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Consequences of the Three Disciplines on the Overall Result in Olympic-distance Triathlon

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Abstract. Olympic-distance triathlon (OD) is a multidisciplinary sport that comprises three different disciplines which are conducted in succession. Overall triathlon time consists of the three disciplines and the two transition times between the three disciplines. In order to achieve the fastest overall time possible, the times needed for each discipline have to be minimized. The aim of the study was to determine the effects of the three disciplines on the overall result in the OD. Methods: Overall times and rankings as well as rankings and times for each of the three disciplines (swimming, cycling, and running) of all elite athletes (participations of the world championship) who competed in the men`s Olympic-distance triathlon world championships between 2004 and 2007 were analyzed. The sample consisted of 318 athletes, ten of which competed in all of the world championships from 2004 to 2007. Results: The highest correlations (pearson coefficient) between the times of the individual disciplines and the overall time can be found for the run. The correlations were even higher for the 20 best-placed athletes. An athlete`s placing after the swim or the cycle has little prognostic relevance for his final placing. Statistical clearing of variance shows the greatest effect for the run. Conclusions: The swim and the cycle act as so-called feeders for the run and have to lay the foundations for the run, which decides over winning or losing more than the other two disciplines. Judging from an efficiency-oriented perspective, triathletes should emphasize training the run rather than emphasising the swim or the cycle.

Key Words: prognostic relevance, success, economic considerations, drafting, competition.

1. Introduction

The Olympic-distance triathlon (OD) consists of a 1.5-km swim, a 40-km cycle, and a 10-km run. The overall result of a triathlon race consists of the sum of the times needed for each discipline, the transition between the swim and the cycle and the transition between the cycle and the run. Successful male athletes at elite international level need between 01:45 and 02:00 hours for the overall distance. Overall times differ depending on the distance profile, geographic, and climatic factors, as well as on specific tactical and technical elements. In order to be on an elite international level the following split times are necessary: 17:00 to 19:00 minutes for the swim, 50:00 to 55:00 minutes for the cycle and 30:00 to 32:00 minutes for the run. When looking at how total competition times break down into the times needed for each of the three disciplines, it can be stated that elite triathletes spend circa 15% of their total competition time in the water, circa 55% on the bicycle and the run accounts for circa 29% of total competition time (Landers et al., 2008). Both transitions together account less than 1% of total competition time (Millet et al., 2000). The same tendency can be found when analyzing how much time elite triathletes spend on training the three different disciplines (Millet et al., 2002). On average they swim 1,000 to 1,250 km (7% of total training distance), cycle 10,000 to 13,500 km (72% of total training distance), and run 2,800 to 4,000 km (21% of total training distance).

In order to be competitive on an elite level in Olympic triathlon, the times required for each of the three disciplines have to be reduced to the greatest extent possible. The ideal triathlete would, therefore, be a person who swims faster, cycles faster and runs faster than all of his or her competitors and needs less time

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for the transitions. However, such an athlete can hardly be found since every athlete has got his or her individual strengths and weaknesses, but most of the athletes are competitive on an international level in each individual discipline.

In Olympic-distance triathlons, drafting in the water and on the bicycle is allowed, whereas drafting is not allowed in ironman-distance triathlons. Triathletes who draft behind other competitors will be disqualified in these competitions (Millet et al., 2004). Drafting is mainly used in sport physiology and biomechanics to describe the tactic of performing a mode of activity in a sheltered position (Brisswalter et al., 2008).

Since the so-called drafting rule was introduced in Olympic-distance triathlons in 1995, cycling performance was reduced (yet cycling is extremely important and challenging from a tactical and technical perspective) and by drafting athletes can substantially reduce their energy expenditure during the cycle (Brisswalter et al., 2008; Chatard et al., 2003; Millet et al., 2004). In order to correct this devaluation of the cycle, the organizers of Olympic-distance triathlons recently often opt for challenging cycle routes.

