %Vmax (intensidades anaeróbicas). Se encontraron diferencias significativas entre el CMJ tras las citadas intensidades ($p < 0.05$). La mayor altura se alcanzó después de nadar en AEI y la menor después de nadar en AEL. El incremento de la frecuencia del batido en el estilo crol demanda un mayor estímulo nervioso, lo cual podría influir en los resultados encontrados. La perseveración podría ser una posible explicación para esta diferencia en la altura alcanzada después de movimientos cíclicos a diferentes intensidades que no se caracterizan por un ciclo de estiramiento-acortamiento (CEA) ni largo ni corto, ni por la aparición del reflejo miotático. El desorden en la función neuromuscular debido diferentes patrones podría ser otra posible explicación para nuestros resultados. Este hallazgo nos permite conocer más acerca del efecto positivo, nulo o negativo del entrenamiento cruzado entre diferentes

Keywords: counter-movement jump, stretching-shortening cycle, first transition, performance

actividades y su uso para conseguir un incremento del rendimiento en triatlón.

Introduction

Triathletes have the ability to develop sudden pace changes in each triathlon leg, using both, elastic explosive and elastic explosive-reactive force manifestations. Swimming, cycling and running depend on different neural firing rates due to specific cyclic frequencies of each movement.

It is known what happens during cycling, running, jumping, but we had not found any previous reference about the effect of swimming on triathlon vertical jump performance.

Stretch-shortening cycle (SSC) in human skeletal muscle gives unique possibilities to study normal and fatigued muscle function; while moderate fatigue may result in slight potentiation, exhaustive fatigue can dramatically reduce reflex contribution. These reduced stretch reflex sensitivity and muscle stiffness deteriorate the force potentiation mechanisms (Komi, 2000). Most crawl style movements are performed by concentric muscular contractions, differing from eccentric-concentric muscular contractions in running or jumping characterized by a short or large SSC using the extra energy provided by muscular and tendinous elastic component and myotatic reflex (Komi, 2000). It is known that neuromuscular properties involved in the counter movement jump (CMJ) are affected by cycling at high intensities but not by running efforts (Lepers et al.,2001; Mon et al., 2005; Marquez et al., 2009). However, swimming leg effects on the triathlete'e implementar ability to run up to the transition zone have not been studied yet. Gottschall and Palmer (2002) postulated that it is possible that neural firing rate after each cycling condition biased the firing rate used subsequently for running. So perseveration, or involuntary and inappropriate maintenance of a previous activity, could be involved in this fact. Nowadays, we know that current triathlon performance not only depends on metabolic factors and that stochastic behavior of cycling leg depending on the individual strategy to begin second transition (T2) in a good position. These characteristics make necessary the finding of new answers to be more successful in first (T1) and second transition. The aim of this study is to assess the effects of prior swimming intensity on elastic explosive force manifestation in well-trained triathletes. Materials and methodology Sixteen international level triathletes, nine men and seven women (table 1), performed a CMJ between 30 and 45s after swimming at four different intensities: intense aerobic (IAE), anaerobic lactic (ALA), anaerobic alactic (AA) and extensive aerobic (EAE) determined using %HRmax (aerobic intensities) and %Vmax (anaerobic intensities). The individual effort heart rate (IEHR) was obtained using Karvonen formula. Trials developed using typical swimming series (4x400m,6x150m, 8x25m and 3x800m for IAE, ALA, AA and EAE intensities respectively). The material used was a contact platform, Chronopic processor, laptop ACER (ASPIRE 1810TZ) and Chronojump software v.0.9. Triathletes were trained in the correct execution of CMJ during first and second week. All tests were carried out during the three weeks of national team training camp(2010). 400m crawl maximal values to obtain individual HRmax and 25m crawl to extract Vmax were collected during second week. Data were collected during third week. Tests were always performed at the same time and previous day training load was low to avoid a possible fatigue that could affect the results. Warm up was 1500m (continuous swim, technique and progressive swim in final part).

Table 1: age, height and mass of triathletes:

	Age	Height (cm)	Mass (kg)
Men	23.1 ± 3.3	176.4 ± 4.5	66.6 ± 4.0
Women	24.7 ± 2.9	167.1 ± 5.5	54.4 ± 3.6

In the first day triathletes performed CMJ after EAE and during second test day triathletes performed the CMJ after ALA and CLA.

The previous work before jump after each intensity was:

- EAE: 3 x 800m/30s at 60-70% of HR_{max}.
- IAE: 4 x 400m/45s at 80-90% of HR_{max}.

- ALA: 6 x 150m/120s at 85-90% of V_{max}.
- AA: 8 x 25m/45s at 95-100% of V_{max}.

We compare CMJ after EAE in two different moments to be sure of correct execution, finding no significant differences ($p>0.05$). This study was an intra-group repeated measures design, representing the changes in the CMJ height depending on the intensity of a prior swimming effort. Means and Standar Deviations were calculated by standard methods, and Pearson correlation coefficients were used to evaluate the relationships among variables as well as inferential analysis and t-test for related samples. Change in jump height compared to swimming intensity is shown by an analysis of variance (ANOVA) for repeated measures. Changes at a value of $P<0.05$ were considered to be significant.

Results

Significant differences were found between CMJ in different situations ($p <0.05$). Higher height was found after IAE and lower height after EAE (figures 1 and 2). Men always jumped more than women and height jump evolution was similar for men and women in each situation. Table 2 shows the height reached in each situation. We found positive correlation between situations and subjects who jump higher were always the same (table 3). After compare different situations we found significant differences ($p<0.001$) between CMJ after swimming at similar competition intensity (IAE) and CMJ after swimming at lower intensity (EAE). Differences were a 13.7% in men and 11.2% in women, and always higher after swimming at greater intensity (table 4). We found a no significant different of 10.2% between CMJ after IAE and CMJ after AA in men, but 8% significant difference (p<.05) was found in women. The significant difference found was between CMJ after ALA and CMJ after EAE (9.6% and 6.7% in men and women respectively), greater after first situation was significant in men and complete our mean results found (table 4).

Table 2: Height in each situation (men and women):

	IAE	ALA	AA	EAE
Men (avg ± sd.)	36.4 ± 3.8	34.4 ± 3.0	32,7 ± 4.1	31,4 ± 4.1
Women (avg ± sd.)	28.6 + 2.8	27.1 + 3.5	26.3 + 3.3	25.4 + 3.4

Table 3: Correlations between different situations (men and women):

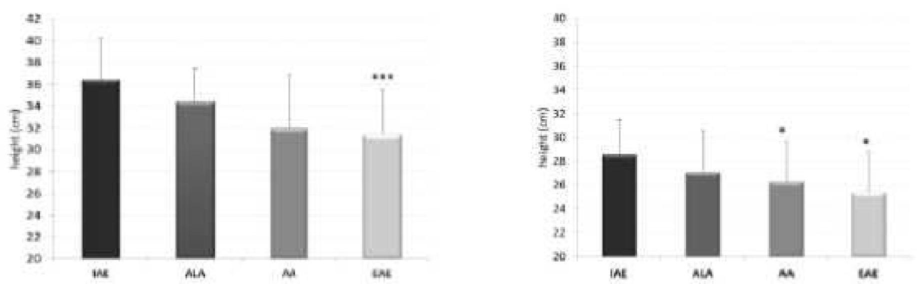
Situations	Men	Sig.	Women	Sig.
IAE & ALA	,670(*)	,048	,839(*)	,037
IAE & AA	,762(*)	,017	,853(*)	,031
IAE & EAE	,875(***)	,000	,857(**)	,003
EAE & AA	,689(***)	,000	,864(***)	,000
EAE & ALA	,805(**)	,001	,883(*)	,020
AA & ALA	,851(**)	,000	,854(*)	,014

Pearson correlation: *p<0.05; ** p<0.01; *** p<0.001

Table 4: Differences (%) in CMJ between 4 situations studied (men and women):

Situations	Men (%)	Women (%)
IAE & ALA	5.5	5.2
IAE & AA	10.2	8(*)
IAE & EAE	13.7(***)	11.2(*)
EAE & AA	4.1	3.5
EAE & ALA	9.6(*)	6.7
AA & ALA	5.2	3

* p<0.05; ** p<0.01; *** p<0.001



Figures 1 and 2: CMJ in male (N=9) and female (N=7) triathletes after swimming at different intensities.

Differences between IAE & ALA, AA, EAE. * p<0.05; ** p<0.01; *** p<0.001

Discussion and conclusions

The main result of this study is the significant and higher CMJ height found in our triathletes after swimming at IEA and EAE intensities, both in men and women (13% and

11.2% respectively). We must analyze the muscular work characteristics of lower limbs in swimming segment to look for an explanation of these results, segment that does not demand adjustments in SSC synchronization with myotatic reflex and in muscular stiffness due to low resistance during crawl kicking. Therefore, changes found in height jump might have been originated at nervous central system level, since the increase of kicking frequency in front crawl, needed for higher swimming speed, demands a higher amount of nervous stimulus. In relation to this argument, many swimmers and triathletes swim with a 2 times kicking at EAE intensities, instead of a 6 times kicking that demands higher kicking frequency and each kicking has a similar duration to the foot contact time

in a slow running or the CMJ execution time. This fact could have influenced a lower jump height after EAE intensity for both men and women. Previous studies showed a subsequent higher jump when prior movement frequency was increased, even after cycling with low resistance (Márquez et al., 2009), or after running at competitive intensity (Mon et al., 2005).

It is known that a reduced stretch reflex sensitivity and muscle stiffness deteriorate force potentiation mechanisms needed in activities with requirements of maximal elastic explosive force (Komi, 2000), measured by CMJ performance. These alterations could be generated by absence of SSC in some sport movements. In this way, triathletes jump less after pedaling in cicloergometer at MAP and ending at a low cadence than after a standard warm up and than after performing a maximal aerobic test (Mon et al., 2005).

Márquez et al. (2009) also found losses in jump height after 15 minutes pedaling at low intensity (50% MAP), related them to a disorder in neuromuscular function due to different movement patterns specially in biceps femoralis muscle, study that reinforces the effect of movements frequency modification on the vertical jumping ability. At this regard, Chapman et al. (2008) shown a slight modification in running mechanical parameters performed in transition compared with isolated one. In this study, the anterior tibial muscle EMG activity was only modified in 35 % of the subjects of whole studied group, so the EMG activity of this muscle group resulted barely altered by prior cycling segment, unlike other muscle groups such as vastus lateralis and gastrocnemius medialis which showed a high EMG activity at early running stages (up to 2km) at the same speed, but in three different situations (isolated running, after 45min low intensity cycling and after 45min cycling near competition intensity) (Mon et al. 2007).Vastus lateralis values for RMS were higher in running after cycling compared with isolated running (25-35%). In triathletes who were well trained in cycling, EMG activity parameters in knee and ankle major extensors were affected by previous cycling but not by its intensity (Mon et al. 2007).

The similarity between transition from cycling to running and from swimming to jumping is the change from a movement with absence of SSC to other where SSC is a key performance. Therefore, it can be observed a temporal alteration in its function, which is reflected in the CMJ performance after swimming at different intensities as in running EMG activity after cycling.

After review, Millet et al. (2009) conclude that it has also been shown that pedaling cadence affects metabolic response during cycling but also during a subsequent running bout. However, the optimal cadence and how the free chosen cadence influences the subsequent run is still under debated; central fatigue and decrease in maximal force are more important after prolonged exercise in running than in cycling (Lepers et al., 2001).

Whether differences in muscle contraction frequency influenced by different volume and intensity during cycling and running training affect the physiological adaptation in these exercise modes is also not known; all these findings might influence the training content and crosstraining effects in triathletes (Millet et al., 2009).

Perseveration could be another possible explanation for this difference in height jump after cyclic movements at different intensities which are not characterized by a long or short stretch-shortening cycle (SSC), nor by appearance of myotatic reflex. According to our results Gottschall & Palmer (2002) found an increase in the subsequent average running speed in 3200m after 30min cycling with faster cadence than preferred (+20%) in triathletes, suggesting perseveration would be the

The lengthening of the previous swimming effort could have had influence in our results because triathletes jump is higher after swimming at IAE and ALA than AA, although at AA legs movement was performed quickly and with a lower metabolic load than at ALA effort. We found a significant difference ($p<.05$) between CMJ after AEI and AA in women (8%), but not in men (10.2%) despite their difference was higher, fact that could explain the possible influence of effort extent. Jump capacity differences found in our triathletes, higher at IAE situation than EAE for men and women, can not be referred to glycogen store depletion, because 1500m swimming time is not enough to provoke that kind of fatigue, not even to be related to T1 in actual triathlon.

Lack of significant differences in our study between CMJ after ALA and other intensities with lower La production rejects the argument of hindered muscular contraction due to a high metabolites accumulation as a possible cause which does not allow a 100% performance in running after swimming (T1). This fact leads us to consider the possibility of a nervous alteration existence in transitions from activities without SSC which affect performance (swimming or cycling) to others where fast or slow SSC (running or jumping respectively) is a performance key factor (Schmidtbleicher., 2000; Komi, 2000; Lepers et al., 2001, Chapman et al., 2008; Márquez et al., 2009; Mon et al., 2005; Millet and Vleck 2009).

Remarkably, muscular stiffness variation can be improved with training, since elite triathletes have better leg stiffness regulation than their less successful counterparts (Millet y cols., 2000). It becomes necessary to establish strategies to improve nervous capacity for fast transitions between different activities in annual training program in order to perform swimming leg in triathlon mechanism responsible for elevated running stride frequency after cycling with high cadences.

In competitive swimming, Potdevin et al (2011) found an improvement in 400m and 50m performance after including a jumping training in swimming seasons, but they did not find any improvement in 25m time swimming only with or without kicking. So these events performance could be related to the applied force in turns or starts, more similar movements to plyometric jumps (CMJ y DJ). Triathletes have to jump in several times during races, at start, to begin the second lap of the 1500m swimming, as well as for the beginning of the cycling and during running leg. Therefore, plyometric training has

multiple applications in triathlon, and they have to train both force manifestations (elastic-explosive and elastic-explosive-reactive) in order to obtain good results.

These findings allow us to know more about possible positive, null or negative cross-transfer training effects between different activities and its use to achieve an increase triathlon performance and start a new research line in this specific part of triathlon competition.

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Chondromalacia Patella in Triathletes

Jodie E. Totten, Medical Student – University of Washington School of Medicine

Mary L. O'Toole- Deputy Director, Washington University in St. Louis School of Medicine

W.D.B. Hiller, MD- North Hawaii Community Hospital, University of Hawaii at Hilo

Questions contact: Jodie Totten PO Box 6009, Sitka, Alaska, USA

Jet25@u.washington.edu phone: 907-738-4262

Summary As triathlon continues to grow in popularity, so does the importance of understanding triathlon related injuries. Though multiple studies to date have examined injuries in triathletes, little is known about recovery from these injuries. Chondromalacia patella, or patellofemoral pain syndrome, is a common injury among athletes. In this survey of 2438 triathletes, information was collected on the self report of injury occurrence, treatment, and recovery associated with chondromalacia patella. Overall rates of chondromalacia patella were greater in women than in men (17.7% vs 13.2%, $p<0.025$) with the greatest rates in the 30-39 year old age group (16.9% vs 12.4% among other age groups, $p<0.025$). Time to recovery did not vary significantly among genders, age groups, or treatments. However, the percentage of those reporting that they "didn't completely recover" from their chondromalacia patella was significantly higher among women and those using physical therapy or anti-inflammatory medications for treatment while those using new shoes for treatment were significantly more likely to report recovery. This information will be useful in advising triathletes during treatment and recovery from the common injury, chondromalacia patella.

Keywords: patellofemoral pain syndrome, knee, anterior knee pain, recovery

Introduction: As triathlon continues to grow in popularity, so does the importance of understanding triathlon-related injuries. Injuries are common among triathletes with up to 91% of those surveyed reporting injury (1). One of the more common areas injured is the knee. Knee injuries have been reported as up 66.6% (2) of all injuries reported among triathletes. This is not surprising given the prevalence of knee injuries in professional cyclists and runners as well (3) (4). One particular knee injury, chondromalacia patellae will be discussed in this paper. Though it is possibly the most sports injury diagnosis and the most common cause of knee pain among cyclists (5) and runners (6), little is known about the incidence, treatment, and recovery associated with chondromalacia patella in triathletes. This study of 2,438 Olympic distance triathletes examined common injuries in the surveyed population, including chondromalacia patella, for their incidence, treatment, and recovery time.

Materials and methodology: 25,000 surveys consisting of 113 questions were mailed to, or included in race packets of all athletes in selected US Triathlon Series races in 1986 and 1987. The occurrence of chondromalacia patella and treatments used were identified by the response to the question "If you have ever had chondromalacia patella, was it treated by a) never had it, b) physical therapy, c) injections, d) anti-inflammatory drugs, e) immobilization, f) braces, g) new shoes, h)heel cups?" The interpretation of complete recovery was left to the athletes and they were asked to choose a time frame to complete recovery ranging from <1 week to 1 year with "didn't completely recover" as an option. Statistical analysis was performed in SPSS, Excel, and VassarStats using chi-squared analysis, summary statistics, odds ratios, and t-tests. This study was completed with the support of the Campbell Clinic, the University of Tennessee Department or Orthopedic Surgery, the Baptist Memorial Hospital, and HealthPlex in Memphis, Tennessee.

Results: 2,438 completed questionnaires were returned for a response rate of 9.75%. Respondents included 1968 (80.7%) males and 470 (19.3%) females whose characteristics are shown in table 1. Knee injuries were reported by 64.4% of respondents, making it the third most commonly injured area behind foot and ankle injuries and back injury or pain. There was no significant difference between the percentage of males and females reporting knee injury. However, females reported significantly more cases of chondromalacia patella than males ((17.7% (83/470) compared to 13.2% (259/1968), p<0.025)(OR=1.4152, 95% CI= 1.0795, 1.8552)). Additionally, 30-39 year olds reported a higher percentage of chondromalacia patella (16.9%) than other any other age group (7.1 to 13.2%, p<0.025).

Table 1. Demographics

	Males	Females
Sex, #(%)	1968(80.7%)	470 (19.3%)
Age (yrs)	33.5 ± 9.1	30.6 ± 7.3
In-Shape Weight (kg)	73.5 ± 7.6	56.2 ± 6.4
Out of Shape Weights (kg)	77.4 ± 9.5	59.5 ± 7.4
Swim Training (h/wk)	2.5 ± 1.4	2.7 ± 1.4
Bike Training (h/wk)	6.3 ± 3.5	6.0 ± 3.6
Run Training (h/wk)	4.0 ± 2.8	4.2 ± 3.7

Demographic characteristics of all survey respondents.

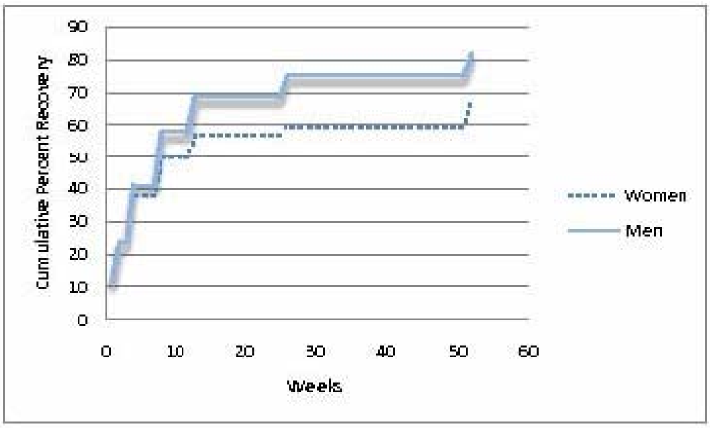

Figure 1. Cumulative percent recovered from chondromalacia patella by time period for men and women.

The recovery timeline is represented in figure1 and table 2. For those who reported recovery from this injury, time to recovery did not vary significantly by age or gender. However women reporting chondromalacia patella were significantly more likely than men to report that they "didn't completely recover", see figure 2 (30.5% vs 16.4%, p<0.01) (OR=2.2329, 95% CI 1.2621, 3.9504).

Table 2. Recovery

Time period	<1 wk	1-2 wks	2-4 wks	1-2 mo	3 mo	6 mo	1yr
Cumulative % recovered by this time period	12.3%	24.3%	41.4%	57.4%	67.7%	73.4%	80.3%

Cumulative recovery from chondromalacia patella by time period for men and women combined.

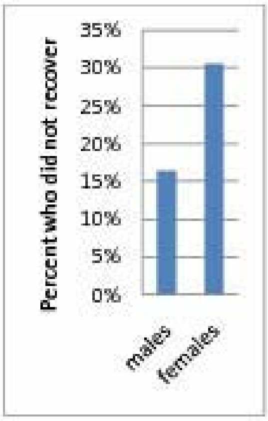

Figure 2. Percent of those reporting chondromalacia patella who had not recovered from chondromalacia patella after one year by gender.

Choice of treatment appeared to be associated with whether or not recovery was complete. The most common treatments were physical therapy (38.8% received PT), anti-inflammatory medications (26.6%), and new shoes (20.1%). There was no significant difference in treatments used by men and women. Those who used new shoes as treatment were more likely to recover (89.8% vs 79.1%, $p<0.025$)(OR=2.6904, 95% CI 1.1022, 6.5667). While those who used anti-inflammatory medications were less likely to recover (70.7% vs 79.1%, $p<0.05$)(OR=0.5381, 95% CI 0.2968, 0.9754) as were those using physical therapy (72.9% vs 79.1%, $p<0.001$)(OR=0.5786, 95% CI 0.3322, 1.0077). Treatment using immobilization, heel cups, braces, or injection was not associated with a change in the frequency of complete recovery.

Discussion and Conclusions: Sixty-four percent of triathletes in this study reported knee injuries which is similar to the 66.6% of triathletes reporting knee overuse injuries in Egermann et al (2), though higher than many other estimates for triathletes, cyclists, and runners(3, 4). This high percentage could be due to the long time frame used in this study and may not be comparable to other reports of triathlete knee injuries. In this study the percentage of athletes reporting chondromalacia patella (14%) was much less than anterior knee pain reported to occur in professional road cyclists (36%) (3) and runners (38-62%)(4), which may be a result of multisport training. The significantly higher reporting of chondromalacia patella among women versus men in this study has been shown in other studies (4). Though age has been suggested as a risk factor for patellofemoral pain syndrome, previous studies reported the highest percentages in those <34 yo (4), not the 30-39 yo age group as was seen here.

Recovery time in this study is similar to previously reported rates of 54-85% (7). Though multiple studies have failed to show gender as a prognostic factor for patellofemoral pain (8), in this study women were significantly more likely than men to report that they did not completely recover from chondromalacia patella (30.5% vs 16.4%).

Treatments of patellofemoral pain syndrome have been well studied, particularly the use of NSAIDs and physical therapy. Though the argument for or against the use of NSAIDs in patellofemoral pain syndrome remains weak (9), physical therapy has been shown to be effective in multiple studies (7). However, in our data both NSAIDs and physical therapy were statistically associated with an incomplete recovery. This could be due to variable interpretation of the term physical therapy or possible self selection of more severe cases to physical therapy or anti-inflammatory medications vs. other treatment options. The only treatment showing improved rates of complete recovery was the use of new shoes. Though it has often been suggested that excessively worn shoes may play a factor in injury rates (7), so far study results have not been clear (10). Treatment by immobilization, heel cups, braces, or injection were not associated with significant differences in percentage reaching complete recovery.

Though this study is the largest study of triathletes to date, it may be criticized for its response rate of 9.75% which may have led to response bias as well as the retrospective design, an undefined recall period, reported injury and recovery not requiring physician diagnosis or evaluation, and lack of randomization to the treatment options. Additionally the use of the term "chondromalacia patella" instead of anterior knee pain or patellofemoral pain syndrome may have affected athletes' recognition of the injury in question.

In summary, in the largest study of triathletes to date, knee injuries and more specifically chondromalacia patella were common. Though knee injury percentages did not vary significantly by gender, women were more likely to report chondromalacia patella. Lower rates of complete recovery were reported by females and by those using physical therapy or anti-inflammatory medications for treatment. The use of new shoes to treat chondromalacia patella was the only treatment variable associated with increased report of complete recovery. This information will be useful for treating and advising triathlete with the common injury, chondromalacia patella and in directing future research in the area.

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Training Intensity distribution during an Ironman season: relationship with competition performance

Jonathan Esteve-Lanao[1],[2], *Roberto Cejuela*[3], *Iker Muñoz-Pérez*[1]

[1]Training Lab, European University, Madrid (Spain).Jonathan.esteve@uem.es

[2]School of Exercise Sciences, Greenwich University, London (UK)

[3]Departmental Section of Physical Education and Sports, University of Alicante (Spain)

Introduction: Triathlon races can be conducted over a wide range of race conditions. Thus, it is not suitable to compare personal best times between triathletes. This is distinct from what happens in pool swimming, track cycling or route races where it is possible to have standard conditions. As such, it is difficult to establish relationships between training loads and competition performances for triathletes. The purpose of this study was to 1) describe training loads during an Ironman training program and 2) observe training-performance relationships in a group of triathletes preparing the same competition.

Methods:9 recreational-level triathletes completed a training program designed for the same Ironman triathlon (Ironman Austria, Klagenfurt, July 4th 2010). They were all trained by the same coach (J. E-L), in a supervised program following the same periodization model. Before starting the training program, all subjects participated in a 25 week training program (21-23 weeks of winter season training plus a 2-4 week transition period). All subjects trained at the same training intensity and followed the same training methods using a reverse periodization program design. Triathletes recorded every training session load during an 18 week training macrocycle.

A graded exercise test was used to determine training zones. Cycling and running tests were conducted with a gas exchange analyzer (VO2000, Medical Graphics, St Paul, Min USA). Two metabolic thresholds were defined, following previous procedures (1). Swimming tests were performed with a portable lactate analyzer (Lactate Pro, ArkrayInc, Amstelveen, NED). Threshold criteria were defined as follows: blood lactate 0,5 mMol/L increase for Aerobic Threshold (AeT), >1,0 mMol/L increase for Anaerobic Threshold (AnT), and 8-9mMol/L for Maximal Aerobic Power (MAP) Power / Speed training zones were increased during the program according to RPE / HR initial training zones. A second metabolic test took place during weeks 9-10 to update the initial zones. Three main training zones were defined for this study: Zone 1 (below AeT), Zone 2 (beyond AeT and below AnT) and Zone 3 (beyond AnT).

Inclusion criteria included the following: 1) complete and record 95% of total training sessions, and 2) complete and perform continuously, without any relevant health, tactical or technical problems, the full distance in competition. Seven subjects (4 males and 3 females, age 38,0 ± 9,0 yr.) met all criteria; 2 subjects had to stop and walk several times to finish the race and were excluded from the study. Pearson correlations were applied between training load and competition variables.

Results: Most of the training time was conducted in zone 1 (68±14 / 28±13 / 4±3% respectively, for zones 1, 2 and 3). However, most of competition time was found in zone 2 (31±24 / 65±22 / 4±6% respectively, for zones 1, 2 and 3). (figure 1). Correlations between training and competition are presented in figure 2. There were significant inverse correlations between total training time or training time in zone 1 and performance time in competition (r= -0,93 and -0,92 respectively). However, there was a moderate direct correlation between total training time in zone 2 and performance time in competition (r=0,49) and a strong direct correlation between % of total training time in zone 2 and performance time in competition (r=0,82).