Studies have shown that by drafting during the swim, water resistance can be reduced by up to 20% for the athlete who swims behind a competitor (Chatard et al., 2003). In cycling energy expenditure can even be reduced by up to 30% for the same speed. This means that triathletes who take advantage of drafting may benefit tremendously and may gain a decisive advantage over their competitors (Brisswalter et al., 2008; Hausswirth et al., 1999; Millet et al., 2000; Vleck et al., 2006). Bentley et al. (2002) emphasize that reduced energy expenditure brought about by drafting is associated with a considerably better running performance. Millet und Vleck (2000) further point out: “Steady state cycling in a sheltered position during the entire cycle of a triathlon led to a considerable reduction in the required energy expenditure at a given speed, and created the conditions for decreased physiological stress at the onset of the triathlon run.” Hausswirth et al. (1999) found significantly reduced heart rates during the cycle, as well as reduced oxygen consumption and reduced lactate levels in athletes who competed in competitions in which drafting was allowed in contrast to those in which drafting was not allowed.

Peeling et al. (2005) showed that reducing intensity during the swim to 90-95% or even 80-85% of maximal intensity has a significant influence on the overall time. Especially cycling performance seems to benefit enormously from sub-maximal swimming intensity: The study by Peeling et al. (2005) shows that the swimming intensity during a sprint distance triathlon does affect the subsequent cycle and overall triathlon performance. Landers et al. (2008) showed that swimming position had a significant influence on triathlon outcome.

This explains why it is not only the endurance capacity of an athlete which decides whether or not he or she is successful. Drafting as a tactic also plays an important role as pointed out by Vleck et al. (2006): “In elite Olympic-distance triathlon, the athletes are allowed to draft during the swimming and cycle stages. This tactic results in a considerable energy saving when compared to exercise in \`isolation´. The athletes who draft may therefore attain a better position in the field than would normally be in line with his or her individual physiological capacity. For this reason, many athletes attempt to position themselves behind athletes of the same or slightly better ability.“ Whereas Vleck et al. (2006) showed that for 24 male triathletes the performance in the swim and the run had a more significant influence on overall performance than the cycle, this article focuses on the following questions:

- To which extent can a general pattern of the interrelation of cycle, swim, and run performance on overall performance be observed?
- Are there differences between certain levels of performance (e.g. all finishers vs. the 20 fastest)?
- Is it possible to identify the decisive discipline via multiple stepwise linear regressions?

The following observations concentrate on the empirical basis of the recent development in Olympic-distance triathlon and individual consequences for potentially successful strategies for athletes are discussed.

2. Methods

In order to assess the relative significance of the three disciplines for overall success in Olympic-distance triathlon on an elite level, individual discipline times and overall placings of the competitors in the world championships (WC) from 2003 to 2007 (elite men) were analyzed. Data analysis was based on the list of results published by the International Triathlon Union ITU (http://www.triathlon.org). Transition times were not listed explicitly in each year. The first transition time was added to swim time and the second transition time was added to the cycle time. The distances of three disciplines can differentiate with different competitions. Besides the distance profiles as well as the geographic profiles can differ (level bicycle, and run distance in Hamburg vs. hilly bicycle distance in Lausanne). The discipline times and rank places were covered to the single competitions. The data of 318 athletes could be analyzed (Queenstown ITU WC 2003 n = 57; Madeira ITU WC 2004 n = 72; Gamagori ITU WC 2005 n = 55; Lausanne ITU WC 2006 n = 68; Hamburg BG WC 2007 n = 66). The actual number of competitors in these world championships exceeded this number but due to drop outs, disqualifications and missing data the sample size was reduced to the data of 318 athletes. The data analyzed consisted of overall the athletes´ overall placings as well as overall times and times for each one of the three disciplines and transition times. Ten athletes competed in every world championships from 2003 to 2007. Description of the results refers to all finishers (all) as well as the top 20 finishers (≤ 20).

3. Statistical Analysis

Statistical analysis included descriptive reference parameters (mean, standard deviation, minimum, maximum) as well as calculations of correlation and multiple stepwise linear regression. Precondition tests were carried out using the usual methods (e.g. K-S-Test for Gaussian distribution). In order to compare the different disciplines, discipline times were z-transformed. Levels of significance were defined as $P < 0.05$. All calculations were carried out using the statistical program SPSS 14.0.

4. Results

The mean times for all disciplines in the world championships 2003 to 2007 are shown in Table 1. Transition times had to be included into the swim and cycle times respectively since they were not listed separately. So the times for the swim include the first transition, and the times for the cycle include the second transition.

Table 1: Times of the individual disciplines of the finishers in the world championships 2003 to 2007

WC	N	Minimum	Maximum	Mean	SD
swim 2003	57	0:17:39	0:19:42	0:18:05	0:00:21
cycle 2003	57	1:02:12	1:10:34	1:05:21	0:01:35
run 2003	57	0:32:08	0:40:44	0:35:26	0:01:48
total 2003	57	1:54:14	2:08:36	1:58:52	0:03:06
swim 2004	72	0:18:55	0:20:31	0:19:37	0:00:21
cycle 2004	72	0:51:27	0:55:32	0:52:56	0:01:09
run 2004	72	0:29:54	0:39:40	0:32:34	0:01:50
total 2004	72	1:41:05	1:51:02	1:45:08	0:02:36
swim 2005	55	0:18:45	0:19:57	0:19:09	0:00:16
cycle 2005	55	0:58:09	1:02:27	0:59:04	0:00:44
run 2005	55	0:31:35	0:40:35	0:34:24	0:02:01
total 2005	55	1:49:32	2:00:39	1:52:37	0:02:23
swim 2006	68	0:18:01	0:19:35	0:18:42	0:00:24
cycle 2006	68	1:01:50	1:12:11	1:04:48	0:02:13
run 2006	68	0:30:47	0:38:18	0:33:31	0:01:38
total 2006	68	1:51:34	2:07:26	1:57:01	0:03:32
swim 2007	66	0:17:42	0:18:46	0:18:20	0:00:14
cycle 2007	66	0:54:59	0:58:25	0:55:59	0:01:11
run 2007	66	0:29:42	0:38:00	0:32:19	0:01:36
total 2007	66	1:43:18	1:54:46	1:46:38	0:02:23

Since total time consists of the addition of the three discipline times and the two transitions the variable total time (100%) could be determined by multiple stepwise linear regressions. Table 2 shows the regression coefficient of the predictor variable as well as the R-square for all finishers. In 2003, 2004, 2005, and 2007 the run was the predictor variable with the highest value. Variance clarification is between 71.8% and 90.5%. In 2006, the cycle had the highest variance clarification (82.4%). Potential correlations between the individual discipline times and overall times were analyzed and are shown in Table 3. The highest correlation found between overall time and running time. Between swimming time and overall time the correlation was lower, and partly negative.

Table 2: Regression coefficients of the multiple stepwise linear regressions (R) as well as R^2 of the individual discipline times in the world championships (WC) 2003 to 2007 for all finishers

	WC 2003		WC 2004		WC 2005		WC 2006		WC 2007	
model	R	R^2	R	R^2	R	R^2	R	R^2	R	R^2
1	.860[a]	.740	.863[a]	.746	.951[a]	.905	.908[d]	.824	.848[a]	.718
2	.995[b]	.990	.994[b]	.987	.994[b]	.987	.995[e]	.989	.996[b]	.992
3	1.00[c]	1.00	1.00[c]	1.00	1.00[c]	1.00	1.00[f]	1.00	1.00[c]	1.00

a = run; b = run, and cycle; c = run, cycle, and swim; d = cycle; e = cycle, and run; f = cycle, run, and, swim

Table 3: Coefficients of correlations for the swim, cycle, run and total time for all finishers as well as for the top 20 finishers in the world championships 2003 to 2007

	WC 2003		WC 2004		WC 2005		WC 2006		WC 2007	
time	all	≤ 20	all	≤ 20	all	≤ 20	all	≤ 20	all	≤ 20
swim	.565**	-.055	.414**	-.152	.031	.147	.515**	.337	.508**	.421
cycle	.842**	.573**	.760**	.189	.627**	.051	.908**	.214	.755**	-.227
run	.860**	.637**	.863**	.994**	.951**	.980**	.803**	.618**	.848**	.993**

** significant P < 0.01 (two-tailed)

Figure 1 shows the times for each discipline and the corresponding z-data as well as overall times of the best 20 athletes who participated in the 2007 world championships in Lausanne. Since this is the data of the 20 best finishers, z-data is negative. The larger the difference to zero, the better the performance is in that discipline and in overall placing respectively.