Figure 1.-Mean ± SD percentage of training time that was spent in each of 3 intensity zones in training (left) and Ironman competition (right).

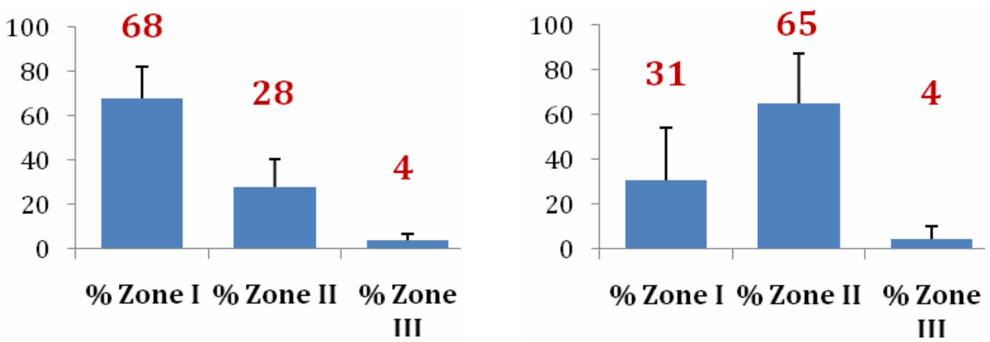
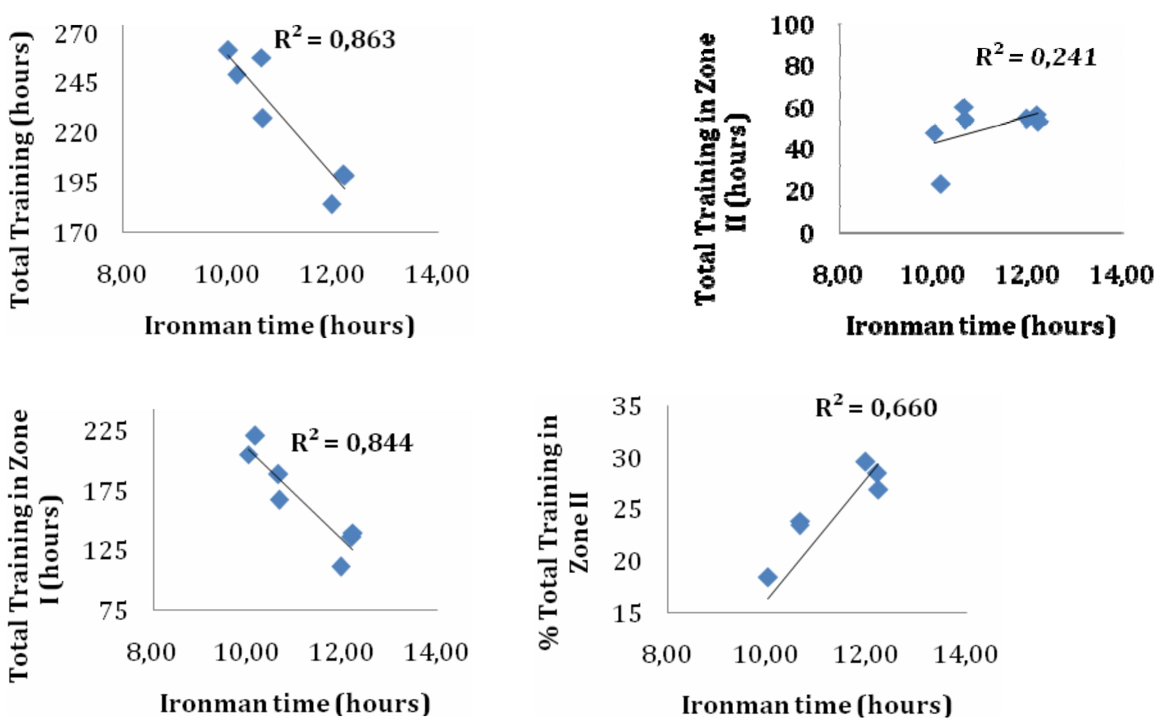


Figure 2.- Training – Performance Correlations



Discussion

Ironman training was performed mainly in zone 1, although competition is mainly performed in zone 2. While a deeper analysis must be made, the training-competition relationship seems to suggest the importance of easy training versus moderate training (2). These results highlight the importance of training intensity distribution for optimal training (3,4). For triathletes who have more time to train, there seems to be a polarized distribution of training. It should be noted that the 2 subjects who were excluded had trained in zone 2 for 40-50% of the total training time, suggesting an upper limit for Zone 2 training accumulation. These data suggest, apart from specific race pace workouts for swimming and cycling events, there is no need to accumulate additional training in zone 2. However, additional training time seems to result in optimal performance. But to be successful in a triathlon, it appears that any extra training should be performed in zone 1. Since triathletes spend the greatest amount time cycling in both training and competition, it is possible that this is where training can be less intense, limiting time in zone 2. Further research is needed to test this hypothesis.

Conclusion

The Ironman triathlon is performed mainly in zone 2 (swimming and cycling phases), but most of the training should be conducted in zone 1 in all disciplines for maximizing performance.

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Body Composition of elite triathletes

José Miguel Martínez Sanz[1], Roberto Cejuela Anta[1], Aritz Urdampilleta Otegui[2], Manuel Gallar Pérez-Albaladejo[3], José Miguel Soriano Del Castillo[4].

1) Triathlon Development Program Alicante University, Spain.

2) Department of Pharmacy and Food Science (University of the Basque Country)

3) Department of Nursing. University of Alicante

4) Area of Nutrition and Food Science. Faculty of Pharmacy. University of Valencia.

First and presenting author:

José Miguel Martínez Sanz

Avenida Vicente Savall Pascual, Nº 10, Bloque III, 1º A

C.P. 03690

San Vicente del Raspeig (Alicante)

E-mail: josemiguel.ms@ua.es

Abstract

Triathlon is a sport that includes the characteristics of all the sports that it comprises. We have evaluated 48 athletes (39 men and 9 women, table 1) participants in the university championship triathlon of Spain (Alicante, 2010). An official meter ISAK (Society for the Advancement of Kinanthropometry) takes measures (skinfolds, perimeters and diameters) that are necessary for following the methodology of Marfell-Jones and colleagues.2001, and for the kinanthropometric assessment. Using the formula described in the GREC Kineanthropometry consensus the body composition was calculated. We have obtained data for describing the anthropometric profile and body composition (mass and percentage (%) greasy, muscular, osseous and residual) of the tested athletes.There were few differences in the greasy percentage according to the sex, approaching those at the greasy percentage of reference, that found that women are below the reference value. In this regard to muscular mass, there are higher rates in men than in women.

Keywords: anthropometry, body composition, triathlon

Resumen

El triatlón es un deporte reciente que engloba las características de las modalidades deportivas que lo componen. Se evaluaron 48 triatletas (39 hombres y 9 mujeres, tabla 1) participantes en el campeonato de España universitario de triatlón (Alicante, 2010). Un medidor acreditado ISAK (Society for the Advancement of Kinanthropometry) tomo las medidas (pliegues, perímetros y diámetros) necesarias siguiendo la metodología de Marfell-Jones y Cols. 2001, para la valoración

cineantropométrica**.** mediante las fórmulas descritas en el consenso de cineantropometría del GREC se calculo la composición corporal. Se obtuvieron datos para describir el perfil antropométrico y de

composición corporal (masa y porcentaje(%) graso, muscular, oseo y residual) de los triatletas evaluados. Se encontraron pocas diferencias en el % graso según sexo aproximándose estos al % graso de referencia, encontrándose el de las mujeres por debajo del valor de referencia. Respecto a la masa muscular, hay mayores % en hombres que en mujeres.

Palabras clave: antropometría, composición corporal, triatlón

Introduction:

The triathlon is a combined endurance sport where seamless develops swimming, cycling and running. The anthropometric characteristics define a triathlete as an athletetall, average weight and low fat percentage. These are similar to high-performancecyclists and middle distance swimmers by gender, but the fat percentage is higher. The aim of this tudy is to asscess the characteristics and composition antropométicas triathletes participating in the university championship triathlon Spain (Alicante, 2010).

Methods:

The study design was observational and descriptive anthropometric characteristics of body composition in athletes participating, in the universitary championship triathlon Spain (Alicante, 2010). We have evaluated 48 athletes (39 men and 9 women, table 1). For undertaking the kinanthropometric evaluation followed the rules and techniques as recommended by the International Working Group of Kinanthropometry, following the methodology described by Ros and Marfell-Jones and adopted by the ISAK and by the Spanish Group of Kineanthropometry (GREC).

An ISAK accredited meter (Society for the Advancement of Kinanthropometry) level. It takes the following steps: a) skinfolds (subscapular, triceps, biceps, ileocrestal, ileoespinal, abdominal, anterior thigh and calf), b) girths (arm relaxed, arm contracted, waist, hip thigh and calf) and c) diameters (humerus, wrist and femur) required for the anthropometric assessment.

By the formulas given in the consensus of the GREC Kineanthropometry, the body composition was calculated using the model of 4 components: a) greasy mass formula was used Withers, 1987; b) muscular mass by Lee et al, 2000;c) osseous mass Rocha d) residual mass by subtracting the total weight of the other components.

Results:

Tables 1.2 and 3 show the anthropometric profile and body composition by sex of the studied subjects:

Tables

SEX		BASIC MEASURES		
	AGE	WEIGHT	STATURE	BMI
Male	24±4,5	70,65±6,01	1,77±0,07	22,58±1,43
Female	23±2	59,89±7,87	1,74±0,06	21,83±2,54

Table 1. Basic measures of elite triathletes.

SEX	Skinfolds							
	Subescapular	Triceps	Biceps	Iliac Crest	Supraespinale	Abdominal	Front Thigh	Medial Calf
Male	8,42±1,83	7,38±2,43	3,82±1,36	11,78±4,14	7,42±2,53	11,38±5,35	11,43±4,25	8,14±4,9
Female	11,86±4,93	14,0±5,15	6,6±2,67	18,06±4,51	13,76±5,61	20,71±6,21	27,97±9,2	16,8±7,03

	Girths				Breadths		
	Arm (relaxed)	Arm (flexed & tensed)	Thigh	Calf	Humerus	Wrist	Femur
Male	29,75±1,36	31,79±1,35	51,95±3,55	36,82±2,3	6,85±0,29	5,66±0,71	9,56±0,77
Female	27,78±2,6	28,16±2,31	46,49±11,91	32,06±8,48	6,01±0,53	5,1±0,48	8,68±0,36

SEX	BODY COMPOSITION				
	% FATTY (withers y col.,1987)	**% MUSCULAR (Lee, 2000)**	**% OSEO (Rocha,74 (V. Döbeln)**	**% RESIDUAL**	**International reference % FATTY**
Male	10,22±2,92	45,27±3,29	16,65±1,34	27,85±2,5	7-10
Female	9,95±2,82	36,85±5,38	15,73±1,49	27,79±3,62	13-18

Table 3. Body composition of elite triathletes.

Discussion/Conclusion:

With the results obtained, there are found little differences in the percentage of greasy body, sex compared to the percentage of greasy reference; found that women are below the reference value. The triathlete has a lower greasy percentage than athletes of the sports involved, which has eliminated a limiting factor.

In this regard to muscular mass is greater percentage in men than in women, but we have

found no references in this compartment, which has an important role in the characteristics of the triathlete to sporting success with the greasy percentage, weight and oxygen consumption .Further studies should be established for the anthropometric characteristics of thetriathlete and evolution taking into account factors such as training and nutrition.

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Somatotype of elite triathletes

José Miguel Martínez Sanz[1], Roberto Cejuela Anta[1], Aritz Urdampilleta Otegui[2], Manuel Gallar Pérez-Albaladejo[3], José Miguel Soriano Del Castillo[4].

1) Triathlon Development Program Alicante University, Spain.

2) Department of Pharmacy and Food Science (University of the Basque Country)

3) Department of Nursing. University of Alicante

4) Area of Nutrition and Food Science. Faculty of Pharmacy. University of Valencia.

First and presenting author:

José Miguel Martínez Sanz

Avenida Vicente Savall Pascual, Nº 10, Bloque III, 1º A

C.P. 03690

San Vicente del Raspeig (Alicante)

E-mail: josemiguel.ms@ua.es

Abstract

Triathlon is a sport that combined the latest features of the sports that comprise it. The mean somatotype of athletes is balanced mesomorph (similar to swimming), but with fewer and more ectomorphy mesomorphy (similar to the runners). We have evaluated 48 triathletes (39 men, 70.75 kg, 1.77 m, 9 female: 59.89 kg and 1.74 m) participating in the university championship triathlon of Spain (Alcante, 2010). An ISAK accredited meter (Society for the Advancement of Kinanthropometry) took anthropometric measurements following the methodology of Marfell-Jones and colleagues, 2001; to calculate of somatotype (endomorphy ,mesomorphy, ectomorphy) by the method of Heath-Carter 2002, somatotypemorphogenetic distance (SAD) and somatotype dispersion mean morphogenetic (SAM). Both sexes make heterogeneous groups. The kids have a balanced mesomorph somatotype as described in the literature with reference somatotype similarity to the girls instead present a balanced endomorph somatotype difference reference.

Keywords: anthropometry, somatotypes, triathlon

Resumen

El triatlón es un deporte reciente que engloba las características de las modalidades deportivas que lo componen. El somatotipo medio de los triatletas es mesomorfo balanceado (similar a las nadadoras), pero con menos mesomorfia y más ectomorfia (similar a las corredoras). Se evaluaron 48 triatletas (39 hombres: 70,75kg, 1,77m y 9 mujeres: 59,89kg y 1,74m) participantes en el campeonato de España universitario de triatlón (Alicante, 2010). Un medidor acreditado ISAK (Society for the Advancement of Kinanthropometry) tomo las medidas antropométricas siguiendo la metodología de Marfell-Jones y Cols. 2001, para el cálculo del somatotipo (endomorfia, mesomorfia, ectomorfia) según el método de Heath-Carter 2002, la distancia morfogenética del somatotipo (SAD) y dispersión

morfogénica media del somatotipo (SAM). Ambos sexos conforman grupos heterogéneos. Los chicos presentan un somatotipo mesomorfo balanceado tal y como se describe en la literatura con similitud al somatotipo de referencia, las chicas en cambio presentan un somatotipo endomorfo balanceado con diferencia con su referencia.

Palabras clave: antropometría, somatotipo, triatlón

Introduction:

Triathlon is sport that includes the latest features of the sports that it comprises. The anthropometric characteristics define a triathlete as a high athlete, average weight and low greasy percentage. The somatotype is the quantitative description of body shape and composition of the human body at any given time, and expressed by three compentes: endomorphy, mesomorphy and ectomorphy, always listed in that order. The mean somatotype of athletes is balanced mesomorph (similar to swimmers), but with fewer and more ectomorphy mesomorphy (similar to the runners). The aim of this study is to evaluate the characteristics of somatotype (body shape and physical) of triathletes participating in the university championship triathlon of Spain (Alicante, 2010).

Methods:

The study design was observational and descriptive of the characteristics of the somatotype in athletes participating in the university championship triathlon of Spain (Alicante, 2010). We have evaluated 48 athletes (39 men, 70.75 kg, 1.77 m, 9 female: 59.89 kg and 1.74 m). For undertaking the kinanthropometric evaluation we have followed the rules and techniques recommended by the

International Working Group of Kinanthropometry, following the methodology described by Ros and Marfell-Jonesand adopted by the ISAK and by the Spanish Group of Kineanthropometry (GREC).

An ISAK accredited meter (Society for the Advancement of Kinanthropometry) level took the 10 steps necessary to calculate the somatotype: a) height, b) weight, c) skinfolds (subscapular, triceps, ileoespinal. And calf), d) circumferences (contracted arm and calf) and e) diameters (humerus and femur).

To calculate the somatotype mean somatotype was determined, the three somatotype components separately (endomorphy, mesomorphy, ectomorphy), the distance morphogenetic somatotype (SAD) and somatotype dispersion meanmorphogenetic (SAM), following the method of Heath Carter. We obtained values of SAM to determine the degree of homogeneity of the group. All parameters were determined and classified by gender, portraying the somatochart.

Results:

The Table 1 shows the characteristics of the somatotype of athletes and valued SAD and SAM. Also in Pictures 1, 2, 3 and 4 the graphical shows the representation (somatochart) as somatotype distribution between boys and girls and their comparison with the international elite:

Discussion/Conclusion:

Both sexes make heterogeneous groups, because high levels of SAM (SAM ≥ 1.0).

The SAD was not significant between boys and girls Spanish (SAD <2) and girls and the reference which shows somatopoints dispersion and differences between the composition and physical fitness, but if it is between boys and their reference level international. The kids have a balanced mesomorph somatotype as described in the literature with reference somatotype similarity to the girls instead present a balanced endomorph somatotype difference reference. We can also find somatotypes endomesomorphic, endomorphs balanced ectomesomorfos, mesomorphic ectomorphand balanced within the sport, as shown in Figure 1. It must analyze the determinants or conditions that can manifest these characteristics of the somatotype, and that may be involved aspects such as food carried out (intake of fats, carbohydrates and proteins), food habits, food intake at certain times, type and hours training, among others.

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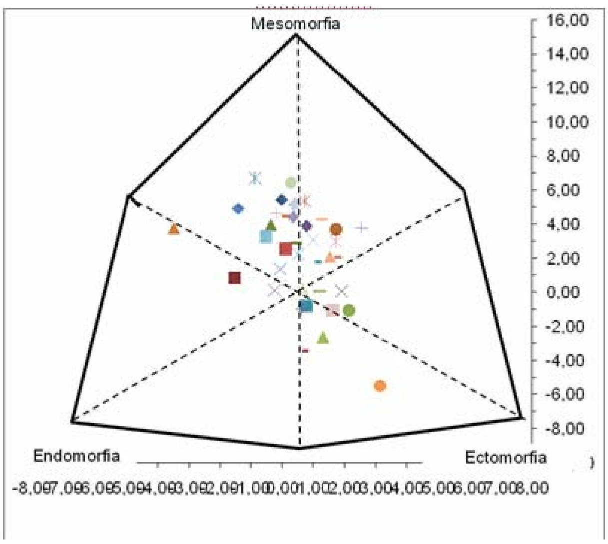
Tables

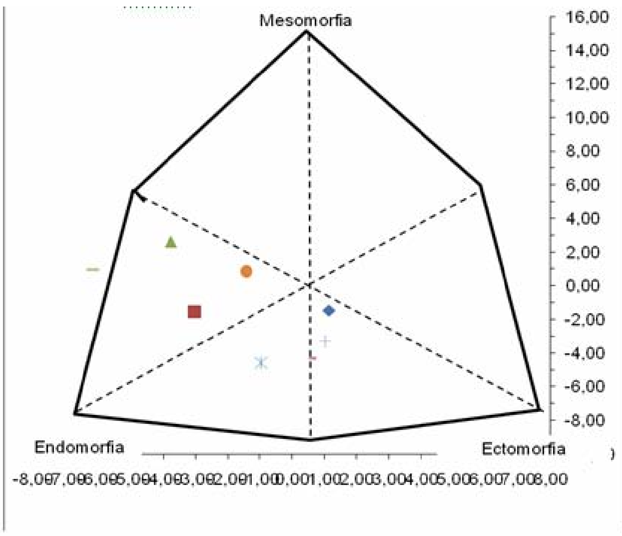
Sex	Ectomorphy	Mesomorphy	Endomorphism	SAD
Boys(1)	2,18±0,62	3,63±1,06	2,75±0,82	1,5(between 1 y 2)
Girls(2)	4,11±1,36	2,07±1,87	2,44±1,16	
Reference international girls(3)	2,6	3,8	3	2,36 (between 2 y 3)
Reference international boys (4)	1,9	4,3	3	0,77 (between 1 y 4)

Table 1. somatotype characteristics of elite triathletes.

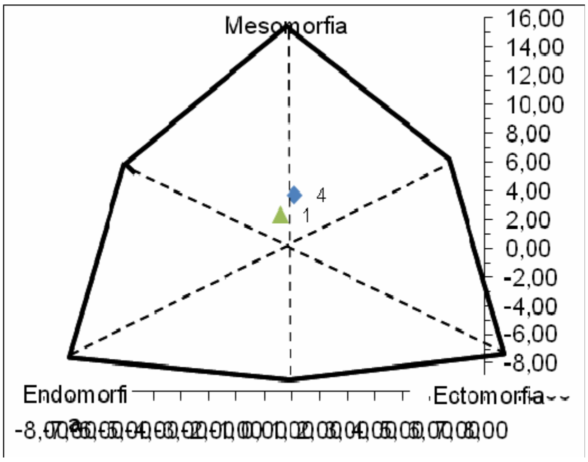
Picture 1. Somatotype distribution, boys. SAM: 1.31



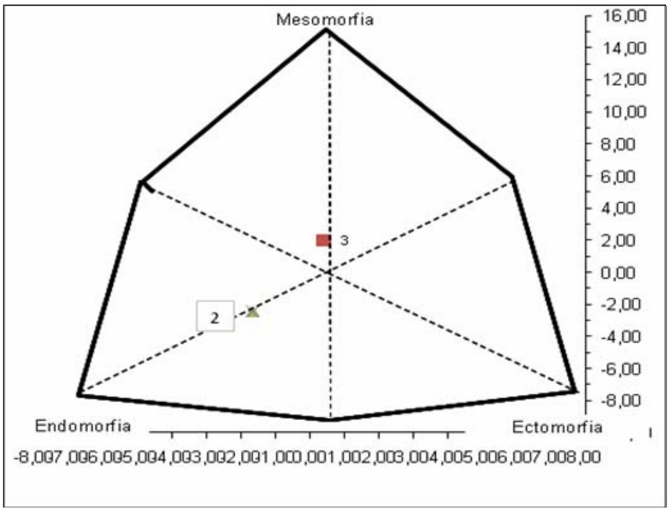
Picture 2. Girls SAM: 2.22



Picture 3.Somatotype average of Spanish boys and boys of international reference



Picture 4.Somatotype average of Spanish girls and girls of international reference



PREDICTION OF SPRINT DUATHLON PERFORMANCE FROM MAXIMAL LABORATORY TESTING

José Ramón Alvero-Cruz, Mauro Ronconi

Exercise Physiology and Performance Laboratory.

Faculty of Medicine. Sports Medicine School. University of Málaga. Spain

Corresponding author:

José Ramón Alvero-Cruz

Sports Medicine School. Edificio López de Peñalver. Campus de Teatinos, s/n.

University of Málaga. 29071. MALAGA

Phone: 0034 952137599

e-mail: alvero@uma.es

Summary

Physiological testing is commonly used to assess the overall fitness level of the athletes and to set guidelines for individualized training. This study investigated whether sprint duathlon performance can be adequately predicted from laboratory tests.

Eight male trained duathletes- triathletes [mean (SD), age 24.8 (6.8) years, height 174.4 (6.8) cm, body mass 67.12 (8.1) kg] participate in this study. Anthropometric measurements (ISAK) were taken to estimate body composition. All duathletes performed two graded maximal exercise test in random order, one on cycloergometer (CE) and other on a treadmill (TR). During each laboratory tests, heart rate (HR), power output (PO), running speed were recorded at first ventilatory threshold (VT1), respiratory compensation point (VT2) and maximal oxygen uptake (VO_{2max}) were continuously measured. Furthermore all athletes competed in two official sprint duathlon competitions: both 5km run, 20-km bike, 2.500- run. A stepwise multiple regression analysis was performed to analyze the relationships between time race as dependent variable and laboratory variables as independent variables.

Results

Stepwise multiple regression analysis revealed significant models between race time (performance) in ALH competition and very high relationships with RIN race, using the following equations:

Duath ALH Time (min) = $WCEVO_2max$ (0.03451) + 50,5729 (R^2 = 0.65, EES: 0.92, p=0.03)

Duath RIN Time (min) = *WCEVT2* (0.02671) + *HRVT2TR* (0.1786) + 28.1779 (R^2 = 0.9952, EES: 0.21, p<0.001)

Discussion and Conclusions

Our data indicate that exercise laboratory tests aimed to determine VO_2max in running and biking test to allow for a precise estimation of duathlon performance. Our results reveal that physiological testing

variables Wmax, WVT2 in bike and HRVT2in treadmill seems useful variables related to performance in sprint duathlon.

Keywords: Duathlon sprint; Race results; Laboratory testing variables

Resumen

Es frecuente la utilización de test fisiológicos para la valoración de la condición física y para la consiguiente individualización del entrenamiento. El objetivo de este estudio es investigar si algunas variables de laboratorio pueden predecir el rendimiento en duatlones sprint

Ocho sujetos varones duatletas-triatletas [media (DT), edad 24.8 (6.8) años, altura 174.4 (6.8) cm, peso 67.12 (8.1) kg] participaron en el estudio. Fueron tomadas una serie de medidas antropométricas para derivar variables de composición corporal. Todos los duatletas realizaron dos pruebas de esfuerzo maximal, en cicloergómetro y en banda rodante. Durante cada valoración se recogieron datos de frecuencia cardiaca, potencia y velocidad de carrera en los umbrales aeróbico y anaeróbico así como el pico de consumo de oxígeno. Los atletas compitieron en dos carreras de 5km carrera1, 20-km bicicleta, 2.500 m- carrera2. Un análisis de regresión múltiple se utilizó para predecir el tiempo de carrera como variable dependiente y las variables de laboratorio como independientes.

Resultados

El análisis de regresión múltiple, reveló modelos significativos en las competiciones ALH y RIN mediante las siguientes ecuaciones:

Duath ALH Time (min) = $WCEVO_2max$ (0.03451) + 50,5729 (R^2 = 0.65, EES: 0.92, p=0.03)

Duath RIN Time (min) = *WCEVT2* (0.02671) + *HRVT2TR* (0.1786) + 28.1779 (R^2 = 0.9952, EES: 0.21, p<0.001)

Discusión y Conclusiones

Nuestros datos indican la utilidad de algunas variables fisiológicas obtenidas en el laboratorio tanto en pruebas de bicicleta como de carrera, permitiendo estimaciones precisas del rendimiento en carreras de

duatlón sprint, destacando variables como la potencia máxima , la potencia en el umbral anaeróbico alcanzada en cicloergómetro, así como la frecuencia cardiaca en el umbral anaeróbico en la banda rodante

Palabras clave: Duathlon sprint; Rendimiento; Variables fisiológicas de laboratorio

Introduction

Physiological testing (Van Schuylenbergh et al , 2004; Schabort et al 2000, Sleivert and Wenger, 1993); is commonly used to assess the overall fitness level of the athletes and to set guidelines for individualized training. The popularity of triathlon and duathlon is rapidly increasing in particular in the shorter distances, such as sprint events. Some physical fitness, maximal graded test variables and anthropometric variables are considered requisites for physiological assessments and relation in high performance in sports. The top level triathletes are characterized by a high aerobic power and peak oxygen uptake as a rule is in the range of 70–90 ml. Corresponding values in cycling are slightly lower (Hue et al. 2000). Still, VO_2 peak has not appeared to be a good predictor of triathlon performance in elite triathletes (Le Gallais et al. 1999). Submaximal exercise intensity markers such as the so-called anaerobic threshold (Schabort et al. 2000) conceivably yield a higher validity to predict triathlon performance. Sleivert, (Sleivert and Wenger, 1993) described the physiological responses of triathletes to simulated competitions. Maximal oxygen uptake is considered an important physiological determinant of middle and long distance endurance performance.