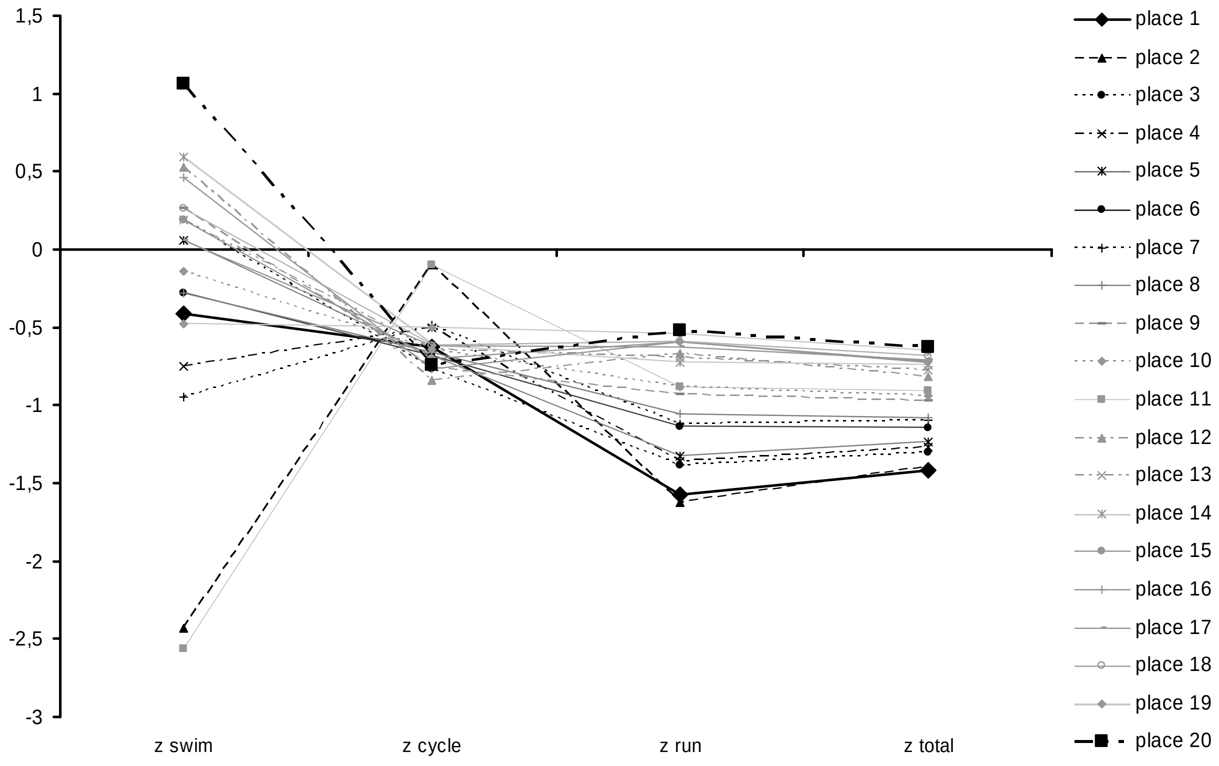

Figure 4: Z-values of the three disciplines and the total rank for the best 20 athletes

5. Discussion

The correlation coefficient and the multiple stepwise linear regressions show that running performance is highly associated with overall time and overall placing in Olympic-distance triathlon (Dengel et al., 1989). Applying the same statistical method (multiple stepwise regression analysis) Schabort et al. (2000) found a highly significant (r = 0.90; P < 0.001) relationship between predicted race time from laboratory measures and actual race time. Sleivert and Wenger (1993) pointed out that the only significant predictor of overall triathlon time for male athletes was running time ventilatory threshold (VT) (r = -0.78). This means that an above-average running performance is essential for placing well in Olympic-distance triathlon. These results support what Vleck et al. (2006) found in their study: "The faster runners in the pool of athletes recruited for this study were eventually the better athletes overall in the race […] this indicates the importance of running in an elite Olympic-distance triathlon." It is economically rational for triathletes who are better runners than their competitors to limit their energy expenditure during the swim and cycle to the lowest extend possible (Dengel et al., 1989; Sleivert et al., 1996). Empirical data also shows that swimming performance has a selective relevance in terms of getting in a good position for the cycle (Peeling et al., 2005). In addition, the first 400 meters in swimming are very important for the further performance in triathlon, especially during a world cup event. Vleck et al. (2006) found a significant correlation between the overall finishing position and the position after the swim ($r = 0.44$; $P < 0.05$). Moreover, the way of drafting in the cycling had a major influence on running performance (Hausswirth et al., 1999; Hausswirth et al., 2001).