Therefore, the primary purpose of this study was to evaluate whether sprint duathlon race time can be adequately predicted from laboratory exercise tests aimed to assess maximal aerobic power and aerobic and anaerobic thresholds in two different sprint duathlon competitions

Methods

Subjects

Eight male trained duathletes- triathletes [mean (SD), age 24.8 (6.8) years, height 174.4 (6.8) cm, body mass 67.12 (8.1) kg] participate in this study, which was approved by Ethics Committee of Faculty of Medicine of University of Málaga. Written informed consent was obtained from each duathlete before their participation in the study. At the time of investigation all athletes had just competed in two official competitions and consist in 5-km. run, 20–km cycle and 2,5 km. run.

Protocol

Anthropometric measurements (body mass, height, skinfolds and circumferences) using international recommended procedures (International Society for Advancement in Kinanthropometry) were taken to estimate body composition : percent body fat (Withers et al, 1987) and skeletal muscle mass (Lee, 2000)

Cycling and running testing

All duathletes performed two graded maximal exercise test in random order, one on mechanically braked cycle ergometer Monark 818E (CE) (Monark, Sweden) and duathletes wore their cycling shoes during all testing, and other on a motor drive treadmill (TR) Power Jog (PowerJog Ltd, England), to determine their peak oxygen consumption (VO_2peak). An incremental cycling testing starting at 60 watts, after which increased 30 watts every 60 s until exhaustion. An incremental running test starting at 6 km/h after which increased 1 km/h/min until exhaustion. During each laboratory tests, heart rate (HR), power output (PO), running speed were recorded at first ventilatory threshold (VT1), respiratory compensation point (VT2) and maximal oxygen uptake (VO_{2max}) were continuously measured during the graded tests.

Determination of ventilatory thresholds

For both graded test a ventilatory thresholds VT1 (aerobic threshold) and VT2 (respiratory compensation point) were determined using a modified Davis method (Davis, 1985)

Duathlon race performance

Within 3-4 weeks all subjects competed in two official duathlon competitions and the time to complete the races were recorded by the organizers to the nearest second. Furthermore all athletes competed in two official sprint duathlon competitions: ALH and RIN, both 5km run, 20-km bike, 2.500- run.

Statistical analysis

Data is expressed as mean ± SD. Pearson product-moment correlation coefficients were performed to establish relationships between variables. A stepwise multiple regression analysis was used to analyze the relationships between time race as dependent variable and laboratory physiological variables as independent variables. Statistical analysis was performed using MedCalc software version 11.5 (Mariakerke, Belgium) and a significance level was set at $p<0.05$.

Results

The descriptive characteristics of the subjects under investigation are shown in Table 1.

Table 1.- Descriptive characteristics

		Mean	SD
Age	(years)	24.8	6.80
Height	(cm)	174.4	6.80
Body mass	(kg)	67.12	8.10
Body fat	(%)	8.59	1.45
Skeletal muscle mass	(%)	50.53	2.27
Bike Training / Week	(km)	191.87	44.96
Run Training / Week	(km)	36.87	15.04

Table 2 displays the physiological variables obtained in laboratory assessment

Table 2.- Physiological variables of laboratory assessment

			Mean	SD	Min	Max
Treadmill						
	HR VT2	(bpm)	161.62	12.79	140	176
	HR VT2/MHR	(%)	88.00	4.90	80	95
	VO2 VT2	(ml kg min-1)	45.65	4.27	41.90	53.90
	VO2 VT2/VO2Max	(%)	78.37	5.07	73	89
	VO2Max	(ml kg min-1)	58.70	5.77	48.50	67.10
	Load VT2	(km/h)	15.90	10.70	14.80	18.10
	Load Max	(km/h)	19.72	0.41	19.00	20.20
Bike						
	HR VT2	(bpm)	159.62	12.82	147	184
	HR VT2/MHR	(%)	82.37	9.52	70	95
	VO2 VT2	(ml kg min-1)	49.77	8.39	42.60	63.80
	VO2 VT2/VO2Max	(%)	78.37	5.07	73	89
	VO2Max	(ml kg min-1)	60.61	6.92	48.3	70
	Load VT2	(watts)	266.25	29.73	210	300
	Load Max	(watts)	363.75	37.40	330	420

HR VT2: Heart rate at Ventilatory threshold 2, HR VT2/MHR: Percentage of heart rate at Ventilatory threshold 2, VO2 VT2 : VO2 at Ventilatory threshold 2, VO2 Max : Maximal oxygen uptake, Load VT2: W in bike and km/h in treadmill at Ventilatory threshold 2, Load Max: W in bike and km/h in treadmill at VO2Max

Correlations

No correlation were found between percent fat and skeletal muscle mass with VO2 max and VO2 in VT2 in bike than in treadmill ($p<0.05$). Non significant correlation coefficient was found between predicted time and time race in ALH duatlon ($R^2=0.013$, $p>0.05$). A great relationships was found in RIN duatlon between predicted time and time race ($R^2=0.995$, $p<0.001$). (Figure 1)

Figure 1.- Relationship between actual al predicted time race

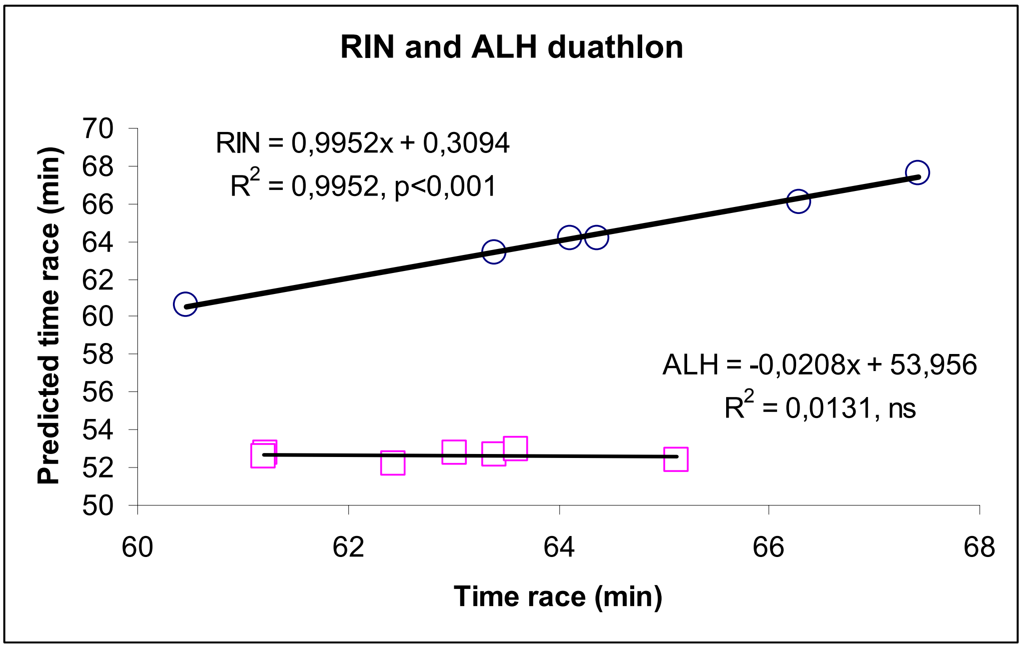


Table 3.- Correlation coefficients between time race and physiological variables

Events	Correlation with time race	R^2	r	*p*<
ALH				
	HR VT2 TR	0.56	0.75	0.001
	Watts VO2Max	0.63	0.79	0.001
RIN				
	HR VT2 TR	0.56	0.75	0.01
	HR VT2 Bike	0.74	0.86	0.001
	HRM/HR VT2 TR	0.49	0.71	0.01
	HRM/HR VT2 BK	0.47	0.67	0.01
	Watts VO2Max	0.58	0.86	0.001
	Watts BK VT2	0.83	0.91	0.001

HR VT2 TR: Heart rate at Ventilatory threshold 2 in treadmill, HR VT2 BK: Heart rate at Ventilatory threshold 2 in bike, HRM/HR VT2 TR: Percentage of heart rate at Ventilatory threshold 2 in treadmill, HRM/HR VT2 BK: Percentage of heart rate at Ventilatory threshold 2 in BikeWattsVT2: W in bike at Ventilatory threshold 2, Watts VO2 Max: Watts in VO2 max in bike

Multiple regression analysis

ALH: The only parameters correlated with the duathlon time were the watts achieved in VO2 max (r = 0.79, *p* <0.01) and the heart rate at VT2 in treadmill (r = 0.75, *p* <0.01).

RIN: WCEVT2 (r = 0.91, *p* <0.001) HRVT2BK (r = 0.86, p < 0.02) and HRVT2TR (r = 0.75, *p* <0.01) were correlated with time race.

Stepwise multiple regression analysis revealed a moderate significant relationship between race time (performance) in ALH competition and very high relationships with RIN competition, using the following equations:

Duath ALH Time (min) = *$WCEVO_2max$* (0.03451) + 50,5729 (R^2 = 0.65, EES: 0.92, p=0.03)

Duath RIN Time (min) = *WCEVT2* (0.02671) + *HRVT2TR* (0.1786) + 28.1779 (R^2 = 0.9952, EES: 0.21, p<0.001)

Discussion and Conclusions

Every competition is different. Our data indicate that exercise laboratory tests aimed to determine VO_2max in running and cycling test to allow for a precise estimation of duathlon performance. Van Schuylenbergh et al found high correlations between VO_2 peak during cycling and running and relevant importance of maximal lactate steady state in running.

The best predictors of performance in Olympic triathlons are in relation of peak power output and peak oxygen uptake (VO2peak) during an incremental cycle and a maximal treadmill running test to assess peak running velocity and VO2peak and maximal speed (Schabort et el, 2000). The same importance is related to blood lactate levels in a high load as 4 w/kg body weight in bike and a blood lactate at 15 km/h in running. Sleivert et al (1993) found significant correlations with relative swim VO2max and velocity at run in ventilatory threshold.

More research is needed to clarify new relationships as load training (years as active runner, average training: volume in hours and kilometres per week, average running speed in training). Our results reveal that physiological testing variables Wmax, WVT2 in bike and HRVT2in treadmill seems useful variables in assessing physiological and related to performance in sprint duathlon.

The high coefficient of determination (R^2) value of RIN duathlon indicated that physiological laboratory measures could account for 99.5% of the variance in race time in RIN duathlon

Keywords: Duathlon sprint; Race results; Laboratory testing variables

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EFFICIENCY OF RESOURCES ON TRIATHLON PROMOTION ACCORDING TO PREVIOUS TRIATHLETE'S EXPERIENCES

Pilar Vílchez Conesa[1], Teresa Nimes Pérez[2]

[1]*Sports Sciences, SHEN and Physiotherapy. Sports Department in University of Murcia*

[2]*Sports Sciences. Federation of Triathlon of Murcia*

Corresponding author: Ms. Pilar Vílchez Conesa

7 Fragata Street. 30720. Santiago de la Ribera (Murcia, Spain)

mp.vilchezconesa@um.es

Phone number: 670992172; Fax: 968335532

Abstract: Triathlon is an emerging sport more and more every year. The objective of this study was to analyse previous experiences of current triathletes in order to render profitable resources of Federations to promotion this sport. Sample consisted about 153 triathletes from every Regions of Spain. Most of current triathletes were popular runners previously. Majority of current resources are assigned to young triathletes and children but popular races are potentially events to promote healthy and popular triathlons. It was important as well to know motives that took triathletes to begin. This study makes clear those interesting topics.

Key words: triathlon, promotion, Young, resources, baggage.

Resumen: El triatlón es un deporte emergente cada año más. El objetivo del presente estudio fue analizar las experiencias previas de los actuales triatletas para rentabilizar los recursos de las Federaciones para promover este deporte. La muestra consistió en 153 triatletas de todas las Comunidades Autónomas de España. La mayoría de los actuales triatletas fueron corredores populares previamente. La mayoría de los recursos actualmente son asignados a los triatletas jóvenes y los escolares pero las carreras populares son pruebas potenciales para promover el triatlón popular y saludable. Resultó también interesante conocer los motivos que llevaron a los actuales triatletas a practicar este deporte. El presente estudio clarifica todas estas cuestiones.

Palabras clave: triatlón, promoción, jóvenes, recursos, bagaje.

Introduction:

The practice of physical activity of Young people is a worse worry each time more and more due to problems in actual society. According to OMS (2003) obesity is considered an epidemic of XXI century and is due to habits of lifestyle during infant and/or adulthood. One of the objectives of contemporary society is involve children in sports (Seifert, 2008). Each sport modality and their management people have responsibility of promotion their sport, instilling young people an active lifestyle and transferring sports values. From triathlon, thanks to his funny characteristic, aerobic and healthy, it should give to know his advantages and satisfactions, giving children motivation that takes competition and/or sport variety.

Considering previous programmers, statutes, budgets and statistics, as International Triathlon Federation than National Spanish Federation, and concreting Murcia Federation, will be make many guidelines to check resources and efforts of Federations, with present study's results. For example, about national field are made many projects from most important organizations (see Table 1). From year 2009, programmer called PROADES under the slogan *"funny triathlon"* devoted to scholar triathlon. Until now, this programmer depends on *Consejo Superior de Deportes* (CSD) and *Spanish Triathlon Federation* (Fetri) but nowadays is responsibility from CSD and *Dirección General de Deportes* (DGD) *of Murcia*, although it is managed and developed from *Murcia Triathlon Federation* (FTRM). As CSD as Fetri and DGD organize national championship and, the last one, collaborating with his regional delegation.

Tabla 1. Comparación de proyectos y órganos responsables en España entre años anteriores y la presente temporada.

ÓRGANO RESPONSABLE	AÑOS ANTERIORES	TEMPORADA 2010/2011
CSD (Consejo Superior de Deportes)	PROADES Campeonatos Nacionales	PROADES Campeonatos Nacionales
DGD (Dirección General de Deportes)	Módulos Deportivos Campeonato Regional y Nacional	PROADES Campeonato Regional y Nacional
FETRI (Federación Española de Triatlón)	Tecnificación Nacional PROADES	Tecnificación Nacional
FTRM (Federación de Triatlón de la Región de Murcia)	PROADES Charlas Colegios E Institutos Tecnificación Regional Campeonatos Regionales Creación De Escuelas Deportivas	PROADES Charlas Colegios E Institutos Tecnificación Regional Campeonatos Regionales Creación De Escuelas Deportivas

Furthermore, national proposals, concreting FTRM is developing from five years ago a powerful marketing on scholar sports. For this theme, it has been concrete efforts in foster personal ways (three technical coordinates by a technical coordinator) and economics resources (see Table 2) in marketing and formation. “Technical programmer” is a programmer in order to improve technical level of triathletes among cadets, junior and sub-23 categories, about both genders. For that, it makes concentrations, taking times, effort proof, also preparation and participation in Spanish championships for scholars. The children triathletes selected are according to his times, but any scholar who wishes to be there can participate freely in many activities organized. Furthermore, championships and regional league, support scholars in National championship, and are made many colloquies about triathlon in schools and high schools (43 colloquies during last academic year). In addition, it was made a course called First level of triathlon coach in order to support formation in base sport. Nowadays, there are six young clubs of triathlon among general clubs in Murcia.

Tabla 2. Partida presupuestaria destinada a los escolares y resultados de los últimos cinco años de la FTRM.

	2007	2008	2009	2010	2011 (previsión)
Menores y promoción			4983,26	7244,27	8500
Tecnificación			8846,59	8857,80	14.500
Concentraciones			1326,40	408,00	1200
Curso de entrenadores			1500,69	460,00	
Número de actuaciones (Categorías de benjamín a junior)			635	878	135
Resultados		Subcampeones de España cadete masculino			Subcampeones de España cadete masculino

This topics makes interesting to consider most resources assigned to promotion of triathlon in young people, considering all efforts and financial to these modalities where more triathletes are performed. For this reason, the objective is to know previous experiences of triathletes, to check how they started and interested about triathlon and what take they to his practice.

Materials and methodology:

This is a descriptive, transversal and retrospective study with questionnaires self-administered. Participants that took part of the study were most triathletes of Region of Murcia and from every parts of Spain, getting a national sample. A total of 152 triathletes compound sample, where only 15 were female. Percentage representative of each Region is shown in Figure 1.

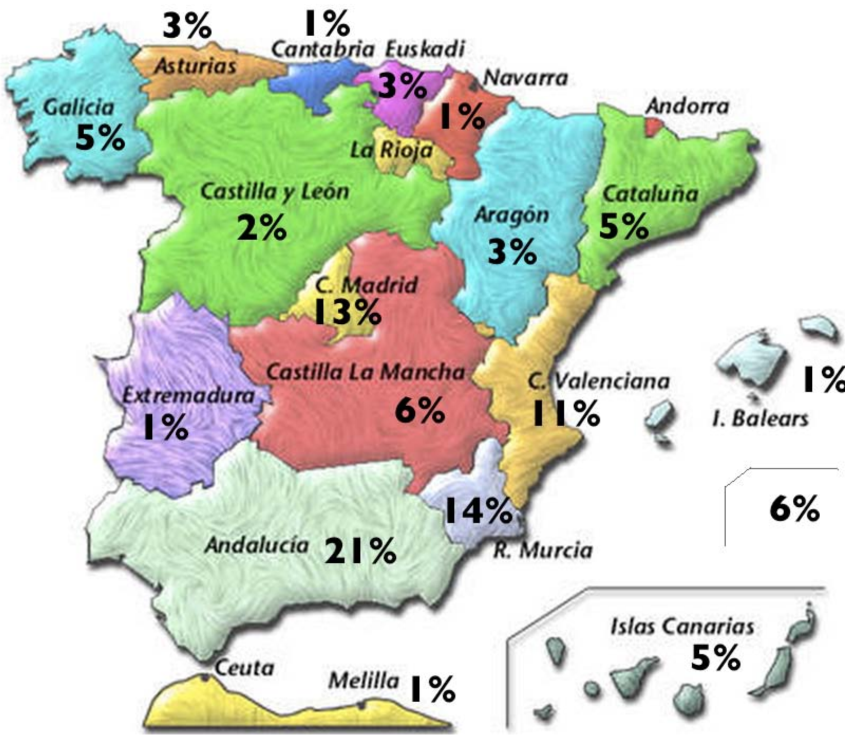

Figure 1. Graphic shows percentage sample from national sample.

There were any socio-demographic variables of the sample due to poor relevancy in results of study. It exits three independent variables: previous experiences in athletics, swimming or cyclist; furthermore, dependent variables were motives that each participant proposed according their initiation in triathlon.

Four triathletes took part of a pilot study to make sure that every participant would understand procedure. When instrument was perfectly made, distribution was completed on four stages:

1. Instrument was sent to triathletes from Murcia with an e-mail address known.
2. It was requested collaboration to Spanish Federation to distribution it to triathletes affiliated to them through "bulletin of triathlon".
3. Same post was sent to clubs and organizations of many events with website available.
4. Some instruments were received without blanks filled up and they were contact again to try on again due to their interest shown.

Participants were filling up instruments during three months.

The questionnaire was made exclusively for this study. It was titled "*Cuestionario de Experiencias Previas de los Triatletas*". This questionnaire was made only compounding one page with four questions: three of them were chosen answers and one was open answer. On summary questionnaire, it was explained objective and guaranteed anonymities. This instrument of the study was only made in digital version, and a database with results was made. Database were analysed with statistical program called SPSS v. 19.0 for Mac.

Results:

First, it is shown percentage of participants that in general had practiced before running (competitive or popular), as well swimming and/or cycling. Modality most practiced was running with 60.3% of total participants, followed by cycling with 47.5%, and finally, by swimming with 41.91%.

However, swimming was modality most unfamiliar for triathletes before triathlon practice, according to 35.94% who never have swim before, 29.41% who didn't know cycling and only 15% percentage haven't run regularly before.

About each modality, triathletes that regularly have practiced each modality competing or like a member of a club were only 28.04%, against a 71.96% who have run before regular and popularly (for their own). About swimming, 66.6% has practiced for their own against 33.3% who have been member or a swimming club or have competed many times. Finally, biggest differences were in bike where only 15.62% have competed or been in a cyclist club against a significant 84.37% that practiced biking for their own regularly.

In order to know which motives takes triathletes to begin to practice this sport, an open answer where defined. Motive most commented by triathletes were "*through a triathlete friend*", "*to change sport*" and/or "*for my own initiative*". There were also frequently motives like "*through someone from my* *family*", "*my partner*", "*due to a sport injury*" or "*through my previous club or coach*". It is interesting to show that "*through media communication*" was only once written.

Discussion:

More than half of participants have practiced before running or track and fields regularly before beginning on triathlon. However, less than half of participants have swim and/or biking before regularly. According data, it could make think that resources to promotion of triathlon given to running area could be more efficient than others modalities. In other hand, it could be possible to think that swimming is modality less efficient to promote triathlon because it was the most unfamiliar to triathletes, but it has to take in mind that swimming is forgotten on promotions, so maybe it is not less efficient than others, maybe there is not enough experience in swimming promotion to determinate which efficacy it could have. Even it could remember that a lot of really Spanish high-level triathletes were swimmers before.

It could be interesting to know in which modality should make promotions and which meet more users interested to practice triathlon. Running only make 28.04% of triathletes, against 71.96% that runs regularly and for their own. According to that, resources could be more effectives if they are designated to popular races, popular runners and gardens or popular tracks in instead of athletic clubs. Swimming only makes 33.3% of triathletes who change their sport to practice triathlon, so users who swim for their own maybe are more interesting to practice triathlon. Cycling only makes 15.62% of triathletes who are interesting on triathlon afterwards, but there are many popular cyclists who finish being triathletes.

It was interested to known why triathletes began to practice triathlon. In this way, friends, change of sport and own initiative were potential efficient motives of triathletes. However, mass media does not capture attention or interest about triathlon that they should. Maybe it is necessary to reflect about quality of information about triathlon to make it more efficient. For example, promotion campaigns should show advantages of variability and a lower risk of injury due to this variability. Media also should give information about triathlon in a more participative, funny and easy to access way to practice triathlon.

Conclusions:

Popular races, popular runner and running lovers would be possible triathletes who are increasingly enjoyed triathlon because most triathletes had run before. However, less than a half had swim or cycled regularly. It could mean two possibilities, few cyclers or swimmers would interest for triathlon or very few campaigns or resources goes to them.

In other hand, if compares results with popular sport without competitions, many popular cyclers ending practice triathlon. For this reason, popular runners are majority to practice triathlon later.

Motives most important to begin practicing triathlon are friends, change of sports (variability) and own initiative. For example, it could be very interesting to organize promotion events with relay races of three components or global classification by groups. However, media (maybe by quality or quantity of information about triathlon) should motivate more to people. Degree in Sports Sciences or National Coach of Triathlon, Federation management or other organisms would be responsible to make publicity or campaigns, more specific, better quality, explanatory or for guidance in spite of give only elite information about triathlon.

Finally, most of resources of FTRM are assigned to young triathletes (young people that already is enhancing on performance), almost half of budget is assigned to children and a little sum of money goes to get-together or training courses to coaches. It would be interesting to know if it is needed more coaches with children who train children from different clubs, in addition, it is important have in mind results of this study in order to assigned each budget to areas more needed and potentially sensitive to practice triathlon, making the most of the area's resources, achieving an optimal relation between supply and demand. For this reasons, it is really important to know profile of current triathletes to consider necessities and interest of them.

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Analysis of pacing strategy during duathlon and triathlon competitions in youth athletes

Comotto Stefania[1] (MS), Capranica Laura[1] (Full Professor), Piacentini Maria Francesca[1] (Associate Professor, Ph.D.)

[1]Department of Human Movement and Sport Science, University of Rome "Foro Italico", Rome, Italy

Corresponding author:

Prof. Maria Francesca Piacentini

Department of Human Movement and Sport Sciences

University of Rome "Foro Italico"

P.za L. De Bosis, 15

Rome, Italy

Phone +39 0636733245

Fax +39 0636733330

Email: mariafrancesca.piacentini@uniroma4.it

ABSTRACT

The aim of the present study was to investigate the swimming, cycling and running velocities during triathlon and duathlon competitions. Four Youth athletes (2 Male and 2 Female, mean age 16±1 yrs) participating in both duathlon and triathlon Italian championships took part in the present study. A wearable 15hrz GPS (SPY Pro, GPSSport, Canberra, Australia) was used to record individual velocities and distance covered. To evaluate pacing strategy, 25m, 100m, and 500m mean distance was considered for swimming, running and cycling, respectively.

Pacing strategy resulted positive for running phase in duathlon (-28%) and for swimming phase in triathlon (-21%). For both races, athletes adopted a negative pacing strategy for cycling phase (duathlon: +20%; triathlon: +12%). Finally, the last phase of both competitions seemed to have a different pacing strategy. In particular, in duathlon athletes adopted an even strategy, whereas in triathlon their velocity showed a 24% decrement.

Young athletes, as already seen for elite, start at a faster pace during both competitions and thereafter velocity decreases highlighting a positive strategy. Indeed, in the first phase of both competitions athletes start as quickly as possible, in order to have an advantage during the subsequent phases, independently of swimming or running. In fact, the importance of performing well the first transition and starting cycling with the first pack seems important also at this younger age and with the shorter distances as confirmed by the final ranking positions in both races.

KEYWORDS: competition, pacing strategy, youth athletes

INTRODUCTION

An individual's pacing strategy is defined as the distribution of work or energy expenditure that occurs throughout an exercise task (Abbiss & Laursen, 2008). It is well documented that during athletic competitions, well trained athletes must regulate their rate of work output in order to optimize overall performance (Foster et al., 2005; Abbiss & Laursen, 2008). The literature on pacing strategy in triathlon, that involves a sequence of swimming, cycling and running phase, have focused on analysis of World Cup races (Vleck et al., 2006, Vleck et al., 2008, Le Meur et al., 2009) and on laboratory tests (Hausswirth et al., 2010). A recent study conducted by Le Meur et al., (2009) demonstrated that during swimming triathletes adopted a positive pacing strategy, meaning a decrease in swimming velocity after peak velocity was reached. Moreover, Vleck et al., (2006) affirm that the ranking position at the end of the swimming phase seems to reflect the final ranking position. During the cycling phase elite triathletes decrease significantly cycling speeds between the initial and the final part (Le Meur et al., 2009). Finally, the analysis of the running phase in World Cup races show that triathletes tend to adopt a positive pacing (Vleck et al. 2006, Vleck et al. 2008, Le Meur et al. 2009). Races of younger age categories are much shorter, however, no study until now has analyzed their pacing strategy. Therefore, the aim of this study was to quantify the velocity during swimming, cycling and running phase, and analyze the pacing strategies adopted by athletes during duathlon (running, cycling and running) and triathlon competitions. In particular the hypotheses of this study were to find higher cycling velocities in triathlon compared to duathlon and to find a similar pacing strategy as elite athletes.

MATERIALS AND METHODOLOGY

Participants

Four Youth athletes (2 Male and 2 Female, mean age 16±1 yrs) regularly training (2h and 30min for 4 days a week) and participating in both duathlon and triathlon Italian championships were recruited for the present study. The official distances of duathlon and triathlon competitions are shown in table 1.

Procedure

Every athletes wore a 15hrz wearable Global Positioning System (GPS, SPY Pro, GPSsport, Canberra, Australia) during both competitions. Distance covered and velocity in each phase was continuously recorded. The mean velocity was calculated every 50m (ms^{-1}) of the swimming phase, every 1000m (kmh^{-1}) during cycling, and every 200m (ms^{-1}) of the running phase. Moreover, the official timing system (Chip System) was used to evaluate the ranking of all participants in both races after each phase. Timing mats were situated at the start and at the end of both races, and at the beginning of each transition phase.

Data analysis

ANOVA for repeated measures ($P<0.05$) was used to evaluate the pacing strategy in each phase. A student paired T-test ($P<0.05$) was used to verify differences between cycling phases of duathlon and triathlon. A Pearson's correlation ($P<0.05$) was used to determine the relationship between overall race position and isolated positions associated with the performance achieved during swimming, cycling and running phases.

RESULTS

During the triathlon's swimming phase athletes showed a higher velocity ($P<0.005$) during the first 50m ($1.5\pm0.1ms^{-1}$) and thereafter decreased by 21% during the last 50m ($1.2\pm0.2ms^{-1}$), adopting a positive pacing strategy. During the first duathlon running phase the highest velocity was recorded after 200m ($5.7\pm0.6ms^{-1}$) ($P<0.0001$). In particular, during this phase, athletes adopted a positive pacing strategy with a 28% velocity decrease ($P<0.0001$) during the last 200m ($4.4\pm0.4ms^{-1}$).

In triathlon and duathlon cycling phase athletes adopted a negative pacing strategy with a 12% and 20% velocity increase respectively ($P<0.0001$). Moreover, in both races the slowest velocity ($P<0.0005$) was recorded during the first 1000m ($29.4\pm3.8kmh^{-1}$ in triathlon and $27.4\pm3.4kmh^{-1}$ in duathlon). Peak velocity ($P<0.001$) was reached at 5000m ($35.3\pm3.3kmh^{-1}$ in triathlon and $34.2\pm2.8kmh^{-1}$ in duathlon) in both races compared to other cycling sections. Comparing the two cycling phases, the first kilometres during triathlon ($33.0\pm2.6kmh^{-1}$ and $32.9\pm3.8kmh^{-1}$ in 2000m and 4000m, respectively) were faster ($P<0.02$) compared to duathlon ($29.8\pm2.1kmh^{-1}$ and $27.3\pm2.5kmh^{-1}$ in 2000m and 4000m, respectively).

During the last phase in triathlon no differences emerged for the first 800m, and the highest velocity was recorded at 600m ($4.5\pm0.9ms^{-1}$). After this point the velocity decreased by 24% until the end of the race ($P<0.001$), highlighting a variable pacing. During duathlon, athletes adopted an even strategy, with no differences in velocity between the first and the last section.

Finally, a positive correlation ($P<0.01$) was found between overall race position and isolated positions after each phase. The data are represented in table 2.

DISCUSSION AND CONCLUSIONS

To our knowledge, this is the first study to evaluate the pacing strategy during triathlon and duathlon competitions in young athletes. Literature on pacing strategy in triathlon has focused in term of tactics on elite athletes and none has been done on duathlon. Le Meur et al. (2009) has observed that triathletes start fast and pace decreases during the competition. Our study confirms that this strategy is adopted also by younger athletes, despite the shorter racing distance. In particular, pacing during the first phase for triathlon is similar to that adopted by elite athletes. This is necessary because athletes need to reach the first places of the pack, and to avoid congestion at the first turn-around buoy. In fact, it has been shown that weaker swimmers in the rear part of the group are disadvantaged (Vleck et al. 2006). Moreover, the same situation is evident for the first phase of duathlon, where athletes start as quickly as possible, in order to have an advantage during the subsequent phases. The second phase for both races seems to have a different pacing strategy from elite athletes. In fact, young athletes adopted a negative pacing strategy, whereas during cycling phase elite triathletes decrease significantly speed between the initial and the final part (Le Meur et al., 2009). This aspect can be explained by the shorter distance of the present event, only 8km compared to 40km in elite competitions. Despite the literature suggests to adopt a constant pace for long duration events (Abbiss & Laursen 2008), Vleck et al., (2006; 2008) show that most athletes, during the third phase, run faster over the first kilometres compared to other running sections, selecting a positive pacing strategy. Also young athletes adopt a similar pacing strategy during triathlon, whereas for duathlon the pace is even, probably due to the different distance covered by the athletes during this phase. Finally, as confirmed by Vleck et al. (2006) the position at the end of swimming in triathlon seems to reflect the position at the end of the race. In fact, the importance of performing well the first transition and starting cycling with the first pack seems important also at this younger age category as confirmed by the correlation between the final ranking positions and the position at the end of the first phase in both races.

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Talent assessment in a short triathlon in the czech republic (case study)

Mgr. Kovářová Lenka, MBA; PhDr. Kovář Karel, Ph.D.; Prof. Ing. Václav Bunc, CSc.; PaedDr. Horčic Josef, Ph.D.

Faculty of Physical Education and Sports, Charles University, Prague, Czech Republic

Mgr. Kovářová Lenka, MBA, lkovarova@ftvs.cuni.cz, José Martiho 31, Praha 6, 161 00, Czech Republic, +420608827981

Summary

The article presents an overview of diagnostic methods for identification of dispositions in short triathlon used in Czech Republic.

It shows the current test battery and presents the case study, whereby it introduces the system of data evaluation and possibilities of their interpretation.

For the evaluation, the standards (T-points) for individual tests are used, which illustrate intra- and interindividual differences with respect to a given model – the norm. We concluded that a below-average result reached in one of the tested areas cannot be compensated by any above-average result in another area.

The most important issue for the assessment of future performance in triathlon is to find the lower limit of 45 T-points, rather than achieving the highest level in some of the tests. For the selection of talented athletes at the age of 18 – 19 years, it is desirable to seek an individual, who has achieved outstanding results in tests that can be considered to be less affected by training (ECM/BCM, VO_{2max}, mobility and concentration of attention); however, another necessary precondition is also the high level of swimming tests with regard to age of athletes.

It is rather essential to distinguish between highly trained individuals who already have the minimal capacity for improvement and may not be perspective in the categories K 23 and adults (the peak of their careers is the junior age).

Keywords: diagnostics, prediction, performance

Introduction:

Long-term performance prediction and talent assessment in triathlon are based on the demands and determinants of performance and its structure we were confirmed by SEM. The test battery for talent assessment is the result of longitudinal study of n=55 young athletes from 1998-2009 (Kovářová 2010; Kovářová, Kovář 2010; Zemanová 2009; Zemanová 2008). In our study we found by SEM that the dispositions for a triathlon were grouped into five separate groups:1. swimming, 2.cycling, 3. running (that is, by individual disciplines), 4. physiological and 5. psychological dispositions. The ultimate factor to the talent assessment were the physiological dispositions (1.00, 0), a very significant importance presented running dispositions (-0.85, 0.28), followed by swimming dispositions (-0.61, 0.63) and cycling dispositions (0.53, 0.72). The lowest importance for talent assessment presented psychological dispositions (0.36, 0.87).

Materials and methodology:

The structure model of talent was composed of thirteen indicators which we can measure by special test battery: Body composition consists of two tests -1. % body fat; 2. the ratio of ECM / BCM test (test measure "the quality" of muscle mass and strength abilities); 3. test of flexibility abilities (flexibility of the shoulder, ankle and hip joints); physiological parameters 4. the maximum aerobic power (VO_{2max}) and 5. % of aerobic power on anaerobic threshold (AT % of VO_{2max}); two swimming tests (6. 400 freestyle and 7. the speed of AT in the field of 100m; two-cycle tests (8.the maximum power and 9. power on AT; three running tests (10. running at 3 km, 11. speed of AT on the 1 km and 12. maximum speed achieved on the treadmill all out test and psychological test - 13. concentration of attention (as a result of five different diagnostic – Bourdon's test, Disjunk's numeric test, Jirasek's rectangle before and after performance).

In all tests we used standards in the form of T-points that illustrate intra- and interindividual differences more precisely (Kovářová 2010). We used transformation of standard quantity (McCall's criteria) where the assessment criterium, was derivate from the mean result of the whole group (n=55), matches with 50 T-points and the zone of one standard deviation matches with 10 T-points. The standard zone is therefore defined by the range of 45 – 55 T-points; the value of 70 T-points represents excellent level, while the value of 30 T-points means insufficient. Every result, in particular tests, is always independently assigned to the zone of T-points. When we set the standards, it was also necessary to determine the lower limit of acceptability, i.e. the value of T-point which is already considered as insufficient with respect to the future performance. In our case, we have defined the lower limit of acceptability of results in individual tests at the level of 45 T-points, in other words the lower limit of the norm.

Results:

Individual triathletes' test results in (Table 1) are demonstrated in radar chart (Graph 1). The ray axis is in the interval 30 – 70 and represents the test results transformed to the T-points; results of individual tests are shown on the axes 1 – 13. Based on these tests, we may assess a talent and we may reveal the strengths and weaknesses.

Figure 1: Individual triathletes' test results N1 recorded by means of T-points in the radar chart

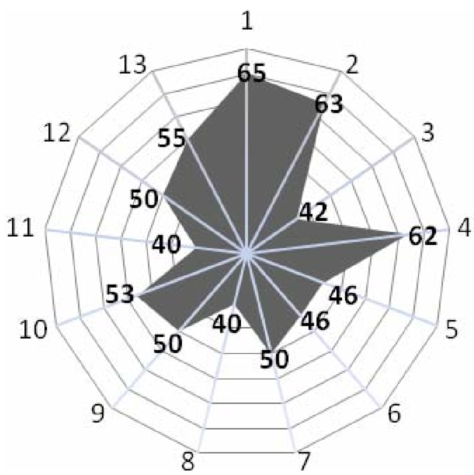

Table 1: Achieved results of a triathlete N1 (junior category) in individual tests transforme points T-points

	Athlete	N1	
number of test	Indicator	performance	T-points
1	ECM/BCM	0,73	65
2	% fat	8,70%	63
3	Flexibility	41,9 p.	**42**
4	Psychological dispositions	62 T p.	62
5	VO_{2max}	68,3	46
6	$\%VO_{2max}$	82,9	46
7	AT swimming	01:18,1	50
8	400 m swimming	4:47	**40**
9	Max speed on the treadmill	18 km (40 sec)	50
10	AT running	3:46	53
11	3 km running	10:05	**40**
12	W_{max}	5,87	50
13	W_{AT}	4,93	55
	Total		667

Notes: Highlighted values are located below the lower limit of standard (45 T- points)

Case study (explanation): We were monitoring sports career N1 from 15 – 25 ages. The athlete did not reach elite performance neither in the junior category, nor in the K23 category. In top level races he had an indelible loss in the swimming part. In subsequent part of the race, he appeared as an excellent cyclist and in races of lower level he was able to erase the loss from the swimming part; his running performance was just average and usually it did not move him forward in the ranking. He is still a regular participant of the Czech Republic Cup, who is regularly placed between the tenth and twentieth rank. For the further progress of his sports career, the transition to longer distance triathlon can be recommended, where the loss after the swimming part is not decisive and a greater proportion on the total result is in the cycling part, or to concentrate on the races, where drafting, (cycling directly behind or alongside another competitor) is not allowed. Performance improvement in the short triathlon can no longer be assumed.

Discussion/Conclusion:

More important issue for the talent assessment is to find the lower limit, rather than achieving the highest level in some of the tests. As the lower limit for the evaluation of dispositions for the future performance in triathlon we established the zone of 45 T-points. Less important parameter for talent assessment is the overall result – the sum of T-points. We can conclude that the lower level in some of the tests cannot be replaced (compensated) by any outstanding performance in another test.

We concluded that the limiting factor for the triathlon performance appears to be the low values in the assessment of swimming dispositions in this age category.

In triathlon we can see a kind of „accumulation” of individual disciplines into the final ranking (performance). If the athlete makes „an error“ in the initial part of triathlon, or his performance in these disciplines is not on the level of the rest of the competitors, this handicap is “transferred” to the next part of the race.

On the other hand, good muscle dispositions (ECM/BCM) predict improved performance in cycling dispositions. In this case, exceeding of the lower limit of the norm in cycling tests does not have to be the limiting factor for the future performance in short triathlon.

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Lost Time in T2 can decide the final result in Men's Elite Olympic Triathlon Competition?

Roberto Cejuela [+]**, Antonio Cala**[2]**, José A. Pérez-Turpin , José G. Villa**[3]

Juan M. Cortell , Juan J. Chinchilla

Departmental Section of Physical Education and Sports, University of Alicante (Spain)

New Zealand Academy of Sport North Island, New Zealand

[3] Department of Physical Education and Sports, University of León (Spain)

[+]**Address for correspondence:**

Roberto CejuelaAnta,

Departmental Section of Physical Education and Sports, University of Alicante (Spain)

Facultad de Educación. Campus de San Vicente del Raspeig.

03540. San Vicente del Raspeig (Alicante). Spain

Tel : +34.965903721 Fax : +34.965903721. Email : roberto.cejuela@ua.es

Abstract

The Olympic-distance Triathlon is a combined endurance sport. It includes back-to-back swimming, cycling, running and the transition between events (T1 & T2). The aim of the current study was to analyse the possible relationship between the Lost Time T1 & T2 and the overall performance. The results showed that the percentages of total time corresponding to each part of the race were: 16.2% for swimming, 0.74% for the swimming-cycling transition (T1), 53.07% for cycling, 0.47% for the cycling-running transition (T2) and 29.5% for running. The correlations between each part of the race and the final classification were: r=0.36 for swimming, r=0.25 for T1, r=0.62 for the cycling, r=0.33 for T2, and r=0.83 for the running. Also, values of r=0.34 &

r=0.43 were obtained for Lost Time T1 and Lost Time T2, respectively. In conclusion, losing less time during T2 has been demonstrated to be related to obtaining a better final result.

KEY WORDS: SWIM, BIKE, RUN, TRANSITION.

Introduction

The Olympic-distance Triathlon is a combined endurance sport. It includes back-to-back swimming, cycling, running and the transition between events (T1 & T2). The transitions are the time the tri-athlete takes for the changeover from swimming to cycling (T1) and from cycling to running (T2).

Triathlon was first conceived as a sport over thirty years ago. It has been officially recognised by the International Olympic Committee and included as an Olympic sport since the Sydney 2000 Games. It was a resounding success, with numerous countries taking part in the inaugural event.

The distance of each phase (swimming, cycling and running) depends on the level of competition. However, the most common race is the Olympic Distance (1.5-km swim, 40-km bike, and 10-km run). In order to study performance in triathlon, we have taken into account that one of the most difficult (strategically and physically) parts of the triathlon is the transition from cycling to running (Cala et al., 2009).

Transitions are a very important part of the race and several studies have assessed their durations (Sleivert et al., 1996; Hue et al., 1998). These authors reported times as short as 8 seconds per phase for elite tri-athletes at national and/or international levels. This can happen when considering the transition phase as only the actions carried out within the box. The first transition period T1 (swimming-to-cycling) includes different actions as removing the neoprene suit, taking the swim cap and goggles off, putting the cycle helmet on and getting on the bike. The second transition period T2 (cycling-to-running) includes parking the bike, removing the helmet and putting the running shoes on.

Speed and precision in the execution of the transitions is a major factor affecting performance in triathlon. The shorter the competition distance is, the more important the transitions are. The percentage of the total race time corresponding to T1 & T2 has been previously reported in Sprint-distance competition (750-m swim, 20-km bike and 5-km run) by Cejuela et al. (2007), showing values of 0.8-1.5%. Most of the studies analyse the transition times (T1 & T2) as total time in seconds or as a percentage of the total race time. But there is a new concept used by the coaches called “the transition lost time”. The “Lost Time” for the swim-cycle and cycle-run transitions corresponds to the time difference between each competitor and the tri-athlete that started the bike/run first. To the best of our knowledge, no study has analysed the possible relationship between the Lost Time T1 and T2 and the overall performance.

Therefore, the aim of the present study is to analyse the possible relationship between the Lost Time T1 & T2 and the overall performance as well as determining the time distribution of each part of the race (swim, T1, bike, T2 & run) during nine top-level Olympic-distance events.

Material & methods

Nine top-level men triathlon competitions held from 2000 to 2008 were studied: 6 World Championships (2000, 2001, 2004, 2006, 2007 and 2008) and 3 Olympic Games (2000, 2004 and 2008). The total number of participants was 537 (n=537), with an average of 59.67±11.08 participants per competition. All the tri-athletes who finished the race were considered for the analysis. We discarded the partial results of competitors who were disqualified or retired. All the participants gave their informed written consent to take part to this study that was conducted according to the Declaration of Helsinki. The Ethics and Research Committee of the Alicante University approved the study.

We gathered the data for all events in collaboration with the International Triathlon Union (ITU). In order to gather the times for all competitions we used the “ChampionChip®” microchip timing system. All athletes wore the chip on their left ankles during the races. When they crossed the reading mats, the partial times for each segment, transition and total competition times were recorded. These mats were placed at the start, entrance/exit to/from the transition area and at the finish line. The data at the 2002, 2003 and 2005 World Championships were not analysed due to the fact that the timing system did not record the time taken to carry out the transitions separately (T1 & T2) but including them into the cycling time.

Determination of lost time in T1 and T2

Lost time in transitions T1 and T2 is the time lag between the first tri-athlete starts cycling or running leaving the transition area, and the rest of the triathletes who arrived at the transition area in the same swimming or cycling pack.

This time depends on two factors. Firstly, the position of the triathlete in the swimming or cycling pack when entering into the transition area. The lower the rank is, the longer is the time lost during transition and vice versa. The higher the rank is, the shorter time is lost. Secondly, the time taken by the triathlete to carry out the specific actions required in the transition area, as changing equipment and crossing the designated area . This time is only valid as a reference for the swimming or cycling pack in which each triathlete reaches the transition area. It cannot be compared with other groups getting into the transition areas at different times.

The time lost in the transitions can be calculated by filming and analysing the videos of each entrance and exit from the transition area (Cejuela et al, 2008) or by mathematical calculations based on partial times.

Lost time in T1 is calculated by the difference (in seconds) between the best partial accumulated time (at the end of T1) and the partial accumulated time of each tri-athlete belonging to the same swimming pack. The criteria used to decide whether two tri-athletes belong to the same pack is when the difference between them at the end of the swimming segment does not exceed 5 seconds.

Lost Time T1=Best partial accumulated time– accumulated time of each triathlete in the same swimming pack

Accumulated time=Time for the swimming segment + time for the swimming-cycling transition (T1)

Lost time in T2 is calculated by the difference (in seconds) between the best partial accumulated time (at the end of T2) and the partial accumulated time of each tri-athlete belonging to the same cycling pack. As in T1, the criteria used to decide whether two tri-athletes belong to the same pack is when the difference between them at the end of the cycling segment does not exceed 5 seconds.

Lost Time T2=Best partial accumulated time – accumulated time of each triathlete in the same cycling pack

Accumulated time=Time for the swimming segment+Time for transition T1+Time for the cycling segment+Time for transition T2

The reason to set five seconds as the bench mark is based on results found in the literature. Hydrodynamic resistance calculations have shown that the ideal distance to draft behind another tri-athlete has not been exactly determined. However, it has been demonstrated thatswimming more than five seconds behind the preceding tri-athlete does not provide any advantage over swimming alone (Chatard et al, 1998;Bentley et al, 2007).

Similar studies in cycling have shown that riding with practically inexistent separations between wheels can lead into 44% reduction in aerodynamic resistance, and up to 27% with a separation of two metres (McCole et al 1990; Lucía et al. 2001;Faria et al, 2005). This is the main reason why five seconds has also been use as the bench mark in the cycling segment to consider whether two tri-athletes belong to the same pack.

Statistical procedure

The descriptive statistical procedure involved the calculations of mean values, typical deviations, frequencies and percentages of the variables analysed. To compare the mean values of the times for each part of the race, a single-factor ANOVA parametric statistical test was used. The level of significance was set at $p<0.05$ (significant) and $p<0.001$ (highly significant).

To establish the relationships between the variables, a bi-variate correlation technique design was utilised, with Pearson's correlation coefficient (r) analysis technique. The level of statistical significance was set at $p<0.05$. To carry out the statistical procedure, we used SPSS statistical programme version 15.0 for Windows and Microsoft Excel 2008.

Results

Table 1 shows the average time spent for each segment, transition and total time for all the competitions analysed. The average total time spent by tri-athletes to finish the races was 1 hour, 52 minutes and 5 seconds. The longest segment was cycling, followed by running and swimming. T1 lasts longer than T2. Cycling was the part of the race with the greatest variability.

Table 2 compares the average times of each part of the race of all the participants with the values of the winners. Significant differences ($p<0.05$) for the total time and very significant differences ($p<0.001$) for the running section, were found.

Table 1. Average time for each segment, transition and total time in all the competitions analysed.

Competition	**Swim**	**SD**	**T1**	**SD**	**Bike**	**SD**	**T2**	**SD**	**Run**	**SD**	**Total Time**	**SD**
Sydney 2000 O.G	17min59s	24s	23s	3s	59min14s	1min27s	19s	2s	33min31s	1min57s	1h51min30s	2min41s
W.C 2000	18min28s	20s	46s	3s	1h1min19s	54s	34s	16s	32min57s	1min30s	1h54min6s	1min57s
W.C 2001	18min36s	32s	54s	3s	58min2s	1min56s	30s	4s	34min13s	1min57s	1h52min16s	3min46s
W.C 2004	18min30s	21s	1min7s	4s	52min19s	1min8s	37s	3s	32min35s	1min50s	1h45min6s	2min37s
Athens 2004 O.G	18min19s	20s	18s	1s	1h3min24s	2min21s	20s	2s	34min18s	1min52s	1h56min20s	3min42s
W.C 2006	17min51s	25s	51s	3s	1h4min13s	2min12s	35s	3s	33min32s	1min38s	1h57min	3min33s
W.C 2007	17min39s	14s	41s	4s	55min38s	1min11s	21s	3s	32min19s	1min36s	1h46min39s	2min22s
W.C 2008	19min1s	13s	46s	4s	59min19s	1min49s	24s	3s	34min13s	1min35s	1h53min43s	2min59s
Beijing 2008 O.G	18min23s	15s	28s	2s	58min52s	21s	30s	2s	33min49s	2min5s	1h52min1s	2min8s
Average Time	18min19s	25s	42s	16s	59min9s	3min41s	28s	7s	33min30s	44s	1h52min5s	4min

Table 2. Comparison of the average times in each part of the race between all the competitors and the winners in all the races analysed. #Highly-significant differences (p<0.001). *Significant differences (p<0.05).

Time	Swim	T1	Bike	T2	Run	Total Time
Average Men	18min19s±25 s	42s±16 s	59min9s±3min41s	19s±7 s	33min30s±44s #	1h52min5s±4min*
Average winners	18min9s±25s	39s±15 s	57min56s±3min2 0s	26s±9 s	31min3s±51s#	1h48min13s±3min44 s*

Table 3 shows the percentage of the total time (%) relative to each segment and transition. Cycling presents the higher value (52.7%), 29.9% corresponds to the running segment, 16.3% to the swim and the transitions only account for 1% of the total duration of the competition.

The percentages of the winners are very similar to the values obtained for the other competitors. Only the running segment showed significant differences (p<0.05) between the groups. Winners showed a lower percentage of time for the running segment than the average of all participants (28.7% versus 29.9%), and a higher percentage for the cycling segment (53.5% versus 52.8%).

In order to see whether the time distribution within the race had any relationship with the overall performance, the correlations between each part of the race (including lost time in T1 & T2) and the final classification were calculated. The results are shown in Figure 1. The running segment presented the higher correlation (0.82 ± 0.05), followed by cycling (0.62 ± 0.26) and Lost Time T2 (0.43 ± 0.14).

Table 3. Percentageof the total time (%) relative to each segment and transition at the competitions analysed for all the competitors and the winners. *Significant difference (p<0.05).

Percentage %	Swim	T1	Bike	T2	Run
Average Men	16.35±0.62	0.62±0.23	52.73±1.47	0.41±10	29.90±0.72*
Average Winners	16.79±0.70	0.60±023	53.50±1.38	0.40±0.13	28.70±0.58*

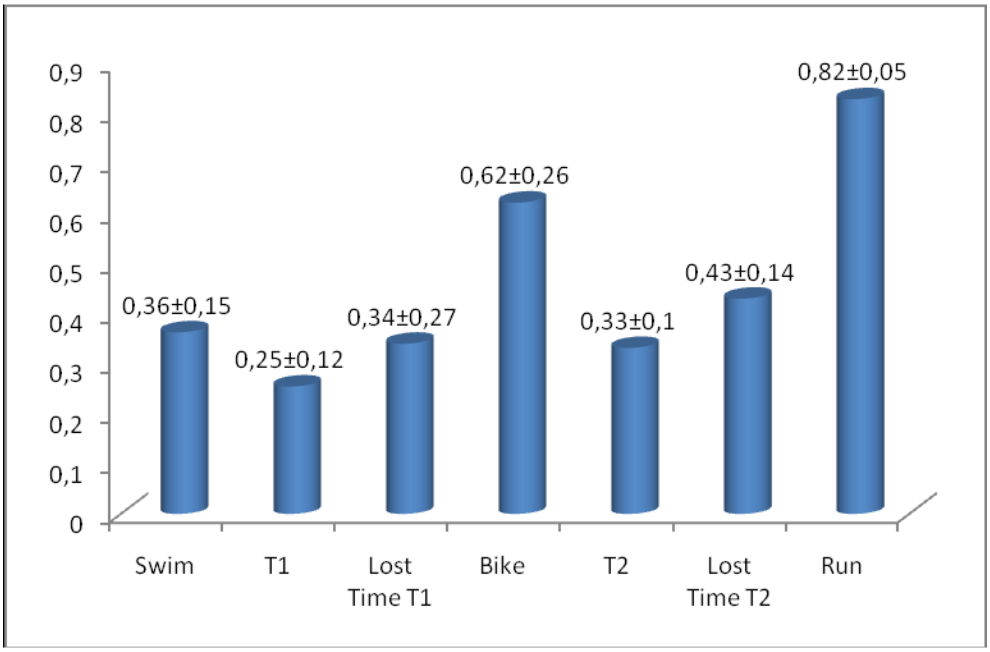

Figure 1. Average correlations obtained (p<0.001) between each segment, transition and lost time T1 & T2 and the final classification.

Discussion

The time lost in T2 showed a correlation of 0.43 with the overall performance of the tri-athletes in competition. This value was even higher than the ones presented by the other two transitions (T1 & T2) and the swimming segment. Losing less time is related to obtaining a better final result. It is a performance factor that should be taken into account when analysing top-level Olympic Triathlon competitions. This new parameter varies from 1 to 15 seconds. It represents a small percentage of a race that last slightly less than 2 hours, but it can make a big difference in the final result as the leading positions are often decided by final sprints with differences of very few seconds. Therefore, this time may be a decisive factor regarding the final classification in a triathlon race.

The time lost in T2 is valid to determine the final performance of tri-athletes arriving at T2 in the same cycling pack. It depends on two factors; firstly, arriving at T2 in the most advanced position possible within the pack, and secondly, carrying out the necessary actions in T2 as quick as possible. Some studies tried to identify the changes in speed at decisive points during the competition using a GPS device for each athlete and several video cameras (Vleck at al., 2007). High correlations were found between the speed and position at the start of the swimming (−0.88 for men, −0.97 for women), cycling (0.81 for men, 0.93 for women) and running segment (−0.94 for men, −0.71 for women). These changes in speed at the beginning and at the end of the segments, together with the transitions, seem to be important factors that may decide the final result. These changes in speed at the start/end of the transitions can be the main reason that could explain the time lost in T1 and T2.

The Olympic Triathlon is a complex sport, not only because three sports are performed back-to-back without stopping the clock, but also because of the speed and precision required during the transitions to pass from one segment to the next (Millet &Vleck, 2000). Transitions are a fundamental part of a triathlon race as they can determine the final results in many competitions. This study takes another step forward in analysing Olympic Triathlon performance as we divided the competition into: swimming segment, transition swimming-cycling (T1), time lost in T1, cycling segment, cycling-running transition (T2), time lost in T2, and running segment.

The swimming segment showed a low correlation (0.36) with the final position at the end of the race. This finding is slightly different to the ones found in other studies. Landers (2002) analysed 10 international ITU competitions and the correlation of the swimming segment with the overall performance was higher (0.49 versus 0.36). This may be due to the increase in the level of the male swimming segment over the last years. It seems the differences in this segment used to be bigger and more decisive in the past than in current competitions nowadays. It is very important to be placed in a good position at the end of the swim part, in order to be able to make the first group in the cycling segment (Millet &Veck, 2000). Drafting is also an important to consider when covering this segment, in order to save as much energy as possible for the rest of the race (Chatard et al, 1998; Millet, et al, 2002). Despite the fact of the low-medium correlation found in the swim, swimming slower does not allow you to compete at the front of the race later on. The level in the swimming segment is very high in the international elite Olympic Triathlon and a very numerous main pack is formed in the lead whose members present a similar swim speed. This means that the tri-athletes who are not part of the front pack will find very difficult trying to win later.

A low correlation (0.25) was found between the first transition (T1) and the overall performance. During the cycling segment it is possible to make up the time lost in T1 by catching up with the pack. This could be the reason that would explain the low value found for this correlation. The profiles of most championship routes do not have difficult mountainous sections (steep hills or mountain passes), except for the 2004 Olympic Games, although they do have certain technical difficulties (sharp bends, narrow sections, etc.). Therefore, drafting may be a beneficial tactic in swimming and cycling to increase elite Olympic triathlon performance (Bentley et al, 2007).

The Lost Time in T1 is different for each swimming pack. We identified two packs in our analysis; 1st and 2nd swimming packs when exiting the water. The mean correlations of the 1st and the 2nd swimming pack with the final position at the end of the race were 0.34 and 0.40, respectively. Again, the reason of these medium-low correlations could be the flat routes presented by the cycling sections, where the tri-athletes can make up the time lost in the transition easier.

During the cycling segment in elite triathlon competitions with flat profiles, one or two (three at the most) packs are formed. Normally, those who are not part of the first pack cannot expect to win. This is shown by the medium-high correlation (0.62) obtained between the cycling segment and the final classification. This result reinforces the hypothesis of the importance of the tactics during this part of the race (Bentley et al, 2007). Significant differences ($p<0.05$) were found in the correlations between the time taken to complete the cycling segment and the overall performance in the different competitions analysed. These differences may be due to two reasons. Firstly, the individual or group tactics adopted by the tri-athletes (aggressive or conservative: trying to break away from the main pack to reach the running segment with a time advantage, or trying to save as much energy as possible to reach the running segment in the best possible condition).And secondly, the orography of the segment (if the profile has mountainous difficulties, the correlation is higher than if the profile is flat). Also, with flat profiles, it is easier and more beneficial to draft in a pack than when riders have to climb mountains, passes or steep slopes (Faria et al, 2005). In this case, the race leads to the creation of smaller packs as it is the case of the 2004 Olympic Games. This was the only competition where the correlation between the cycling segment and the final classification was higher (0.86) than the correlation obtained for the running part (0.76).

The second transition (cycling-running or T2) has been described as the most important with regard to the final result of the competition (Millet &Veck, 2000). However, we found a low correlation (0.33 men, 0.36 women) between the time taken for T2 and the final classification. Carrying out a good T2 determines the time lost in T2, which showed a higher correlation (0.43) with the final result.

The running segment has been described as the most decisive segment regarding the performance in triathlon (Slelvert&Rowlands, 1996; Hue et al, 2002; Bentley et al, 2007). In the present study, we obtained the highest correlation with the final classification of all the segments and transitions (0.83). This finding reaffirms the data found in the literature. Also, the tactics adopted in the cycling segment will affect the correlation between the running part and the overall performance.

Two different race scenarios that could cause differences were identified. The first one, when the profile of the cycling segment has major orographic difficulties. 2004 Olympic Games was the only race analysed that showed a higher correlation for the cycling segment (r=0.86) than for the running segment (r=0.76). This was probably due to the fact that the cycling segment was performed over a mountainous profile. The second one, when aggressive tactics leading into breakaways are adopted during the cycling segment. This was the case of the 2006 World Championships, and the correlation between the cycling segment and the overall performance was similar to the one obtained for the running part (0.82 versus 0.83).

According to the competitions analysed, it seems that the tactics adopted by the male tri-athletes during the cycling segment tend to be conservative. Also, it could be that it is more difficult to create circumstances where breakaways reach the running segment with a clear advantage. In addition, the performance level in the cycling segment may be very similar for all the participants, and the fact that there is little collaboration or teamwork may be the reason why breakaways rarely happen. New studies analysing trends during the cycling part in the current format of the World Championship Trial Series competition are needed for further understanding.

Determining the duration of each part of the race (swim, T1, bike, T2 & run) was the second aim of the present study. The results show that the average total time found for the men's Olympic Triathlon competition is similar to the values obtained by other investigations (Landers, 2002). Also, highly significant differences ($p<0,001$) were found for the swimming segment between the present study and the previous ones. Faster swim times were obtained this time, so it seems that the current swim performance is higher nowadays. The average time to complete the cycling segment was similar to the ones reported by other studies. However, the references in the literature analysed events where drafting during the bike was not allowed, so this segment could cause greater fatigue prior to the running segment (Paton and Hopkins, 2005). Finally, the average times for the running segment did not show significant differences ($p < 0.05$).

Comparisons between the male winners and all participants were carried out. The results showed highly significant differences ($p<0.001$) for the running time (31:03±00:51 versus 33:30±00:44), and significant differences ($p<0.05$) for the total duration of the race (1:48:13±03:44 versus 1:52:05±04:00) (Table 2). Also, the relative distribution (%) of event time (Table 3) were examinated. As it ocurred with the absolute times, the running segment showed the greatest difference between the winners and the rest of the participants, indicating that the performance in this segment has a greater importance for the final result. Considering the fact that the swimming/cycling segments offer the possibility of swimming/riding in a pack, and that the level of the participants are very similar, the time differences appear in the last segment. Running in a group has less biomechanical and physiological effects than in the other two segments, and the preceding fatigue has a very significant influence. These findings represent an important difference with the other triathlon modalities where drafting is not allowed during the cycling (e.g. the Ironman). Therefore, the analysis of the competition and final performance factors are different from the Olympic-distance Triathlon competition (Paton & Hopkins, 2005; Bentley et al, 2007).

Conclusions

Losing less time during T2 has been demonstrated to be related to obtaining a better final result. Lost Time T2 varies from 1 to 15 seconds and it represents a small percentage of the race, but it can make a big difference in the final result as the leading positions are often decided by final sprints with differences of very few seconds.

Competitors need to leave the water in the leading pack to have better chances of winning. The time lost in T1 can be made up in the initial kilometres of the cycling segment, with a medium-low ($p<0.05$) significance regarding the final classification. The orography of the cycling section and any breakaways can lead to differences in the importance of the time lost in T2. The tactics adopted in the cycling segment may affect the correlation between the running and the final result, which showed the highest values overall.

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ANTHROPOMETRIC VARIABLES OF FUTURE TALENT IN TRIATHLON VS CYCLING

Irene López , [+]Roberto Cejuela , José A. Rodríguez-Marroyo , Jose M. Martínez Sanz[3] Alejandro Imbernón , Alberto Ferriz

Departmental Section of Physical Education and Sports, University of Alicante (Spain)

Department of Physical Education and Sports, University of León (Spain)

[3]Triathlon Development Program Alicante University, Spain.

[+]Address for correspondence:

Roberto Cejuela Anta,

Departmental Section of Physical Education and Sports, University of Alicante (Spain)

Facultad de Educación, Campus de San Vicente del Raspeig.

03540. San Vicente del Raspeig (Alicante). Spain

Tel : +34.965903721 Fax : +34.965903721

Email: roberto.cejuela@ua.es

Summary

Key words: young athletes, somatotype, performance.

Introduction

Studies about young athletes have become more and more frequent nowadays, in order to target new talents and therefore allow them to have an early start that leads their careers to the path of success by the time they have reached their adult age.

One of the main deciding factors of success in cyclic sports of resistance, like triathlon and cycling is the capacity of keeping a high energy burning level for long periods of time (Astrand & Rodal 1986; O'Toole & Douglas, 1995). Nevertheless, another main factor which leads to success is the sportsperson's anthropometric conditions.

Studies exist (Landers, 2002; Cejuela, 2009) in which anthropometric parameters are described, as well as height, size and both fat mass and free of fat mass in the body. All of these directly affect the performance in triathlon and cycling.

The object in this study is to describe and to compare sports talents –both male and female - in triathlon and road cycling in terms of anthropometric parameters for the detection of talents.

Material & methods

A number of 44 athletes, 21 triathletes –13 male and 8 female– were selected, age 16±1.4, height 169.8±8cm and weight 58.9±7.4kg. Also, another 23 male cyclists, aged 17±0.9, Development Programme Spanish National Triathlon and Cycling, were selected in 2007, 2008 and 2009 for this study.

All the athletes, as well as their parents or legal tutors, were informed about the characteristics of the research and also gave their consent by signing a document approved by the University of Alicante Ethics Committee, prior to the beginning of the study.

All anthropometric measurements were taken in the same tent, at ambient temperature (22 ± 1ºC) and by the same investigator, who was an International Society for the Advancement of Kinanthropometry (ISAK) Level 3 anthropometrist. Measurements followed the protocols of ISAK (Jones et al. 2006).

The equipment used included a Holtain skinfold calliper (Holtain Ltd. U.K), a Holtain bone breadth calliper (Holtain Ltd., U.K), scales, stadiometer and anthropometric tape (SECA LTD., Germany).

Muscle mass was calculated using the Lee equation (Lee et al., 2009). Fat mass was calculated using for the Withers equation (Withers et al., 1987). Bone mass was calculated using the Döbeln equation, modified by Rocha (as cited in Carter & Yuhasz,

1984). Somatype was calculated using the Heath Carter equations (Carter, 2002).

A test of normality and variable homogeneity was done initially using the Statistical Programme Package for Social Sciencies (SPSS) v.14.0. Following this, descriptive statistics were generated and finally the student's test for independent samples was applied. Significance levels were set at $p \leq 0.05$.

Results

Data of the athletes can be found on chart 1, referring to their weight, height, body size, total number of skin folds, wrist and femur diameter and also those of the somatotype –endomorphy, mesomorphy and ectomorphy.

There are significant differences between triathletes and cyclists in terms of weight, total number of skin folds and the mesomorphy and ectomorphy data. Furthermore, there are significant differences also between different genres of triathletes, in all data but the one referring to weight, and highly significant in the total number of skin folds.

Table 1. Basic measurements according to genere, and type of sport. Significant differences ($p<0.05$) and highly significant differences ($p<0.001$).

Athletes	Male triathletes	Cyclists	Female triathletes
Age	16.4±1.2	17.3±0.9	15.5±1.4
Weight (kg)	58.9±7.9*	67.0±4.6*	56.5±6.0
Height (cm)	172.5± 8.3	175.2±5.3	164.3±3.4*
Arm Spam (cm)	175.8±10.7		166.6±4.9*
Σ Skin Folds (mm)	55.6±11.7*	43.4 ±6.9*	79.4±18.5#
Wrist diameter (cm)	5.4±0.5	5.5±0.2	5.0±0.3*
Femur diameter (cm)	9.5±0.6	9.7±0.4	9.1±0.5*
Endomorphy	2.26±0.5	2.10±0.08	3.70±0.6*
Mesomorphy	3.11±0.71	4.47±0.94#	2.38±0.83
Ectomorphy	3.56±0.72*	2.93±0.73	2.31±0.84
SAM	1.04	0.57*	1.10

As far as the morphogenetic average dispersion of the somatotype (SAM) is concerned, there seems to be more homogeny among the group of the cyclists rather than the triathletes one.

Table 2. SAD, average morphogenetic length ratio of the somatotype, difference between two points, significant >2

Athletes	Male triathletes vs cyclists	Male triathletes Vs female triathletes	Male triathletes Vs cyclists
SAD	1.50	2.05*	2.70*

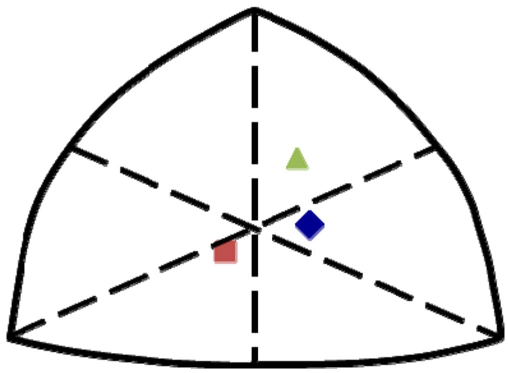
As for the studied somatotype, there are no significant differences in the morphogenetic distance between cyclists and male triathletes, although there is between genres. Triathletes present, nevertheless, a balanced ectomorphic somatotype and cyclists a meso-ectomorphic somatotype.

Significant differences exist in the morphogenetic distance of the somatotype, between the cyclists and the female triathletes, and also between the male and female triathletes.

Discussion

Several studies have found that elite triathletes possess long limbs and low levels of fat in their bodies (Ackland et al., 1998). Our triathletes respond to this characteristics, although they present a higher number of skin folds in comparison to the cyclists. When the triathletes and cyclists' total weight is compared, the cyclists present a significantly superior level. Their height is, however, similar. Thus, the free of fat mass of the cyclists is significantly superior to the one of the triathletes in terms of percentage and absolute levels.

Figure 1. Cyclists (green), male triathletes (blue) and female triathletes' (red) somatotype.



This information might come from the fact that each of the competitions has different needs in each sport (Wutscherk, 1988; Carter & Ackland, 1994).

A lower weight may be good in a running race. But such a lower percentage of fat mass as the one of a cyclist may not be good for swimming. On the contrary, in cycling the aerobic performance is increased when the percentage of mass free of fat in the body is lower.

The triathletes have a physical structure more similar to the one of the athletes or swimmers rather than the cyclists, due to the needs of their competition. Our study, thus, supports Leake & Carter's (1991) theory.

Conclusions

The biotype of reference for the triathlon and cycling presents obvious differences. The triathletes must present long upper and lower limbs, while in cycling length has to be found mainly in the femur.

The total weight is a performance factor in both sports, but we must look for a lower weight in triathlon and a lower mass in cycling, regardless the total weight.

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INTERMITTENT HYPOBARIC HYPOXIA EXPOSURE INCREASES VENTILATORY THRESHOLD BUT NOT RUNNING PERFORMANCE IN TRIATHLETES

Rodríguez FA[1], Iglesias X[1], Barrero A[1], Moreno D[1], Abellán R[2], Segura J[2]

[1]Institut Nacional d'Educació Física de Catalunya, INEFC Barcelona Sport Sciences Research Group. Universitat de Barcelona.

[2]Institut Municipal d'Investigació Mèdica (IMIM), Departament of Pharmacology. Barcelona, Spain.

Presenting author:

Ferran A. Rodríguez

Institut Nacional d'Educació Física de Catalunya, Universitat de Barcelona

farodriguez@gencat.cat

Introduction: Short-term intermittent hypoxia exposure (IHE) combined with sea level training has shown to improve cycling performance in world-class track cyclists (1), and middle-distance swimming performance (2-3) or VO_2max and ventilatory threshold in competitive swimmers (2-3). This study investigated the effect of IHE on aerobic capacity and running performance in triathletes.

Methods: After initial testing (Pre), 14 male triathletes of national level were matched and randomly assigned to either hypoxia (HYPO) or normoxia (NORM) groups. The HYPO group was exposed to IHE at rest for 3 h/day, 5 days/week, for 4 weeks in a hypobaric chamber (4,000 up to 5,500 m). At Pre, immediately after (Post), and two weeks later (Post 2wk), subjects performed a graded running test in a 400-m track and velocity at VO_2max (vVO_2max) was determined. At Pre and one week afterwards

(Post 1wk), subjects performed a graded, maximal test on a treadmill. Breath-by-breath gas exchange parameters were monitored (CPXII, Medical Graphics, USA), and ventilatory thresholds ($AT1_{vent}$, $AT2_{vent}$) were calculated.

Results: 12 subjects completed the study, and their results are summarized in the table.

	HYPO (n = 5)				NORM (n = 7)			
	Pre	Post	Post 1wk	Post 2wk	Pre	Post	Post 1wk	Post 2wk
vVO_2max, $km \cdot h^{-1}$	16.2 ± 1.1	16.2 ± 1.1	–	16.4 ± 0.9	16.5 ± 1.0	16.3 ± 1.0	–	16.3 ± 0.8
VO_2max, $mL \cdot kg^{-1} \cdot min^{-1}$	58.8 ± 4.6	–	61.0 ± 4.4	–	60.3 ± 9.5	–	60.9 ± 5.9	–
VCO_2max, $mL \cdot min^{-1}$	5345 ± 390	–	4882 ± 359*	–	5465 ± 804	–	5063 ± 546	–
$AT1_{vent}$, $\%VO_2max$	79.8 ± 3.9	–	83.3 ± 3.1*	–	80.5 ± 5.6	–	78.5 ± 5.7*	–
$AT2_{vent}$, $\%VO_2max$	89.1 ± 2.3	–	92.4 ± 2.0**	–	94.5 ± 2.7	–	91.6 ± 2.9**	–

* $p<0.05$, ** $p<0.001$ compared with Pre (MANOVA, Student post-hoc test); data are mean ± standard deviation

Discussion/Conclusion: $AT1_{vent}$ (+4.4%) and $AT2_{vent}$ (+3.8%) significantly increased, while CO_2 production at maximal effort decreased (–8.6%) in the HYPO group. VO_2max did not significantly change, although a trend was observed in the HYPO group (+3.7%, p=0.2). These results could not confirm previous observations in which VO_2max during swimming significantly increased after IHE during two weeks (2). In contrast with the previously observed increase in performance in an maximal 4-min cycling test (1), and 200-m swimming time trial (2), this longer protocol did not improve graded running performance in the track. The increase of ventilatory thresholds is in line with previous results with swimmers, but not with runners, exposed to an identical IHE protocol (3).

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ASSESSMENT OF BREATHING PATTERN IN A SIMULATED LABORATORY SPRINT DUATHLON

Fernández Vázquez R [1], Alvero-Cruz JR [1], Ronconi M [1], Naranjo Orellana J [2]

[1] Exercise Physiology and Performance Laboratory. Sports Medicine School. Faculty of Medicine. University of Málaga. Spain

[2] Pablo de Olavide University. Sevilla. Spain

Corresponding author:

José Ramón Alvero-Cruz

Sports Medicine School. Edificio López de Peñalver. Campus de Teatinos, s/n.

University of Málaga. 29071. MALAGA

Phone: 0034 952137599

e-mail: alvero@uma.es

Abstract

Introduction

The ventilatory response to submaximal exercise with constant intensity has three stages. However, during exercise with an increasing intensity up to exhaustion the increase in ventilation is progressive and it depends on the parameters of the breathing pattern. These two situations are the most common in exercise tests in the laboratory, but to our knowledge, the breathing pattern has not been studied during a simulated competition. The aim of this study was to assess the breathing pattern in a simulated laboratory competition of sprint duathlon.

Methods

Eight male trained duathletes (age 24.8 ± 6.8 years, height 174.4 ± 6.8 cm, body mass 67.1 ± 8.1 kg) were studied. All of them performed two maximal tests on a cycle-ergometer and a treadmill to determine VO2peak. A competition was simulated in the laboratory: 20 min running (Run1), 40 min cycling (Bike) and 12 min running (Run2). Tidal volume (VT), breathing frequency (Bf), lung ventilation (VE), mean inspiratory flow (VT/Ti) and Ti/Ttot relationship were measured during the tests. A one-way analysis of variance (ANOVA) was used to analyze differences and statistical significance was set at $p<0.05$.

Results

The VO_2peak was 59,66 ± 6,23 mL/kg/min; the maximal aerobic speed was 19,73 ± 0,41 km/h and the maximal aerobic power was 363,75 ± 37,39 watts. The simulated competition was carried out at 89.6 ± 6.1 % of MAS in Run1; 85.1 ± 8.6 % of MAP in Bike and 87.1 ± 6.9 % of MAS in Run2.

Discussion and Conclusions

No changes were observed in VE from start to end in any of the sectors and Ti/Ttot remained almost constant. Run1 was characterized by a significant increase in Bf ($p = 0.003$) and VT/Ti ($p = 0.009$), but the increase in VE was not significant. Bike sector was defined by a significant decrease in VT ($p = 0.0001$) and an increase in Bf ($p= 0,04$) without changes in VT/Ti or Ti/Ttot, so there was no change in VE. No significant changes were observed in Run2 sector.

When the three sectors were compared, no significant differences were observed in the breathing pattern, although VE and VT/Ti (assessed at the end of the test) were lower in the cycling sector.

Breathing frequency has been shown to depend on metabolic demand and to be affected by stepping frequency during walking or running, but we did not found differences between cycling and runing.

Keywords: Duathlon sprint; Breathing frequency, Tidal volume, Ventilation, Vt/Ti, Inspiratory duty cycle

Resumen

Introduccion

La respuesta ventilatoria al ejercicio submáximo de intensidad constante se define con 3 fases y en el ejercicio incremental la ventilación aumenta de forma progresiva. Estas situaciones se observan comúnmente en ejercicios de laboratorio pero no ha sido estudiado en competiciones simuladas. El objetivo del presente trabajo es valorar los patrones respiratorios en una competición simulada de tipo duatlón sprint

Metodos

Ocho sujetos varones duatletas-triatletas [media (DT), edad 24.8 (6.8) años, altura 174.4 (6.8) cm, peso 67.12 (8.1) kg] participaron en el estudio. Todos los duatletas realizaron dos pruebas de esfuerzo maximal, en cicloergómetro y en banda rodante para valoraciones máximas de esfuerzo. Se valoraron los volúmnes corrientes, la frecuencia respiratoria, la ventilación, el flujo inspiratorio y el ratio Ti/Ttot durante todo el test de simulación de la competición. Los atletas compitieron en dos carreras de 5km carrera1, 20-km bicicleta, 2.500 m- carrera2. Se aplicó un analisis de la varianza (ANOVA) para la comparación estadística aplicando un valor de $p<0.05$

Resultados

El VO2 pico fue de 59,66 ± 6,23 mL/kg/min; la velocidad aróbica máxima (VAM) de 19,73 ± 0,41 km/h y la potencia aeróbica máxima de 363,75 ± 37,39 vatios. Se realizo una prueba competitive simulada en el laboratorio al 89.6 ± 6.1 % de la VAM en carrera1; un 85.1 ± 8.6 % de la PAM en el sector de bicicleta y un 87.1 ± 6.9 % de la VAM en Carrera2.

Discusión y Conclusiones

No se demostraron cambios en la VE desde el inicio al final de cada uno de los sectores el ratio Ti/Ttot permaneció también constante. La Carrera1 se caracterizó por un aumento de la frecuencia respiratoria desde el inicio al final del sector (p = 0.003) así como el ratio VT/Ti (p = 0.009), pero el aumento de la VE no fue significativo. El sector de bicicleta produjo un descenso significativo del volumen corriente (p = 0.0001) y un aumento de la Frecuencia respiratoria (p= 0,04) sin cambios en VT/Ti y Ti/Ttot, ni VE. No se observaron cambios en el sector Carrera2. Cuando son comparados los sectores no se observan diferencias en el patrón respiratorio aunque VE y VT/Ti fueron menores en el sector de bicicleta. La frecuencia respiratoria como se ha demostrado depende de las demandas metabólicas ser estar afectada por la carrera y sin existir diferencias con el secor ciclista

Keywords: Duathlon sprint; Frecuencia respiratoria, volumen corriente, Ventilación, Vt/Ti, Ti/Ttot

Introduction

The ventilatory response to submaximal exercise with constant intensity has three stages: Stage I consists of an abrupt increase of VE during the first 30-50 seconds and in Stage II there is a slow increase of VE during 3-5 minutes until a steady state is reached (Stage III). (Dempsey et al, 1996) However, during exercise with an increasing intensity up to exhaustion the increase in ventilation is progressive and it depends on the parameters of the breathing pattern (Naranjo et al, 2005).

The breathing pattern depends on a variety of factors, such as the direct action of the central nervous system, relatively unknown humoral mechanisms, and the activation of several central or peripheral receptors. Most experts agree that the quotient between Vt and inspiratory time (Ti)—called inspiratory flow, Vt/Ti, or ‘‘driving’’ component—increases with progressive effort. However, the situation is different if we consider the relation between Ti and total respiratory time (Ti/Ttot)—duty cycle or ‘‘timing’’ component. Some authors have reported a fall in Ti/Ttot in response to a VE increase in sedentary people, but others found an increase in the same circumstances or during exercise. However, many studies that only included athletes10–13 suggest stabilisation of Ti/Ttot during exercise, maintaining a similar duration for inspiration and expiration. (Lind an Hesser, 1984). These two situations are the most common in exercise tests performed in the laboratory, but to our knowledge, the breathing pattern has not been studied during a simulated sprint duathlon competition. The aim of this study was to assess the breathing pattern in a simulated laboratory competition of sprint duathlon including the three sectors of the trial (Run1-Bike-Run2).

Methods

Eight male trained duathletes (age 24.8 ± 6.8 years, height 174.4 ± 6.8 cm, body mass 67.1 ± 8.1 kg) were studied. All of them performed two maximal tests on a mechanically cycle-ergometer (Monark 824, Sweden) and a motor-drive treadmill (PowerJog Serie 200, Ltd, England) to determine their peak oxygen consumption (VO2peak) in both situations with a breath by breath system (CPX – Medical Graphics, Minnesota, USA). A competition was simulated in the laboratory with 3 sectors: 20 min running (Run1), 40 min cycling (Bike) and 12 min running again (Run2). The duration of the sectors was fixed from the average time of the subjects in sprint duathlon competition (5 km run1, 20 km bike, 2.5 km run2).

Respiratory variables: Tidal volume (VT), breathing frequency (Bf), lung ventilation (VE), mean inspiratory flow (VT/Ti) and Ti/Ttot relationship were measured during the trials. For the analysis, we obtained the mean of these variables during the first and the final three minutes of each sector (Start and End). A one-way analysis of variance (ANOVA) was used to analyze differences and statistical significance was set at $p<0.05$.

All the subjects were informed and gave their consent for the experiment. The study was approved by the Ethics Committee of the School of Medicine of the Málaga University.

Results

The VO_2peak was 59,66 ± 6,23 mL/kg/min; the maximal aerobic speed (MAS) was 19,73 ± 0,41 km/h and the maximal aerobic power (MAP) was 363,75 ± 37,39 watts. The simulated competition was carried out at 89.6 ± 6.1 % of MAS in Run1; 85.1 ± 8.6 % of MAP in Bike and 87.1 ± 6.9 % of MAS in Run2.

Table 1 shows the values (mean ± SD) of VT, Bf, VE, VT/Ti, and Ti/Ttot for the 3 sectors as well as the p value for the comparison between Start and End.

TABLE 1.- Respiratory variable measured in simulated sprint duathlon

		VT (mL/min)		Bf (min-1)		VT/Ti (mL/s)		Ti/Ttot		VE (L/min)	
		Start	End	Start	End	Start	End	Start	End	Start	End
Run1	Mean	2062,38	2030,25	46,25	56,50	3411,00	4088,00	0,48	0,47	99,21	111,34
	SD	588,94	605,93	7,74	9,93	1061,53	925,71	0,03	0,03	37,61	28,23
	p		0,77		0,003		0,009		0,41		0,17
Bike	Mean	2076,63	1727,88	46,00	53,00	3660,14	3108,50	0,45	0,46	93,54	84,21
	SD	413,32	416,74	9,29	8,14	598,31	547,89	0,04	0,03	19,41	16,63
	p		0,0001		0,04		0,15		0,89		0,13
Run2	Mean	1849,00	1779,14	55,63	59,63	3506,50	4124,00	0,48	0,47	99,04	104,20
	SD	489,98	537,43	12,53	13,71	577,13	1284,70	0,02	0,03	17,17	23,50
	p		0,94		0,09		0,29		0,28		0,16

Discussion and Conclusions

No changes were observed in ventilation (VE) from start to end in any of the sectors and Ti/Ttot remained almost constant. Run1 was characterized by a significant increase in Bf ($p = 0.003$) and VT/Ti ($p = 0.009$), but the increase in VE was not significant. Bike sector was defined by a significant decrease in VT ($p = 0.0001$) and an increase in Bf ($p= 0{,}04$), without changes in VT/Ti or Ti/Ttot, so there was no change in VE. No significant changes were observed in Run2 sector. The increase in VE during exercise is due to increases in both tidal volume and breathing frequency. In this study the increase of VE is due to increase on breathing frequency because the exercise is performed in high intensity (Dempsey et al, 1996). The increase of VT during exercise is due to a decrease of end-expiratory lung volume and an increase in end-inspiratory lung volume and these responses were not observed, in three sectors. While VT remains constant or shows little changes and this situation has been referred as the tachypneic breathing pattern of heavy exercise and when it reaches approximately 50-60% of vital capacity (Dempsey et al, 1996). The mechanisms underlying this tachypneic breathing pattern are unknown but include inspiratory muscle fatigue pulmonary edema and altered respiratory mechanisms. Breathing pattern during exercise may also vary with the type of exercise, for example VT is less and breathing frequency is greater during arm cranking than during cycling (Louhevaara et al, 1990)

When the three sectors were compared, no significant differences were observed in the breathing pattern, although VE and VT/Ti (assessed at the end of the test) were lower in the cycling sector.

Breathing frequency has been shown to depend on metabolic demand (Loring et al, 1990) and to be affected by stepping frequency during walking or running, but we did not found differences between cycling and running.

Neither the intensity (close to competition) nor the sorts of exercise do not seem to affect the breathing pattern in trained duathletes.

Keywords: Duathlon sprint; Breathing frequency, Tidal volume, Ventilation, Vt/Ti, Inspiratory duty cycle

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ANTHROPOMERICAL AND PHYSIOLOGICAL PROFILE OF THE TOP YOUNG CZECH TRIATHLETES.

Prof.Dr.Vaclav Bunc, Dr. Josef Horčic and mgr. Lenka Kovářová

Faculty of Physical Education and Sports Charles University, Sport Research Centre, Prague, Czech Republic

Prof.Dr.Vaclav Bunc, Faculty of P.E. and Sports Charles University, J.Martiho 31, CZ 162 52 Prague 6,

Czech Republic, bunc@ftvs.cuni.cz, te./fax +420 220172288

Author responsible for correspondence: Prof.Dr.V.Bunc

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1. ABSTRACT

To characterize the physiological profile of top young triathletes, 58 top female (mean age=17.3±1.1 years, mass=61.8±3.6 kg, height=169.9±2.0 cm, body fat=12.5±2.6%, BCM=30.8±2.9kg, and ECM/BCM=0.74±0.08) and 96 top male (age=17.2±2.2years, mass=69.7±7.1kg, height=179.8±4.1cm, fat=10.4±2.2%, and ECM/BCM=0.72±0.06) were evaluated on a treadmill. Mean $VO_{2max}.kg^{-1}$ was $71.9\pm5.9 ml.kg^{-1}.min^{-1}$ in boys and $61.9\pm2.5 ml.kg^{-1}.min^{-1}$ in girls. Mean value of v_{max} was 18.8 ± 1.3 $km.h^{-1}$ in boys and 15.7±0.6 $km.h^{-1}$ in females. The selected functional variables at VT level in boys and girls corresponded to $VO_2.kg^{-1}$ 56.0 ± 5.4 and 51.4 ± 2.6$ml.kg^{-1}.min^{-1}$, respectively, speed of running 15.4±1.5 and 13.2±0.8 $km.h^{-1}$, respectively, $\%VO_{2max}$ at VT 82.7 ± 2.1 and 83.1 ± 1.6%, respectively and the coefficient of energy cost of running C was 3.74 ± 0.13 and 3.71 ± 0.13 $J.kg^{-1}.m^{-1}$, respectively. According to our results and according to the data from the literature we can conclude that physiological predispositions in age of 17 years for success in international triathlon may be as

follows in boys and girls: ECM/BCM < 0.72 and 0.74, respectively, $VO_{2max}.kg^{-1}$ > 75 and 68 $ml.kg^{-1}.min^{-1}$, respectively, v_{max} > 19.5 and 17.5 $km.h^{-1}$, respectively, running speed at "VT" > 16 and 14 $km.h^{-1}$, respectively, $\%VO_{2max}$ at VT level > 82.5 percent in both sexes, and the C < 3.74 and 3.72 $J.kg^{-1}.m^{-1}$, respectively. These data are not the sole predictor of racing success but they play a decisive role in the selection of talent for the triathlon.

Key words: young athletes, boys and girls, triathlon, functional characteristics, endurance

2. INTRODUCTION

Participation in sports activities of different performance increased in recent years not only in adult but also in young athletes. The actual motor performance and thus the actual state of physical fitness of subjects is partly a consequence of their genetic predisposition and partly a consequence of the moving training they undertake. In practice it is difficult to separate these two components.

Both aerobic and power and speed predispositions must be assessed in young athletes. From this point of view the deciding role for success in particular sports event plays the talent identification, i.e. determining of functional standards for biological age of subject which based the starting position for success in adult age (Astrand and Rodahl 1986)..

The primary determinant of success is the ability to sustain a high rate of energy expenditure for prolonged periods of time. Exercise training-induced physiological adaptations in virtually all systems of the body allow the athlete to accomplish this. Aerobic capacity described with help of VO_{2max}, economy of movement and fractional utilisation of maximal capacity reflect the integrated responses of these physiological adaptations (Astrand and Rodahl 1986; O´Toole, Douglas 1995).

The energy requirement per unit of time (mainly 1 min) (metabolic power requirement – E and resting energy E_o) for proceeding at speed of moving v is given by (Bosco et al. 1987)

$E = C*v + E_0$

The aim of this study was: 1. to evaluate the young top Czech triathletes of both sexes in the laboratory. 2. according to our data and data presented in the literature to determine the physiological standards for young top triathletes.

3. METHODS

The groups of the top Czech female and male triathletes (Table 1) were evaluated by means of an incremental exercise test to subjective exhaustion on a treadmill at 5% inclination. The initial speed of running was 11 and 13 $km.h^{-1}$. The running speed was increased each minute by 1 $km.h^{-1}$ till subjective exhaustion.All subjects were the best young Czech athletes. The best of them regularly participated were successful in Europa- or World junior Championships. All subjects trained at least 6 days a week and had been engaged in high-intensity training for at least 5 years, and the mean time spent in intensive sports training unit was 2 $h.unit^{-1}$.

Body composition was meassured using a commercially available bioimpedance system BIA 2000-M by a tetrapolar electrode configuration in positions which are recommended by producer. For calculation of ECM and BCM were used capacitance and resistance from whole impedance. The respiratory variables and gas exchange were measured using an open system. The coefficients C were calculated from the maximal intensity of exercise where a reliable relationship between the intensity of exercise and the energy expenditure was still observed, this corresponds to the "ventilatory threshold - VT" (Bunc et all. 1987).

Conventional statistical methods were used to calculate mean values and standard deviations. For evaluation of differences a non-paired t-test was used, and the Pearson´s correlations were employed to obtain a coefficient of correlation.

4. RESULTS

The selected anthropometrical data together with BMC and relationship ECM/BCM are collected in Table 1.

Table 1 Means and standard deviations of selected physical characteristics of male subjects

	Age *(years)*	Mass *(kg)*	Height *(cm)*	%fat *(%)*	BCM *(kg)*	ECM/BCM
Boys (n=96)	17.2±1.8	69.7±6.9	179.8±4.1	10.4±2.2	36.2±3.9	0.72±0.06
Girls (n=58)	17.3±1.1	61.8±3.6	169.9±2.0	12.5±1.9	30.8±2.9	0.74±0.08

The %BF was higher in female athletes than in male of the same sports event. The similar values of %BF were found in young endurance athletes (Bunc et al. 1987). The lowest values of BCM were similarly found like in %BF in subjects with endurance exercise. We did not found any significant differences in ECM/BCM values between followed groups of athletes

Table 2 presents a profile of the scores on some of the maximal functional variables for both groups of young athletes.

Table 2 Means and standard deviation of selected maximal functional variables determined by help of treadmill ergometry (%5 slope).

	$VO_{2max}.kg^{-1}$ *(ml)*	V_{Emax} *($l.min^{-1}$)*	v_{max} *($km.h^{-1}$)*	LA_{max} *($mmol.l^{-1}$)*
Boys (n=96)	71.9±5.9	137.6±15.7	18.8±1.3	12.8±2.1
Girls (n=58)	61.9±2.4	126.6±13.0	15.7±0.6	12.7±1.2

The mean values for selected functional variables at the VT in these groups of athletes are given in Table 3. The same table presents the value for the coefficient of energy cost of running C. The values of C were non-significantly lower in girls than in boys.

Table 3 Means and standard deviations of selected functional variables on the level of VT and coefficients of energy cost of running C (slope of 5%).

	$VO_2.kg^{-1}$ *(ml)*	$\%VO_{2max}.kg^{-1}$*(%)*	v *($km.h^{-1}$)*	$\%v_{max}$*(%)*	C*($J.kg^{-1}.m^{-1}$)*
Triathletes (n=96)	59.5±4.9	82.7±2.1	15.4±1.5	81.9±2.6	3.74±0.13
Triathletes (n=58)	51.4±2.9	83.1±1.9	13.2±0.8	84.0±1.9	3.71±0.13

In endurance oriented young athletes the correlation analyses showed a non-significant relation between sport performance and pulmonary ventilation and blood lactate when estimated jointly in both sexes. In contrast, we have found a significant relationship between competition performance and $VO_{2max}.kg^{-1}$ (in boys r=-0.731, in girls -0.746), maximal speed of treadmill running (-0.598, and -0.656), speed of running at the VT level (-0.663, and –0.714) (all $p<0.05$).

5. DISCUSSION

Variations in the ECM/BCM index were due to accretion of BCM, which was associated with of imposed training load quality and with an increase of ICW (Bunc et al. 1996).

Values of maximal oxygen uptake are typical for athletes with high endurance abilities (Astrand and Rodahl 1986; Deitrick 1991; Hiller et al. 1987; Holly et al.1986). Both specific muscle mass and oxidative capacity of working muscles may be increased by specific training and thus the $VO_{2max}.kg^{-1}$ reflects actual specific predispositions for endurance exercise.

The values of $VO_{2max}.kg^{-1}$ were similar to these of top young Czech young endurance athletes. $VO_{2max}.kg^{-1}$ has routinely been used to assess endurance running performance. In fact, successful performance in competitive distance running has been primarily attributed to $VO_{2max}.kg^{-1}$. A number of investigators found highly significant correlations between $VO_{2max}.kg^{-1}$ and endurance race success in cross studies (Astrand, Rodahl 1986; O´Toole, Douglas 1995).

The literature regarding the physiological characteristics of elite young endurance athletes reveals that nearly all male competitors have $VO_{2max}.kg^{-1}$ values higher than 73 and female higher than 65 $ml.kg^{-1}.min^{-1}$. (Astrand, Rodahl 1986). Thus, a high $VO_{2max}.kg^{-1}$ is considered a prerequisite for success in distance running and sets the limits of a runner's endurance potential. The importance of the run segment to overall triathlon performance was recently made evident by a study which noted it to be the best predictor of overall time in a triathlon (O´Toole, Douglas 1995).

Metabolic adaptation, which can be indirectly characterized as the ability to utilize effective the functional capacity of the organism during a prolonged period, can be evaluated according to percent of maximal functional variables (mainly VO_{2max}) at the VT level (Bunc et al. 1987). In untrained subjects, the values of % VO_{2max} are in the range of 50%-70% of VO_{2max} in trained subjects, these values are in the range of 80%-90% of VO_{2max} (Bunc et al. 1987). The coefficient C can be used for the evaluation of the adaptation to the moving. The higher the level of adaptation to a given type of exercise, the lower is the C coefficient.

The better predispositions for endurance exercise in girls than in boys (Astrand, Rodahl 1986; Bunc et al. 1996; Kohrt et al. 1989) may be confirmed by slightly lower values of the coefficient C and higher values of % maximal functional variables at VT in girls than in boys.

According to our results and according to the data from the literature we can conclude that physiological predispositions in age of 17 years for success in international triathlon may be as follows in boys and girls: ECM/BCM lower than 0.72 and 0.74, respectively, treadmill $VO_{2max}.kg^{-1}$ higher than 75 and $68 ml.kg^{-1}.min^{-1}$, cycle ergometer lower about 5% in both sexes, v_{max} higher than 19.5 and $17.5 km.h^{-1}$,respectively, cycle performance W_{max} higher than 6.7 and 6.1 $W.kg^{-1}$ respectively, LA_{max} higher than 12 and 11 $mmol.l^{-1}$, respectively, running speed at "VT" higher than 16.0 and 14.0 $km.h^{-1}$, respectively, percent VO_{2max} at VT level higher than 82.5% in both sexes, and the C than 3.74 and $3.72 J.kg^{-1}.m^{-1}$, respectively

As in other sports events of an endurance native, the physiological data are not the sole predictor of racing success. On the other hand we must remark than these standards are necessary but not sufficient conditions for success in the race. These data play important role in selection of talents for particular sports event.

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IS ELITE TRIATHLETE TRAINING POLARIZED?

[1]Veronica Vleck Ph.D., [2]Gregoire P. Millet, Ph.D. [1]Francisco Bessone Alves Ph.D.

[1]CIPER. Faculty of Human Kinetics, Technical University of Lisbon, Estrada da Costa 1499-002 Cruz Quebrada-Dafundo. Portugal.

[4]ISSUL Institute of Sport Sciences-Department of Physiology. Faculty of Biology and Medicine, University of Lausanne. Batiment Vidy, CH-1015, Lausanne, Switzerland.

Corresponding author:

Veronica Vleck.

CIPER.

Faculty of Human Kinetics

Technical University of Lisbon

Estrada da Costa 1499-002

Cruz Quebrada-Dafundo.

Portugal.

E-mail: vvleck@fmh.utl.pt

Tel: (+351) 21 419 6777

Fax: (+351) 21 415 1248

Summary:

It is unclear whether better Olympic distance (OD) triathletes implement the “polarized” training model that has been reported for elite Nordic skiers and runners (Esteve-Lano et al., 2005, Seiler & Kjerland, 2006). **Methods:** Thirty weeks’ training of 71 British National Squad triathletes were monitored via a custom-written prospective longitudinal training diary (Vleck, 2010). Training content was recorded daily for each of five intensity levels (L1-L5, with L1 being the lowest and L3 corresponding to OD race intensity). Said levels were both categorized according to rating of perceived exertion, work: rest ratio and % of maximum heart rate. The race paces that were calculated from each athlete´s L3 times and distances were validated against their OD competition times. The 95% confidence limit was taken as the level of significance. **Results:** Fifty one of the 67 athletes who participated finished within the top 50 of the British non-drafting National OD Championships, in week 21, or in the year prior to, the study. The L1-2, as well as the L3-4 data, of the ten athletes who participated without interruption up to and including week 21 were combined. Said athletes spent 11514.0 ± 3634.4 minutes training, of which 24.5 ± 8.0, 56.0 ± 14.6% and 19.5 ± 8.3% (all $p<0.01$ except swim *vs.* run) was swim, cycle and run training, respectively. They spent ≈ 70% of overall, as well as discipline specific training time, below their racing intensity. Both the effect of, and the underlying physiological mechanism behind, increasing or reducing L1-2 time on race performance (Esteve-Lano et al. 2007), as well as the underlying physiological mechanisms behind any such effect (Millet, Vleck & Bentley, 2009) warrant investigation.

Keywords: elite, triathlon, training, polarization, optimisation, zones.

¿ES EL ENTRENAMIENTO DEL TRIATLETA DE ÉLITE "POLARIZADO"?

No está claro si los mejores triatletas en distancia olímpica (DO) utilizan el entrenamiento "polarizado" que se ha presentado en esquiadores Nórdicos y corredores (Esteve-Lano et al., 2005, Seiler & Kjerland, 2006). **Métodos:** El entrenamiento de triatletas del Equipo Nacional Británico fue registrado durante 30 semanas mediante un cuestionario de entrenamiento prospectivo y longitudinal (Vleck, 2010). El contenido del entrenamiento se recogió diariamente en cinco niveles de intensidad (L1-L5, siendo L1 el más bajo y L3 la intensidad de carrera en DO). Estos fueron categorizados de acuerdo a la percepción subjetiva del esfuerzo, ratio trabajo:descanso y % de la frecuencia cardiaca máxima. Los ritmos calculados para el tiempo y la distancia de la intensidad L3 de cada atleta fueron validados frente a sus competiciones (DO). El 95% del intervalo de confianza se tomó como nivel de significación. **Resultados:** 51 de los 67 atletas que participaron en los Campeonatos Nacionales Británicos en DO en la semana 21, o en el año previo al estudio, terminaron en el top 50. Los datos de L1-2, y de L3-4, de los diez atletas que entrenaron sin interrupción hasta la semana 21 fueron combinados. Estos entrenaron 11514.0 ± 3634.4 minutos, de los cuales 4.5 ± 8.0%, 56.0 ± 14.6% and 19.5 ± 8.3% ($p<0.01$ para todos excepto natación *vs.* carrera) fueron en natación, ciclismo y carrera respectivamente. Entrenaron por debajo de su intensidad de carrera ≈ 70% del entrenamiento total y específico de la disciplina. El efecto del aumento o descenso del tiempo en L1-2 sobre el rendimiento en competición (Esteve-Lano et al. 2007), y los mecanismos fisiológicos subyacentes a tal efecto (Millet, Vleck & Bentley, 2009), garantizan investigación.

Introduction

Although Olympic distance (OD) triathlon is acknowledged to both possess different physiological demands to its component single sports, and provide a good model for investigation of the adaptations to cross-training (Millet, Bentley & Vleck, 2009), how triathletes actually train is under-reported. It is unclear whether better triathlon performers implement the "polarized" training model that has been reported for elites in other endurance sports (Billat et al., 2001; Esteve Lano et al., 2005, Seiler & Kjerland 2006), rather than a "threshold-training" model (Seiler, 2004).

Materials and methodology

Thirty weeks of the training of 71 British National Squad triathletes were monitored via a custom-written prospective longitudinal training diary (Vleck, 2010), returned on a monthly basis. Training content was recorded daily for each of five intensity levels (L1-L5, with L1 being the lowest and L3 corresponding to OD race intensity). Said levels, which were categorized according to rating of perceived exertion, work: rest ratio and % of maximum heart rate; were agreed with the National coaches; and separately validated in the laboratory. The race paces that were calculated from the L3 times and distances that each athlete recorded were also validated against their OD competition times in each discipline in the year of the study. Data were analysed using SPSS, with $p<0.05$ taken as the level of significance.

Results

Fifty one of the 67 athletes who participated finished within the top 50 of the British non-drafting National OD Championships, in week 21, or in the year prior to, the study. The ten athletes who completed the diaries without interruption up to and including week 21 were selected for this analysis. Their data both for L1-2, and for L3-4 were combined, so as to allow for easier comparison of our results to the literature (Esteve-Lanao et al., 2005, 2007; Seiler & Kjerland, 2006). Said athletes spent 11514.0 ± 3634.4 minutes training, of which 2836.0 ± 1319.5, 6307.1 ± 2104.5 and 2370.9 ± 1393.0 minutes respectively (24.5 ± 8.0, 56.0 ± 14.6% and 19.5 ± 8.3%, all $p<0.01$ except swim *vs.* run) were swim, cycle and run training, respectively. Total overall training time in L1-2 was significantly higher than that spent in either L3 or L4-5 (both $p<0.001$, Figure 1). Similar effects were seen in all three disciplines in isolation (Figure 2). No differences were seen between disciplines in the relative proportion of training that was spent in each zone.

Discussion and conclusions

Triathletes who perform well in non-drafting OD competition appear to exhibit "polarized training" behaviour *i.e.* they spend ≈ 70% of their overall, as well as of their discipline specific training time, below their racing intensity. This finding agrees with observational data collected for elite endurance athletes in other single sports and warrants confirmation on the basis of both identifiable physiological markers obtained from laboratory testing and heart rate monitoring (Millet, Vleck & Bentley 2009). Both the effect of improving or reducing time spent in L1-2 on race performance (Esteve-Lano et al., 2007), and the underlying physiological mechanisms behind any such effect, should be investigated further.

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TRIATHLON INJURY: WHAT DO WE KNOW?

[1] Veronica Vleck Ph.D., [1] Francisco Bessone Alves Ph.D.

[1] CIPER. Faculty of Human Kinetics, Technical University of Lisbon, Estrada da Costa 1499-002 Cruz Quebrada-Dafundo. Portugal.

Corresponding author:

Veronica Vleck.

CIPER.

Faculty of Human Kinetics

Technical University of Lisbon

Estrada da Costa 1499-002

Cruz Quebrada-Dafundo.

Portugal.

E-mail: vvleck@fmh.utl.pt

Tel: (+351) 21 419 6777

Fax: (+351) 21 415 1248

Summary:

Triathlon's increasing popularity has not been matched by an increase in the quantity and quality of triathlon injury research. We carried out an English language computer search of the 'Medline', 'PubMed', and 'PsychLit' databases, from 1986-2009 using the headings: 'triathlon', 'triathlete', 'swimming', 'cycling', 'running', 'runner', 'injury' / 'injuries', and 'epidemiology'. Articles that were in press and unpublished, postgraduate theses were also sourced direct. Less than 50, mostly retrospective, peer-reviewed publications, covering novice-Elite athletes over the sprint- Ironman distances, existed. No data were available for youth or junior athletes, different senior age-groups, or para-triathletes. Overall (competition plus practice) rates of injuries and tabular summaries of injury rates and or clinical incidence, as well as anatomical and environmental information for said injuries, were generated (Vleck, 2010). Injury type, chronometry, outcomes and risk factor data that had been tested for correlation or predictive value were reviewed.

Although the long term implications for pulmonary, musculoskeletal or cardiac health of triathlon training and competition are unknown, triathlon "appears to be relatively safe for persons of all ages assuming that high risk individuals undertake health screening" (Dallam, Jonas & Miller, 2005). Most injuries appear to be gradual onset or overuse, running training related, lower limb injuries. However, injury recurrence rates may be significant. Nor is it clear whether cross-training exacerbates or lessens injury incidence and or severity. Catastrophic injuries are largely unreported. Minimal rigorous scientific study of existing medical guidelines has been conducted. It is recommended that a consensus statement on definition and recording of triathlon injuries be developed. Ideally, the registry system arising from this would be subsequently implemented within a prospective longitudinal survey of International Triathlon Union events.

Resumen

El incremento de la popularidad del triatlón no se ha acompañado por un aumento de la cantidad y la calidad de la investigación en lesiones. Realizamos una búsqueda en Inglés en las bases de datos *Medline*, *PubMed* y *PsychLit* entre 1986-2009 utilizando los localizadores: *triathlon*, *triathlete*, *swimming*, *cycling*, *running*, *runner*, *injury* / *injuries*, y *epidemiology*. Se encontraron menos de 50 publicaciones evaluadas por pares, mayormente retrospectivas. No se encontraron datos para atletas jóvenes o junior, diferentes grupos de edad sénior o paratriatletas. Se generaron el ratio de lesiones y la incidencia clínica (entrenamiento + competición), así como la información anatómica y ambiental, y los factores de riesgo relativos a las mismas (Vleck, 2010).

Aunque las implicaciones a largo plazo sobre la salud pulmonar, musculo esquelética o cardiaca del entrenamiento en triatlón no son conocidas, el triatlón "parece ser relativamente seguro para personas de todas las edades asumiendo que individuos con alto riesgo llevan a cabo un chequeo de salud" (Dallam, Jonas & Miller, 2005). La mayoría de las lesiones parecen desarrollarse gradualmente o por sobreuso, relacionarse con el entrenamiento de carrera y localizarse en el miembro inferior. Sin embargo, la recurrencia de la lesión puede ser significativa. No está claro si el efecto combinado del entrenamiento aumenta o disminuye la incidencia y/o severidad de la lesión. No se presentaron lesiones muy graves. Estudios mínimamente rigurosos de guías médicas no se han realizado. Se recomienda el desarrollo de un documento de consenso sobre la definición y la recogida de lesiones en triatlón. Idealmente, el sistema de registro que surgiera de este sería posteriormente implementado en un cuestionario prospectivo y longitudinal de eventos internacionales.

Palabras clave: elite, triathlon, entrenamiento, polarización, optimización, zonas.

Introduction

Although triathlon is increasing in popularity, this has not been matched by an increase in the quantity and quality of triathlon injury research. We reviewed the current state of knowledge of the distribution and determinants of injury, and the efficacy of preventive measures in the sport. Recommendations for the design of future triathlon injury research, such that the results from it may be more easily transferable into real-world (health and safety) gains (Finch, 2006) in training and race course design, were also made.

Materials and methodology

An English language computer search of the 'Medline', 'PubMed', and 'PsychLit' databases, from 1986 onwards, was carried out using the headings: 'triathlon', 'triathlete', 'swimming', 'cycling', 'running', 'runner', 'injury' / 'injuries', and 'epidemiology'. Articles that were in press and unpublished, postgraduate theses were also sourced directly from authors in the field. Less than 50, mostly retrospective, peer reviewed publications, covering novice, competitive/ age-group to National Squad level athletes, who competed over the sprint to Ironman distances, were obtained. No data were available for youth or junior athletes, different senior age-groups, or for athletes with a disability. Overall (competition plus practice) rates of injuries and tabular summaries of injury rates and or clinical incidence, as well as anatomical and environmental information for said injuries, were generated (Vleck, 2010). Injury onset and chronometry were reviewed. Injury type, time loss, clinical outcome and economic cost data were also summarised across papers. Only risk factor data that had been tested for correlation or predictive value were included in the subsequent analysis of why and how of injury may have occurred.

Results

Although triathlon injury research is in its infancy, and the long term implications for pulmonary, musculoskeletal or cardiac health of triathlon training and competition are unknown, triathlon "appears to be relatively safe for persons of all ages assuming that high risk individuals undertake health screening" (Dallam, Jonas & Miller 2005). Most injuries appear to be gradual onset or overuse, training related, lower limb injuries, mainly occurring during running. However, injury recurrence rates may be significant. Nor is it clear whether cross-training exacerbates or lessens injury incidence and or severity. Catastrophic injuries are largely unreported in the literature but usually occur "as a result of failure to adjust pace within safe limits for specific environmental conditions" or inadequate implementation of safety guidelines (O'Toole, Miller & Hiller, 2001). Minimal rigorous scientific study of the medical guidelines that are currently in place, or of any other potential preventative measures for injury, has yet been conducted.

Discussion and conclusions

It is recommended that a consensus statement on definition and recording of injuries in the sport be developed. Ideally, the registry system arising from such work would be subsequently implemented within a longitudinal prospective survey of injury in International Triathlon Union events. Central collation of the data so obtained could allow analysis of how to lessen injury risk through, for example, improvements in course design. Determination of the effects of triathlon training on musculoskeletal health both at a young age, and in the long term, via longitudinal prospective survey, is also highly recommended.

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THE WETSUIT EFFECT ON ITU WORLD CUP SWIM PERFORMANCE

[1] Veronica Vleck Ph.D., [1] Francisco Bessone Alves Ph.D., [2] Romuald Lepers Ph.D.; [3] David J. Bentley Ph.D., [4] Gregoire P. Millet, Ph.D.

[1] CIPER. Faculty of Human Kinetics, Technical University of Lisbon, Estrada da Costa 1499-002 Cruz Quebrada-Dafundo. Portugal.

[2] Faculty of Sport Sciences, INSERM U887, BP 27877 Dijon cedex, France.

[3] University of Adelaide, Australia

[4] ISSUL Institute of Sport Sciences-Department of Physiology. Faculty of Biology and Medicine, University of Lausanne. Batiment Vidy, CH-1015, Lausanne, Switzerland.

Corresponding author:

Veronica Vleck.

CIPER.

Faculty of Human Kinetics

Technical University of Lisbon

Estrada da Costa 1499-002

Cruz Quebrada-Dafundo.

Portugal.

E-mail: vvleck@fmh.utl.pt

Tel: (+351) 21 419 6777

Fax: (+351) 21 415 1248

Summary:

Wetsuit (WS) use is generally advantageous to Olympic distance triathlon swim performance (Millet & Vleck, in press), although the extent to which performance improvement or energy sparing occurs varies between individuals (Chatard et al., 1995). It is not clear to what extent wetsuit use has influenced male and female Elite, draft-legal, ITU World Cup competition results over time (Vleck et al., 2008). We categorised the official swim results for the top ten male and female finishers for 161 ITU World Cup events, dating from Ishigaki 1997 up to Tongyeong 2010, into wetsuit (WS) and non-wetsuit (NWS) events. Races where the swim was markedly shortened or deleted were then excluded. Absolute swim times (in seconds) were then compared, by year, using a Kruskal-Wallis ANOVA of ranked results. $P<0.05$ was taken as the level of significance.

On average, 11.7 ± 2.9 races were available for analysis each year. The yearly average proportion of races that were WS tended to decrease over time. WS and NWS times were significantly different ($p<.001$) in both males and females. The gender difference in swim performance remained similar both across succeeding years and between WS ($8.2 \pm 1.6\%$) and NWS ($8.4 \pm 1.4\%$) events. No clear trends emerged as regards WS effect over time on swim performance, emerged. It does not appear, therefore, that females are at a disadvantage relative to males in terms of how much they can benefit from wetsuit use. Whether this is because the relative extent to which overall race result is weighted by performance in the swim (as opposed to the cycle or run) discipline may differ with gender is unclear.

Keywords: wetsuit, performance, elite, triathlon, longitudinal, gender.

Resumen:

El uso del neopreno generalmente supone una ventaja para el rendimiento en natación de un triatlón olímpico (Miller & Vleck, 2011), aunque el grado en el que mejora el rendimiento o el gasto energético varía entre individuos (Chatard et al., 1995). No está claro si el uso del neopreno ha influido en los resultados a lo largo del tiempo de hombres y mujeres en competiciones de categoría élite. Nosotros categorizamos, en eventos con neopreno (N) y sin neopreno (SN), los resultados oficiales de natación en hombres y mujeres que finalizaron en el top 10 de 161 pruebas de Copa del Mundo ITU (Ishigaki 1997 -Tongyeong 2010). El tiempo absoluto en natación fue comparado por año utilizando un ANOVA de Kruskal-Wallis. El nivel de significación se fijó en $p<0.05$.

De media, se analizaron 11.7 ± 2.9 carreras cada año. La proporción de carreras N durante el año tiende a disminuir a lo largo de tiempo. El tiempo en eventos N y NS fue significativamente diferente ($p<0.001$) en hombres y mujeres. La diferencia en el rendimiento entre géneros fue similar a lo largo de los años y entre eventos N (8.2 ± 1.6%) y NS (8.4 ± 1.4%). No aparecieron efectos sobre el rendimiento a lo largo del tiempo en relación al uso del neopreno. Por lo tanto, no parece que las mujeres estén en desventaja frente a los hombres en términos de cuánto pueden beneficiarse por el uso del neopreno. No está claro si esto se debe a una posible diferencia entre géneros en la importancia relativa de la natación en el rendimiento en triatlón (frente al ciclismo o la carrera) en el rendimiento global.

Palabras clave: neopreno, rendimiento, élite, triatlón, longitudinal, género.

Introduction

Wearing a wetsuit (WS) is generally advantageous to Olympic distance (OD) triathlon swim performance. Athletes wearing a WS can swim ~45-70 s faster over 1500m than when they are not wearing a wetsuit (NWS) (Millet & Vleck, 2011). However, the extent to which performance improvement and or energy sparing occurs varies between individuals. Less able swimmers generally benefit more from WS use (Chatard et al., 1995). Given anecdotal evidence that both swimming performance and density in International Triathlon Union (ITU) World Cup triathlons, in both genders, has increased since the start of the first Olympic Games qualification cycle in 1997, one could hypothesise, therefore, that the WS advantage in ITU World Cup competition has decreased over time. However, suit design and materials have improved. Moreover, as females are generally more buoyant than males, they may inherently be less able to benefit from WS. It is not clear, therefore, what extent wetsuit use has influenced Elite, draft-legal, ITU World Cup competition results over time. Nor is it known whether the extent of any WS effect differed between genders (Vleck et al., 2008).

Materials and methodology

We categorised the official swim results for the top ten male and female finishers for 161 consecutive ITU World Cup events, dating from Ishigaki 1997 up to Tongyeong 2010, into wetsuit (WS) and non-wetsuit (NWS) events. Races where the swim was markedly shortened or deleted owing to adverse weather conditions were excluded from further analysis. A Kruskal-Wallis ANOVA of ranked results was then used to compare absolute swim times (in seconds) by year. $P<0.05$ was taken as the level of significance.

Results

On average, 11.7 ± 2.9 races were available for analysis each year. The yearly average proportion of races that were WS was 28.1 ± 8.6%, but tended to decrease over time. WS and NWS times were significantly different ($p<.001$) in both males (Figure 1) and females (Figure 2). The difference in swim performance between the two genders remained similar both across succeeding years and between WS (8.2 ± 1.6%) and NWS (8.4 ± 1.4%) events. No clear trends as regards whether WS use was having an increasingly greater or lesser effect over time on swim performance, emerged.

Discussion and conclusions

We demonstrated that both the top 10 male, and the top 10 female, finishers in ITU World Cup triathlons over the period 1997-2010 swam significantly faster when they were wearing a WS than when they were not. The actual swim times of the females were slower than those of the males but the gender difference did not differ with or without WS. It does not appear, therefore, that females are at a disadvantage relative to males in terms of how much they can benefit from wetsuit use. Whether this is because the relative extent to which overall race result is weighted by performance in the swim (as opposed to the cycle or run) discipline may differ with gender (Vleck et al., 2008) is not known.

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TRIATHLON IN SCHOOL-BASED PHYSICAL EDUCATION

Author: Victoria E. Machota Blas .PhD. Head of Physical Education Department

Academic Institution: Secondary School "Antonio Hellín Costa". Puerto de Mazarrón. Murcia. Spain

Corresponding author:

Victoria E. Machota Blas

C/ Pedro López Meca 50

Bloque 1, Escalera C, 2º28

Bolnuevo (Mazarrón). Murcia. Spain

Email: vmictoriaeugen6@gmail.com

Telephone: (34) 968150865

(34) 630563196

Fax: 968 33 20 74

Summary and Keywords

The aim of this poster is to describe the implementation of Triathlon in the school-based Physical Education. A teaching unit of triathlon of 12 lessons was designed to become part of the Physical Education syllabus with the aim to work on the technique and tactic of each of the three disciplines and the different transitions and sum up with a competition. Students became aware of the sport of Triathlon demonstrating outcomes and motivation to future practise of triathlon in order to increase their levels of physical activity. This unit shows that appropriate modifications allow this sport to be adapted and included in the framework of school-based Physical Education.

Keywords: Teaching unit. Secondary School. Individual Sports.

El objetivo de este póster es describir la implementación del deporte de Triatlón en la Educación Física Escolar. Para ello, se diseñó una unidad didáctica de Triatlón integrada por 12 sesiones incluida en la Programación Docente del Departamento de Educación Física cuyo objetivo era trabajar la técnica y táctica de cada una de las tres disciplinas y las diferentes transiciones culminando con una competición. Los alumnos conocieron el Triatlón demostrando los aprendizajes y la motivación necesaria para su futura práctica y con el fin de incrementar sus niveles de actividad física. Esta unidad demuestra que con las modificaciones apropiadas, este deporte puede incluirse en el marco de la Educación Física Escolar.

Palabras clave: Unidad didáctica. Educación Secundaria. Deportes Individuales.

Introduction

In the recents years, Triathlon has become an extremely popular sport in Spain and worldwide. The Spanish Sport Authority (1) is promoting its practice in collaboration with The Spanish Triathlon Federation (2) which has modified rules and regulations to match the skill levels and needs for young people (age, ability and mature level). Given the positive benefits of the practice of triathlon and the need to increase adolescents physical activity according to national data (3), the aim of this poster is to present the implementation of triathlon within the school-based Physical Education.

Method

A teaching unit of triathlon (4) was designed to become part of the physical education syllabus. The main objectives were:

- ❖ To introduce students to the sport of Triathlon and its other two disciplines (Duathlon: running and cycling; Aquathlon: swimming and running).
- ❖ To develop student´s knowledge and skills enabling them to practise and participate in the interschool sports competitions.
- ❖ To make students aware of the positive benefits of practise and participation in triathlon.
- ❖ To promote growth and development throughout triathlon practise.
- ❖ To support the implementation of Triathlon in school-based physical education.

The unit was buit up of 12 lessons, 50 minutes each which were developed on a theoretical and practical basis following the scheme of an introduction-warming up, the development of the main contents of the session and a review-reflection about the work done and an introduction to the next session. The unit was conducted with a total of 98 (57 boys; 41 girls) 14-15 year-old students at a Secondary School (5) during the 3rd. school term (2010) taking advantage of the good weather. The students worked on the technique and tactic of each of the three disciplines (swimming, cycling and running) and the different transitions. The unit also included contents of water and road safety, how to train different modalities and distances and how to deal with competitions. To sum it up, the students took part in an inter-school aquathlon competition held by the local council. Regarding the facilites and equipment, most of the lessons took place in the school´s physical education sports facilities (classrooms, sports court and pavilion) adapting these and only requiring the use of a 25 m. outdoor council swimming-pool in 4 ocasions. In the same way, the students and the teacher contributed to the unit with their own bikes in order to teach cycling and transitions with the celebration of a local ride with the support of the local police officers.

Results

Students have become aware of the sport of Triathlon demonstrating outcomes on knowledge and understanding and basic skills related to this sport. This unit has provided them with the opportunities to learn about this sport contributing to the motivation and future practise of triathlon beyond this school-based physical education unit.

Conclusion

Triathlon is a sport which may be practised by adolescents in order to increase their levels of physical activity. Its initial development may seem conditioned upon location (facilities) and characteristics of very specific material. However, appropriate modifications allow this sport to be adapted and included in the school-based Physical Education Syllabus so it may contribute to maintain healthy and physically active lifestyles. Research is needed in order to study the impact of Triathlon in school-based physical education.

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THE EFFECT OF SUB-MAXIMAL SWIMMING ON BLOOD LACTATE REMOVAL AFTER A SHORT TRIATHLON RACE

SCHWERDTFEGER, WAGNER DANIEL CINTRA. wagner.dcs@hotmail.com

ANDRIES JÚNIOR, ORIVAL. orivaljr@fef.unicamp.br

AQUATIC ACTIVITS LABORATORY, DEPARTMENT OF SPORT SCIENCE, SCHOOL OF PHYSICAL EDUCATION, UNICAMP – UNIVERSITY OF CAMPINAS, BRAZIL

Corresponding author:

Prof. Dr. Orival Andries Júnior

Avenida Érico Veríssimo, 701 - Cidade Universitária Zeferino Vaz - Barão Geraldo

CEP: 13.083-851 / Caixa Postal: 6134

Campinas – SP, Brasil

Phone: 55 19 35216620

Fax: 55 19 3251-6750

Abstract

The aim was to examine the effect of sub-maximal swimming lactate removal after a triathlon race. Five trained male and five trained female age-group triathletes performed two half-sprint triathlon races, 375-meters swimming, 10-kilometers cycling and 2.5-kilometers running. After each test the athletes had fifteen minutes of recovery with four blood lactate concentration measurements at 0, 5, 10 and 15 minutes post effort. The first one was with passive recovery (PR) and the second one was swimming at intensity between 60 and 70% of the speed obtained in swimming phase of the triathlon race (AR). Significant differences were observed at post 10 and post 15 measurements. The decline induced for the SR was 62%, while the passive recovery was 45% of the lactate concentration. The results suggest that active recovery can be a good strategy to adopt to avoid the fatigue and make the athletes ready for return to training as soon as possible.

Keywords: triathlon, swimming, lactate removal, active recovery.

Resumen

El objetivo fue examinar o efecto da natación sube-máxima en la remoción del lactato del sangre después de una prueba de triatlón. Cinco triatletas varones y cinco damas trenados del grupo de edad realizaran dos pruebas de triatlón medio-sprint, 375 metros de natación, 10 kilómetros pedaleando y 2.5 kilómetros de carrera. Después de cada test los atletas tuvieran quince minutos de recuperación con cuatro coletas de la concentración de lactato del sangre con 0, 5, 10 y 15 minutos pos esfuerzo. El primer fue con recuperación pasiva (RP) y el segundo con recuperación activa nadando (RN) en intensidad entre 60 y 70% de la velocidad obtenida en la fase de natación durante la prueba de triatlón. Diferencias significantes en las concentraciones pos 10 y pos 15 fueran observadas. La reducción inducida por RA fue de un 62%, aunque la reducción de la RP fue de un 45% de la concentración de lactato. El resultado sugiere que la recuperación activa puede ser una buena estrategia para evitar la fatiga y mantiene el atleta listo para el entrenamiento más rápido.

Palabras clave: triatlón, natación, remoción de lactato, recuperación activa.

Introduction

Due to a calendar with many competitions and the need to train three different modalities the athletes must return to the training sessions almost immediately after the competition.

Currently the lactate origin (Robergs RA, 2001) and its metabolism (Gladden L, 2004) during physical exercise are already clear to the researchers and there are strong indications about their kinetic and their advantages during active recovery (Kelley MK, Hamann JJ, Navarre C, Gladden B, 2002).

Toubekis AG, et al. (2008) showed in recent research that swim at 60% of 100-m pace could be beneficial between training sets, but it can compromise swimming performance when recovery durations are shorter than two minutes. In the same way, Dupont G; Blondel N; Berthoin S (2003) hypothesized that the energy required to run during short active recovery between running sets would result in less oxygen being available to reload myoglobin and haemoglobin, to remove lactate concentrations and to resynthesize the phosphocreatine, concluding that passive recovery will induce a longer time to exhaustion than active recovery for intermittent runs. In the other hand, another study suggests that cycling at sub-maximal intensity between sets in four minutes intervals could enhance performance comparing with passive recovery (Spierer DK, et al, 2004).

Despite of have a large number of publications comparing active and passive recovery between sets of different sports, there isn’t any specific evidence of the efficacy of active recovery routines after triathlon.

Thus, the purpose of this study was to examine the effect of sub-maximal swimming, cycling and running on blood lactate removal after a triathlon race.

Materials and Methodology

Five trained male [mean (SD) age 23.8 (2.7) years, height 176.8 (4.2) cm, body mass 72.0 (6.1) kg] and five trained female [mean (SD) age 24.0 (2.9) years, height 165.6 (3.0) cm, body mass 62.7 (7.1) kg] age-group triathletes volunteered to perform two half-sprint triathlon races, 375-meters at a 25 meters swimming pool heated to 28ºC, 10-kilometers cycling on a CompuTrainer Pro Lab electromagnetically-braked cycling ergometer and 2.5-kilometers running on a outdoor 400 meter official track.

After each test the athletes had fifteen minutes of recovery with four blood lactate concentration measurements at 0, 5, 10 and 15 minutes post effort. The first one was with passive recovery (PR) and the second one was swimming at intensity between 60 and 70% of the speed obtained in swimming phase of the triathlon race (AR).

Before testing, all possible risks were thoroughly explained to the subjects and their written informed consent was obtained in according with the Research Ethics Committee of the Medicine Faculty of the University of Campinas (UNICAMP).

Results

As exposed in table 1 no significant differences were observed between PR vs AR at pre, post 0 minutes and post 5 minutes. Significant differences were observed between PR vs AR at post 10 minutes and post 15 minutes measurements.

Table 1. Lactate concentration. Values given are mean (SD) expressed in mmol·l^{-1}.(*PR* Passive recovery, *AR* Active recovery)

	Pooled	
	PR	**AR**
Pre	2.4 (0.6)	2.0 (0.4)
Post 0	8.5 (1.5)	8.5 (2.6)
Post 5	7.2 (1.8)	6.4 (2.3)
Post 10	6.2 (1.4)	5.1 (1.7)*
Post 15	5.6 (1.4)	4.1 (1.6)*

*Decreased significantly over time comparing AR vs PR ($p < 0.05$)

The decline induced for the swimming recovery was about 62%, while the passive recovery was about 45% of the lactate concentration. No significant differences were evident between genders.

Discussion and conclusion

The results suggest that lactate uptake by skeletal muscles and other tissues increased due metabolic rate increase during the active recovery causing a more efficient recovery (Bangsbo J, et al, 1995).

Another benefit of active recovery was showed by Wigernaes I, et al (2001) in a study proving that the active recovery at low intensity (15 minutes at 50% of maximal oxygen consumption) could be used as a preventive measure by counteract the increase of free fatty acid post exercise, nullified the decreases in neutrophil and monocyte counts and also counteract the rapid return of hormones concentration towards baseline levels.

It is important to consider that each athlete has their own best modality and it probably can contribute to a better or worse recovery. Apart from that the positive effect on blood lactate clearance of endurance training was exposed by Fukuba Y, et al, (1999) in research with triathletes.

In conclusion, the decline induced during the active recovery protocol was bigger than passive causing a more efficient recovery. This indicates that it might be a good strategy to adopt after a triathlon race to avoid the fatigue and make the athletes ready to return to training as soon as possible.

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METHOD FOR THE INDIVIDUAL AND COMPARATIVE ANALYSIS OF THE TRIATHLETE'S PERFORMANCE IN THE COMPETITION

Ivo Clotet Nyffenegger[1], Ricard Perez Pinazo[2]
1) Degree in Sciences of Physical Activity and Sports, International Triathlon Coach
2) Computer Science Engineering, Triathlon Coach

Corresponding authors:

Ivo Clotet Nyffenegger
Manresa. Spain
Email: ivo.clotet@tristats.net

Ricard Perez Pinazo
Figueres. Spain
Email: ricard.perez@tristats.net

Abstract

The aim of this method is **to facilitate studies focusing on the analysis of the performance of any triathlete** in any competition, both individually and compared with other triathletes and different types of competition, further defining their individual performance profile.

The analysis of the performance of a triathlete **facilitates decision making** at different levels such as:

- guidance on talent identification
- establishing selection criteria for different international competitions
- advice and guidance as to the needs and possibilities for improvement in certain segments
- the establishment of a national strategy to develop triathletes with the necessary profile to yield optimally high competition

Keywords

statistics, performance, chart, graph, profile

Introduction

The assessment of the performance of a triathlete in a competition should not be limited to observing only the final position achieved. If the issue is going to improve our performance over time, we must consider further the development of competition, as each competition and / or circuit is developed with a different dynamic.

If we accept that each competition is different, then: **to reach the same position in two different competitions means that we had competed in the same way?**

This method allows to analyze the performance of a triathlete in a competition to know all the details of the development of the test.

Development

The aim of this method is **to facilitate studies focusing on the analysis of the performance of any triathlete** in any competition, both individually and compared with other triathletes and different types of competition, further defining their individual performance profile.

The analysis of the performance of a triathlete **facilitates decision making** at different levels such as:

- guidance on talent identification
- establishing selection criteria for different international competitions
- advice and guidance as to the needs and possibilities for improvement in certain segments
- the establishment of a national strategy to develop triathletes with the necessary profile to yield optimally high competition

Initial data

Initial information to develop this method can be easily obtained from the lists of results from a competition, so **we are faced with a very accessible method**.

The method requires minimal data available to all athletes from the competition. These initial data are:

- Name of triathlete
- Final position
- Final time
- Time in the swim segment

- Time in the bike segment
- Time in the run segment

If you want to perform a more detailed study of the performance of the triathlete you can also include the times of each of the transitions.

Calculation of the initial data

From the initial data is performed a first calculation process is held to obtain:

For each triathlete

- Position in the swim segment
- Time difference in the swim segment regarding the best register
- Position in the bike segment
- Time difference in the bike segment regarding the best register
- Position in the run segment
- Time difference in the run segment regarding the best register

For the competition (all triathletes)

- Number of participants
- Number of athletes who finish the race
- Number of athletes who do not start the competition (DNS)
- Number of athletes who do not finish the race (DNF)
- Number of athletes disqualified (DSQ)
- Average finish time
- Average time in the swim segment
- Average time in the bike segment
- Average time in the run segment
- Standard deviation of time in the swimming segment
- Standard deviation of time in the bike segment
- Standard deviation of time in the run segment
- Coefficient of correlation between the swim segment and the final position
- Coefficient of correlation between the bike segment and the final position
- Coefficient of correlation between the run segment and the final position

Statistical data collection

If you want to make a more precise analysis of the data is possible to apply various statistical concepts within this method.

Standard deviation

Concept and formula

The standard deviation is a measure that reports the average distances that have data regarding their arithmetic mean, expressed in the same units as the variable. **The standard deviation of a set of data is a measure of how much the data deviate from its mean**. This measure is a very stable index and considers the value of each item.

$$S = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

where

x_i is the individual value

$\bar{x}$ is the average value

n is the number of records

Grounds

To know more accurately a group of triathletes, is not enough to know the measures of central tendency, but also we need to know the deviation presented by the triathletes in their distribution from the mean of the distribution, in order to have **a vision of them more in line with reality** at the time to describe and interpret for decision-making.

Example

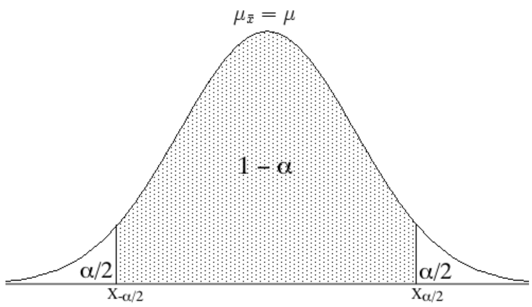
If you want to know the **standard deviation of the swim segment of a competition** you should calculate the formula

$$S = \sqrt{\frac{\sum_{i=1}^{number\ of\ triathletes}(triathlete_i\ swim\ time - competition\ swim\ time\ mean)^2}{number\ of\ triathletes - 1}}$$

Confidence Interval

Concept and formula

Confidence interval is called a **pair of numbers which is estimated to be some unknown value with a given probability of success**, usually of a 0.95 (1 - α).



$$IC\ 95\% = \left(\mu_{\bar{x}} - 1.96 * \frac{s}{\sqrt{n}} \quad , \quad \mu_{\bar{x}} + 1.96 * \frac{s}{\sqrt{n}}\right)$$

where

- $\mu_{\bar{x}}$ is the average of all sample means
- μ is the population mean
- α is the significance level
- s is the standard deviation

Grounds

Sometimes one triathlete's performance differs widely from the average behavior of other participants. These cases, which represent an exception to the average, statistically are known as outliers.

In case you want to analyze all the participants of the competition ignoring exceptional cases that cause a change in the average value you should **identify athletes who are outside the confidence interval of 95%**.

Example

If you want to know the **requirements that must have a triathlete in the swim segment** to fit the profile of the test you should calculate the formula

$$CI\ 95\% = (swim\ time\ mean\ -\ 1.96 * (swim\ standard\ deviation)/\sqrt{}(number\ of\ triathletes)\ \ , s$$

in this case we obtain the confidence interval 95% of swim time of the competition and we can compare this range of values with triathlete records.

<u>Pearson correlation coefficient</u>

Concept and formula

The Pearson correlation coefficient is an index that **measures the linear relationship between two quantitative random variables**. Unlike the covariance, the Pearson correlation is independent of the scale of measurement of variables.

$$r = \frac{\sigma_{XY}}{\sigma_X \cdot \sigma_Y}$$

where

σ_{XY} is the covariance of (X, Y)

σ_X and σ_Y are standard deviations of the marginal distributions

Covariance (X, Y) formula

$$S_{XY} = \frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})$$

Grounds

This type of statistic can be used to **measure the degree of relationship between two variables** if both use a scale to measure at interval / ratio level (quantitative variables). The numerical result ranges from +1 (perfect linear relationship) to -1 (inverse linear relationship), where 0 means that there is no relation.

Example

If we want to measure the **degree of relationship between the difference of time in the swim segment and difference of final time in a competition** we should calculate the formula

$$r = \frac{\sigma_{(difference\ time\ swim)(difference\ final\ time)}}{\sigma_{(difference\ time\ swim)} \cdot \sigma_{(difference\ final\ time)}}$$

in case that the r value resulting from the above formula is +1 means that there is a positive perfect direct linear relationship between two variables. That is, the triathletes who swim close to best swimmer finished the race a short time difference of the first classified. A correlation of 0 is interpreted as the nonexistence of a linear relationship between the difference in swim time and time difference in the final position. In general, from a correlation of 0.6 can be seen that there is a correlation.

ITU World Championship Grand Final Budapest 2010

(correlation coefficient run – final position)

Men. $r = 0.86$

Women. $r = 0.88$

Application of the method

This analysis method allows processing of data both at the individual, segmented by group-level and global level and a competition circuit.

Individual Level

Thanks to this method you can **obtain individual records of a triathlete** in his performance in a competition to **analyze his performance** in each of the segments.

Performance of a triathlete

To calculate the performance of a triathlete in a segment you must have the following information:

- Average time of the competition in the segment
- Time segment of the triathlete

From the formula

$$performance = \frac{average\ time - triathlete\ time}{average\ time}$$

which relates the time of the triathlete with the time of the rest of participants, we can obtain a numerical value with which to compare different triathletes.

If we wish to obtain more understandable values we should consider the average value of the competition as the 100% of the performance and modify the formula above to obtain a percentage value, where a value greater than 100% indicates that the triathlete has shown superior performance to the average value of other participants

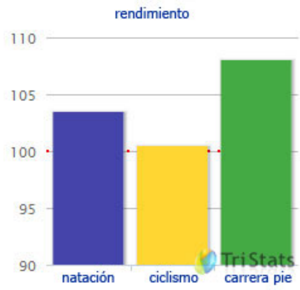
$$performance = 100 + \left(\frac{average\ time - triathlete\ time}{average\ time} * 100\right)$$

ITU World Championship Grand Final Budapest 2010
(performance of Javier Gomez Noya in each segment)

$$swim\ performance = 103.47\ \%$$

$$bike\ performance = 100.55\%$$

$$run\ performance = 108.05\ \%$$



(figure 01. Performance of the triathlete chart)

If you want to compare the performance of a triathlete on a subset of participants (eg positions 1 to 10), you should obtain the average time of the subgroup of participants in order to apply the relevant formula

Global level

Thanks to this method you can obtain the **global competition logs** to **analyze the development of each of its segments**.

Table of triathletes and segments

To obtain a table describing the **performance of triathletes in each segment** is necessary to have the following data for each of the triathletes to show in the table:

- Final position
- Position in the swim segment
- Time in the swim segment
- Time difference in the swim segment regarding the best register
- Position in the bike segment
- Time in the bike segment
- Time difference in the bike segment regarding the best register
- Position in the run segment
- Time in the run segment
- Time difference in the run segment regarding the best register

You can get the triathletes and segment table which shows the performance of triathletes in each of the segments, just sorting the above data by the end position.

#	posición nat.	tiempo natación	diferencia natación	posición cic.	tiempo ciclismo	diferencia ciclismo	pos. car.	tiempo carrera pie	diferencia carrera pie
1	3	00:17:12	00:00:03	48	00:53:54	00:01:02	1	00:30:00	00:00:00
2	1	00:17:09	00:00:00	49	00:53:54	00:01:02	2	00:30:05	00:00:05
3	37	00:17:48	00:00:39	23	00:53:22	00:00:30	3	00:30:29	00:00:29
4	11	00:17:24	00:00:15	45	00:53:50	00:00:58	4	00:30:29	00:00:29
5	24	00:17:30	00:00:21	39	00:53:39	00:00:47	5	00:30:40	00:00:40
6	61	00:18:11	00:01:02	5	00:53:00	00:00:08	6	00:30:44	00:00:44
7	6	00:17:21	00:00:12	44	00:53:47	00:00:55	7	00:30:46	00:00:46
8	21	00:17:29	00:00:20	35	00:53:37	00:00:45	8	00:31:08	00:01:08
9	45	00:17:57	00:00:48	16	00:53:13	00:00:21	9	00:31:16	00:01:16
10	7	00:17:21	00:00:12	46	00:53:52	00:01:00	10	00:31:17	00:01:17
11	20	00:17:28	00:00:19	43	00:53:47	00:00:55	11	00:31:19	00:01:19
12	62	00:18:11	00:01:02	2	00:52:52	00:00:00	14	00:31:30	00:01:30
13	60	00:18:10	00:01:01	6	00:53:00	00:00:08	13	00:31:22	00:01:22
14	49	00:18:02	00:00:53	4	00:52:59	00:00:07	15	00:31:32	00:01:32
15	63	00:18:11	00:01:02	1	00:52:52	00:00:00	16	00:31:36	00:01:36
16	16	00:17:27	00:00:18	37	00:53:39	00:00:47	19	00:31:41	00:01:41
17	25	00:17:31	00:00:22	34	00:53:37	00:00:45	18	00:31:38	00:01:38
18	54	00:18:07	00:00:58	11	00:53:05	00:00:13	20	00:31:42	00:01:42
19	31	00:17:37	00:00:28	26	00:53:24	00:00:32	22	00:31:50	00:01:50
20	18	00:17:28	00:00:19	32	00:53:37	00:00:45	21	00:31:45	00:01:45
21	19	00:17:28	00:00:19	33	00:53:37	00:00:45	24	00:31:53	00:01:53
22	38	00:17:49	00:00:40	25	00:53:24	00:00:32	26	00:31:55	00:01:55
23	22	00:17:30	00:00:21	38	00:53:39	00:00:47	23	00:31:50	00:01:50
24	65	00:18:13	00:01:04	3	00:52:55	00:00:03	27	00:31:59	00:01:59
25	2	00:17:11	00:00:02	50	00:54:07	00:01:15	25	00:31:53	00:01:53
media	30.4	00:17:40	00:00:31	27.8	00:53:28	00:00:36	14	00:31:17	00:01:17

(figure 02. Table of triathletes and segments)

Segment analysis table

To obtain a table describing the **final performance of the triathletes according to their position obtained in a segment** you must have the following data for each of the athletes to show in the table:

- Final position
- Position in the segment
- Time in the segment
- Time difference in the segment regarding the best segment register

You can get the segment analysis table which presents the final classification of triathletes according to their position in the segment, just sorting the above data by the value of the position in the segment.

	nombre	tiempo cic.	diferencia cic.	ritmo ciclismo	pos final
1	Nicola Spirig	01:03:54	00:00:00	37.6 km/h	6
2	Ai Ueda	01:03:56	00:00:02	37.5 km/h	17
3	Christiane Pilz	01:04:08	00:00:14	37.4 km/h	26
4	Emma Moffatt	01:04:12	00:00:18	37.4 km/h	3
5	Ricarda Lisk	01:04:12	00:00:18	37.4 km/h	15
6	Jessica Harrison	01:04:13	00:00:19	37.4 km/h	12
7	Kiyomi Niwata	01:04:13	00:00:19	37.4 km/h	9
8	Andrea Hewitt	01:04:15	00:00:21	37.4 km/h	8
9	Samantha Warriner	01:04:15	00:00:21	37.4 km/h	16
10	Daniela Ryf	01:04:17	00:00:23	37.3 km/h	7
11	Helen Jenkins	01:04:17	00:00:23	37.3 km/h	21
12	Debbie Tanner	01:04:17	00:00:23	37.3 km/h	10
13	Sarah Haskins	01:04:18	00:00:24	37.3 km/h	11
14	Vanessa Fernandes	01:04:18	00:00:24	37.3 km/h	2
15	Emma Snowsill	01:04:20	00:00:26	37.3 km/h	1
16	Magali Di marco Messmer	01:04:22	00:00:28	37.3 km/h	13
17	Julie Ertel	01:04:23	00:00:29	37.3 km/h	19
18	Juri Ide	01:04:23	00:00:29	37.3 km/h	5
19	Laura Bennett	01:04:23	00:00:29	37.3 km/h	4
20	Kathy Tremblay	01:04:23	00:00:29	37.3 km/h	31
21	Yuliya Sapunova	01:05:18	00:01:24	36.8 km/h	24
22	Tania Haiboeck	01:05:22	00:01:28	36.7 km/h	27
23	Kate Allen	01:05:24	00:01:30	36.7 km/h	14
24	Olga Zausaylova	01:05:24	00:01:30	36.7 km/h	36
25	Ewa Dederko	01:05:24	00:01:30	[illegible]	[illegible]
media		01:04:28	00:00:34	37.2 km/h	14.7

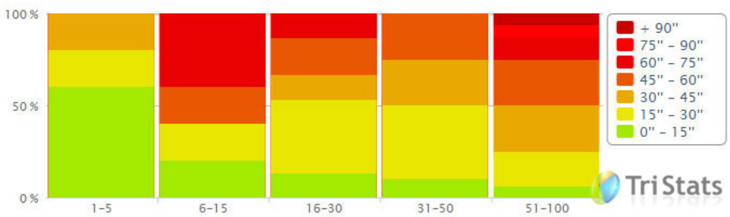
(figure 03. Segment analysis table)

Segment analysis graph

From the data in the segment analysis table you can get a graph showing the **relationship between the final position of the triathletes and an interval of time difference** in the segment.

To generate this graph is necessary to consider one group of triathletes according to their final position in the competition and intervals of time difference as to the best triathlete in the segment.

The chart obtained shows what percentage of each group of athletes has made the segment analyzed within each of the previously established time intervals.



(figure 04. Segment analysis graph)

This chart shows visually the relationship between final position and time difference in getting the best part (the expected behavior is that the best positions in the final classification should be in smaller intervals of time difference regarding worst positions in the classification which will be at intervals greater time difference).

Percentage positions table

From the data in the segment analysis table is possible to obtain a new table describing the **final performance of groups of triathletes according to their position in a segment**.

To generate this table is necessary to consider one group of triathletes according to their final position in the segment and a group final positions in the competition.

You can get the table of percentages of segment, which shows what percentage of each segment group triathletes managed to complete the competition within each of the groups previously established final positions, just sorting the above data by the value of the position in the segment.

	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	+40	DQ
1-5	76.7 %	17.3 %	2 %	1.3 %	1.3 %	0.7 %			0.7 %	
6-10	15.3 %	63.3 %	14.7 %	2.7 %	1.3 %	0.7 %	1.3 %	0.7 %		
11-15	4.7 %	14 %	50 %	14.7 %	5.3 %	6.7 %	1.3 %	2 %	0.7 %	0.7 %
16-20	2 %	4.7 %	22 %	47.3 %	10.7 %	4 %	4 %	2 %	2.7 %	0.7 %
21-25		0.7 %	9.3 %	21.3 %	44 %	11.3 %	8 %	2 %	3.3 %	
26-30	0.7 %		2 %	8.8 %	24.3 %	44.6 %	14.2 %	1.4 %	4.1 %	
31-35	0.7 %			2.9 %	9.6 %	22.8 %	40.4 %	13.2 %	10.3 %	
36-40				1.7 %	4.2 %	9.2 %	25.2 %	43.7 %	[illegible]	
+40					0.8 %	2.1 %	3.3 %	15.4 %	78.4 %	

(figure 05. Percentage positions table)

This table is used to visually observe the relationship between the position in the segment and the final position (the expected behavior is that the best positions in the segment should be at intervals of final rankings on best to worst positions in the segment, which will be in intervals worst final rankings).

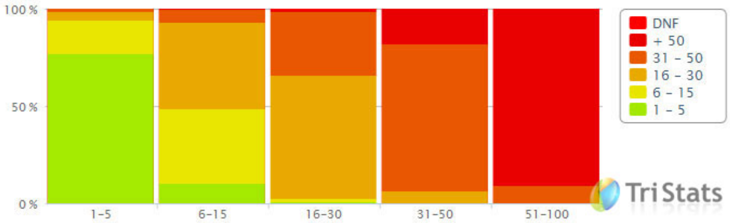
This expected behavior is true to a greater or lesser extent depending on the segment analyzed although the general trend by analyzing a set of tests of a circuit which causes more accurately meet the expected behavior.

Segment percentages graph

You can get a graph showing the **relationship between the final performance of groups of triathletes with their position obtained in a segment**, just from the data in percentage positions table.

To generate this graph is necessary to consider one group of triathletes according to their final position in the segment and a group of final positions in the competition.

The graph obtained shows what percentage of each segment group triathletes managed to complete the competition within each of the final positions groups previously established.



(figure 06. Segment percentages graph)

This chart shows visually the relationship between the position in the segment and the final position (the expected behavior is that the best positions in the segment should be at intervals of final rankings on best to worst positions in the segment, which will be in intervals worst final rankings).

Conclusions

The method, therefore, provides information that at first glance, but insight into a very experienced coach, we can't observe.

Information focuses primarily on obtaining information on:

- Triathletes
- Events
- Circuits
- Countries

These data may be referred to the individual analysis (a triathlete, a test circuit, a country), group and compared (several triathletes, several tests, several circuits, several countries). In this way we can know what the general requirements in any desired position to **compete with guarantees** in a given circuit (continental cup, world cup, world championship series ...). It also allows to **check the evolution** in time, in the desired range of any data.

Another important application of the method is that it allows shelling which is the **performance profile of any triathlete** or group of triathletes and fit the individual profile within the general profile, **knowing strengths and weaknesses**, own and others.

In this way the coach or trainer, and the triathlete, have valuable information that should allow an **optimization of the decision making process of training**, with the aim of improving performance of the triathlete.

As an example **we applied this method** to analyze firstly the **relationship between the position in the swim segment and the final result during the World Cup cycle 2005-2008** and, secondly, the **performance requirements in the segments of swim and run, for the top 15 positions in the World Championship Series 2010**.

The method has been applied to **both male and female categories** and have obtained the following:

a) World Cup 2005-2008. Men

Data on the podium positions (1, 2, 3):

- The 52'3% of the podium positions were achieved by triathletes who have swum in the top 10 positions.

- The **82'69% of the podium positions** were achieved by triathletes who have **swum in the top 20 positions**.

- The 67'29% of the podiums have been made by triathletes who swam in less than 20" difference to best register in the segment.

- The **84'27% of the podiums** have been made by triathletes who **swam in less than 30" difference to best** register in the segment.

Information concerning the top-10 positions:

- The 38’1% of the top-10 positions have been won by triathletes who have swum in the top 10 positions.

- The 65’4% of the top-10 positions have been won by triathletes who have swum in the top 20 positions.

	1-10	11-20	21-30	31-40	41-50
1-10	38.1 %	22.9 %	13 %	7.9 %	5.5 %
11-20	27.3 %	25.5 %	18 %	14.2 %	5.7 %
21-30	16.8 %	22.2 %	24.6 %	15.6 %	6.6 %
31-40	9.2 %	13.3 %	21 %	21.8 %	13.1 %
41-50	7.4 %	11.5 %	15.3 %	21.3 %	17.7 %

(figure 07. Percentage positions table in the swim segment)

- The **82’2% of the top-10** positions have been won by triathletes who have **swum in the top 30 positions**.

- The occupancy rate of **places 4-10 getting out of the water in less than 40"** difference is **84'90%.**

b) World Cup 2005-2008. Women

Data on the podium positions (1, 2, 3):

- The 60'32% of the podium positions were achieved by triathletes who have swum in the top 10 positions.

- The **90'49% of the podium positions** were achieved by triathletes who have **swam in the top 20 positions**.

- The 72'32% of the podiums have been made by triathletes who swam in less than 30" difference to best register in the segment.

- The **82'37% of the podiums** have been made by triathletes who **swam in less than 40" difference to best** register in the segment.

Information concerning the top-10 positions:

- The 48’6% of the top-10 positions have been won by triathletes who have swum in the top 10 positions. Those who swam between positions 11-20 were 28’9% of the final top-10.

	1-10	11-20	21-30	31-40	41-50
1-10	48.6 %	24.6 %	10.2 %	5.1 %	1.1 %
11-20	28.9 %	32.1 %	19.5 %	4.9 %	2.3 %
21-30	16.6 %	26.7 %	27.3 %	11 %	4.7 %
31-40	8.2 %	16.3 %	27.6 %	19.2 %	5.1 %
41-50	3.8 %	10.3 %	19.2 %	23.5 %	16.4 %

(figure 08. Percentage positions table in the swim segment)

- **77'5% of the top-10 positions** have been won by triathletes who have **swum in the top 20 positions**.

c) **World Championship Series 2010. Men**

Data concerning the top 15 positions of the 7 events of the circuit:

- You need to **swim in 18'05''** in position 24.1, at 21'' to best register in the segment.

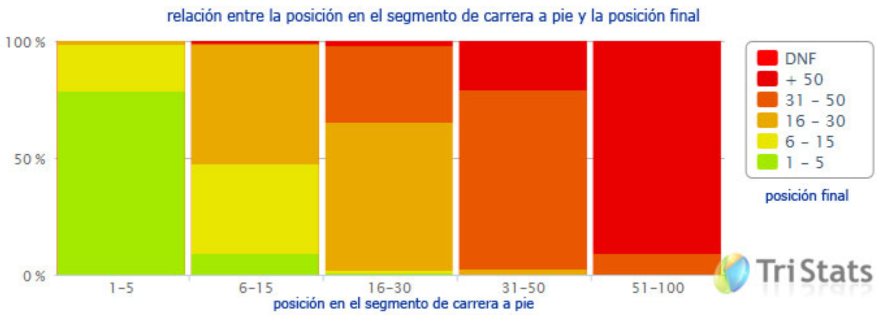
#	pos nat.	tiempo natación	diferencia natación	pos cic.	tiempo ciclismo	diferencia ciclismo	pos car.	tiempo carrera	diferencia carrera
1	10.8	00:17:52	00:00:08	28.2	00:57:46	00:00:55	3.7	00:30:36	00:00:18
2	14.7	00:17:54	00:00:10	35.7	00:58:07	00:01:16	2	00:30:27	00:00:09
3	19.2	00:18:00	00:00:16	30	00:58:00	00:01:09	3.7	00:30:46	00:00:28
4	12	00:17:54	00:00:10	30.5	00:57:51	00:01:00	9.5	00:31:09	00:00:51
5	24.7	00:18:06	00:00:22	22.8	00:57:38	00:00:47	10.3	00:31:14	00:00:56
6	34.7	00:18:18	00:00:34	20.7	00:57:49	00:00:58	6.7	00:31:02	00:00:44
7	22.5	00:18:03	00:00:19	28.8	00:58:13	00:01:22	5	00:30:52	00:00:34
8	19.7	00:17:58	00:00:14	26.8	00:58:07	00:01:16	9	00:31:13	00:00:55
9	28.8	00:18:11	00:00:27	22.8	00:57:57	00:01:07	8.7	00:31:13	00:00:56
10	8	00:17:51	00:00:07	38.3	00:58:16	00:01:25	10.8	00:31:21	00:01:04
11	24.2	00:18:05	00:00:21	29.5	00:58:11	00:01:20	9.5	00:31:19	00:01:01
12	36.8	00:18:15	00:00:31	20.5	00:58:00	00:01:09	11.2	00:31:28	00:01:10
13	35.5	00:18:18	00:00:34	19.5	00:57:58	00:01:07	12	00:31:28	00:01:10
14	36	00:18:22	00:00:38	17	00:57:39	00:00:48	15.5	00:31:47	00:01:29
15	33.5	00:18:11	00:00:27	21.8	00:58:02	00:01:12	14.8	00:31:41	00:01:24
media	24.1	00:18:05	00:00:21	26.2	00:57:58	00:01:07	8.8	00:31:10	00:00:53

(figure 09. Table of triathletes and segments. World Championship 2010 men)

- You need to **run in 31'10''**, at 53'' to best register in the segment.

- Those who **swim in less than 30'' difference** to best register get the **82'22% of the top-15 places**.

- **Those who ranked 1-5 are the best swimmers and runners**.



(figure 10. Segment analysis graph. World Championship 2010 men)

d) World Championship Series 2010. Women

Data concerning the top 15 positions of the 7 events of the circuit:

- You need to **swim in 19'39''** in a position 17.4, at 25'' difference to best register in the segment.

#	pos nat.	tiempo natación	diferencia natación	pos cic.	tiempo ciclismo	diferencia ciclismo	pos car.	tiempo carrera	diferencia carrera
1	24	00:19:44	00:00:30	11.7	01:02:26	00:00:25	1.5	00:34:18	00:00:15
2	20.8	00:19:42	00:00:28	15.7	01:02:29	00:00:28	3.2	00:34:39	00:00:37
3	12.2	00:19:33	00:00:20	20.3	01:02:37	00:00:36	3.3	00:34:39	00:00:37
4	20.3	00:19:46	00:00:32	14.7	01:02:23	00:00:22	5	00:34:46	00:00:44
5	17.3	00:19:38	00:00:24	15.7	01:02:32	00:00:31	4.8	00:34:58	00:00:55
6	17.5	00:19:39	00:00:25	16.5	01:02:30	00:00:29	5.8	00:35:04	00:01:02
7	10	00:19:29	00:00:15	23	01:02:42	00:00:41	8.5	00:35:14	00:01:11
8	6.5	00:19:26	00:00:13	24.3	01:02:44	00:00:43	9.3	00:35:26	00:01:24
9	14.8	00:19:37	00:00:23	17	01:02:33	00:00:32	10.2	00:35:30	00:01:28
10	15.5	00:19:31	00:00:17	19.8	01:02:40	00:00:39	13	00:35:45	00:01:42
11	25.5	00:19:52	00:00:38	11.8	01:02:19	00:00:18	14.5	00:35:57	00:01:55
12	13.5	00:19:35	00:00:21	18.7	01:02:35	00:00:34	15.7	00:36:03	00:02:00
13	21	00:19:41	00:00:27	14.8	01:02:28	00:00:27	17.2	00:36:14	00:02:11
14	17.5	00:19:41	00:00:27	22.8	01:02:47	00:00:46	15.2	00:36:04	00:02:02
15	24.5	00:19:49	00:00:36	16	01:02:28	00:00:27	19	00:36:23	00:02:21
media	17.4	00:19:39	00:00:25	17.5	01:02:33	00:00:32	9.7	00:35:24	00:01:21

(figure 11. Table of triathletes and segments. World Championship 2010 women)

- You need to **run in 35'24''** at 1'21'' difference to best register in the segment.

- Those that **swim in less than 30'' difference** to best register get the **74'44% of the top-15 places**.

- **The triathletes ranked in the 6-10 positions are the best swimmers, and those who are ranked in the 1-5 are the best runners**.

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Cognitive strategies, perceived exertion and running performance.

De la Vega R[1], Rivera O.[2], Segovia JC[3], Ramos JJ[3], Hernández JM[1], Ruiz R[1] .

1) Universidad Autónoma de Madrid.

2) Máster Psicología del Deporte (UAM-COE)

3) Universidad Complutense de Madrid.

First Author (Presenting Author)	
Last Name	De la Vega
First Name	Ricardo
Affiliation	Universidad Autónoma de Madrid
Email	ricardo.delavega@uam.es

Keywords

Association, Dissociation, Attention Focus, Fatigue, Running Economy

Summary

The purpouse of the present study was to determinate which is the cognitive strategies effect on the perceived exertion (central & peripheral) while the workload speed and the associative and dissociative task are controlled. Long distance runners N = 20 (6 women) a mean age of 31.25 (SD = 8.74) years, with a running experience of 9.65 (SD = 7.72) years volunteered for the study. Every runner performed a control task for both cognitive strategies associative and dissociative while performing a 55 minutes treadmill run at the aerobic threshold workload speed. The result showed that there was no difference in central & peripheral percieved exertion between associative and dissociative task (RPE cental mean 10.54, SD = 2.24 & 10.44, SD = 3.30; RPE peripheral mean

10.74, SD = 2.58 & 10.57, SD = 2.29). Furthermore there was no differences in oxygen consumption between associative (VO_2 mean 39.40 mL/Kg/Min, SD = 8) & dissociative (VO_2 mean 38.80 mL/Kg/Min, SD = 4.05). During a running at aerobic threshold speed the perceived exertion and oxygen consumption are not determined by the use of association and dissociation strategies.

Resumen

El propósito del presente estudio fue determinar cuál es el efecto de las estrategias cognitivas en la percepción subjetiva de esfuerzo (central y periférica) cuando se controla tanto la intensidad del ejercicio y uso de las estrategias de asociación y disociación. Participaron voluntariamente corredores de fondo N = 20 (6 mujeres) con un promedio de edad de 31.25 (DE = 8.74) con una experiencia media de 9.65 (DE = 7.72) años. Cada corredor realizó una tarea control para ambas estrategias; asociativa y disociativa mientras corría 55 minutos a la velocidad del umbral aeróbico. Los resultados indican que no hubo diferencia en la percepción subjetiva de esfuerzo de los corredores en función de las estrategias asociativa y disociativa (RPE central mean 10.54, DE = 2.24 & 10.44, DE = 3.30; RPE periférica mean 10.74, DE = 2.58 & 10.57, DE = 2.29). El consumo de oxígeno tampoco presento diferencias respecto a la estrategias asociativa (VO_2 mean 39.40 mL/Kg/Min, DE = 8) y disociativa (VO_2 mean 38.80 mL/Kg/Min, DE = 4.05). Mientras se realiza una carrera a la velocidad del umbral aeróbico la percepción subjetiva de esfuerzo y el consumo de oxígeno no están determinados por uso de las estrategias de asociación y disociación.

Introduction

Triathlon is the perfect venue to allow athletes to push their limits, physically and mentally, the need to perform at an excellent level make it one of the most demanding sports. What happens in the mind of the athlete while making an effort? In order to understand what happened in the athlete`s mind during a endurance running Morgan & Pollock6 provide the concepts of cognitive strategies of association (monitory sensory input like breathing, muscular pain, fatigue & heart rate to adjust the running pace) and dissociation (distract the attention out of the sensory input to avoid fatigue). Previous studies have suggested that associative strategies are related to a better performance [2,3,4,6,7] some have showed that dissociative strategies decreased subjective effort perception [1,5,7,9,10] and furthermore can improve the running economy. [8] The purpouse of the present study is to determinate which is the cognitive strategies effect on the perceived exertion while the workload speed and the associative and dissociative task are controlled.

Materials and methodology

Twenty trained (6 women) long distance runners with a mean age of 31.25 (SD = 8.74) years, with a running experience of 9.65 (SD = 7.72) years volunteered for the study. The study protocol consisted in 3 sessions, the first to determinate the aerobic threshold for the setting of the individual workload speed, every runner performed a control task (using a specialized mobile application and software) for both cognitive strategies associative (focus on breathing) and dissociative (focus on a visual target during a presentation) while performing a 55 minutes (+ 3 warmup) treadmill run at the aerobic threshold workload speed, in order to determinate the perceived exertion the RPE 6-20 Borg Scale (central & peripheral) values were obtained at intervals of 5 minutes, to establish differences in running economy oxygen consumption (VO_2) was measured continuously using a breath by breath procedure and average VO_2(mL/Kg/Min) values from minutes 6-55 were calculated.

Results

Total and 3 stages average RPE and VO_2 values were analyzed, the results showed that there was no difference in central *(Z= -0.403; p> 0.05)* & peripheral *(Z= -0.504; p >0,05)* RPE values between associative and dissociative task (RPE cental mean 10.54, SD = 2.24 & 10.44, SD = 3.30; RPE peripheral mean 10.74, SD = 2.58 & 10.57, SD = 2.29). During a 55 minutes race both associative & dissociative sessions had an effect on central $(X^2_{(2)}= 23.74\ ;\ p<0.001,\ X^2_{(2)} = 24.40;\ p<0.001)$ & peripheral $(X^2_{(2)} = 26.69;\ p<0.001,\ X^2_{(2)} = 24{,}71;\ p<0.001)$ perceived exertion. Furthermore there were no differences in oxygen consumption between associative (VO_2 mean 39.40 mL/Kg/Min, SD = 8) & dissociative (VO_2 mean 38.80 mL/Kg/Min, SD = 4.05) task *(Z= -0.224; p> 0.05)*.

Discussion and conclusions

The controlled use of association and dissociation strategies during a treadmill race at aerobic threshold speed did not affect the perceived exertion and the oxygen consumption. When the workload speed is controlled the use of associative strategy does not cause an increased in the perceived exertion despite the athletes were focused on their breathing. Moreover, the distraction of the sensory input during running was not related with a better running economy. At aerobic threshold speed the perceived exertion and running economy are not determined by the use of association and dissociation strategies.

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