The data at hand is in agreement with the findings of Millet and Bentley (2004): They found correlations between overall triathlon performance and individual times of the three disciplines, and confirm that cycling and running are more important for overall SD triathlon performance than swimming. However, the strength of the correlation was lower with swimming than with cycling or running. Nevertheless, the swimming stage of an SD triathlon is probably more important mainly for tactical reasons in the subsequent draft legal cycle stage.

Similar conclusions are drawn by Bentley et al. (2002) who studied the correlation between physiological parameters during the three disciplines. Training the swim resulted in specific adaptations which lead to improvements in the swim but did not improve cycling or running performance. Millet et al. (2002) recommend a combination of cycling and running training in order to improve running performance. If physiological parameters like VO_{2peak} and ventilatory threshold (VT) are not available, running time can be used to predict overall competitive success in Olympic-distance triathlon (De Vito et al., 1995).

Triathletes who are above-average cyclists must try to finish the cycle ahead of those competitors who are better runners if they want to keep a chance to place well. In contrast to that, Vercruyssen et al. (2005) showed that choosing a low cadence during the final minutes of the cycle improves subsequent running time to fatigue. Furthermore, Tew (2005) found that a slow cadence condition was associated with a significantly lower heart rate and ventilation during cycling than in the faster cadence condition. At this point a general recommendation cannot be given as to which strategy is the better one. This decision has to be made based on the athlete´s individual condition.

Generally speaking, it has to be stated that those triathletes who are able to reach average times in two of the three disciplines and above average times in one discipline, have better chances of placing well in Olympic-distance triathlon competitions if running is their outstanding discipline. In order to place well in Olympic-distance triathlons at an elite level (world championships) running times of about 30:00 minutes are necessary (cf. Table 1, as well as http://www.triathlon.org). The results at hand show that drafting does have a significant influence on the overall finishing times and placings of elite triathletes in Olympic-distance competitions (Hausswirth et al., 1999; Hausswirth et al., 2001). Swim and cycle performance, respectively, are important in order to get into a good position for the following discipline and to avoid being so much behind the competitors before the run that the lost time cannot be made up for during the run. However, energy expenditure during the swim and the cycle should be kept as low as possible since it could be shown that running performance is of outstanding relevance for the overall success in Olympic-distance triathlon (Brisswalter et al., 2008). Drafting during the swim and the cycle must be considered an important tactical action that enables the athlete to swim and cycle at sub maximal intensity which reduces this athlete´s energy expenditure during these two disciplines, saves energy for the run and can therefore decide the outcome of a competition (Brisswalter et al., 2008; Peeling et al., 2005). Furthermore studies on pedalling cadence in cycling showed that it had an influence on the running stage (Bernard et al., 2003; Tew, 2005; Vercruyssen et al., 2005).

6. Practical application and limitation of the study

Several recommendations can be derived from these findings: First of all it has to be pointed out that running performance is a more important criterion for overall success in Olympic-distance triathlon than swimming or cycling performance. This means that individual weaknesses in swimming or cycling performance can be compensated by an above average running performance. When planning and evaluating training programs for Olympic-distance triathlon an emphasis should be put on training the run. Competition times of ≤ 29:30 minutes or at least ≤ 30:00 minutes for the run must be accomplished in order to win or place among the top finishers, most of whom run the first as well as the final 1,000-m of the run in less than 2:50 minutes respectively (personal communication, National Head Coach of the German Triathlon Union). Sprint training should also be practised since often a competition is so close that there is a sprint at the final meters of the run. Moreover, tactical behaviour within a team should be considered and also practised.

Athletes whose running performance is not adequate to compete successfully in Olympic-distance triathlon should consider to compete in the longer distances (middle to Ironman distances) since swimming and cycling are relatively more decisive in the longer distances than they are in Olympic-distance triathlon (Abbiss et al., 2006). Each athlete has to have his training program individually planned and evaluated in order to find the optimal cost-benefit ratio of training input for each discipline that results in an optimal overall output.

The importance of running performance in Olympic-distance triathlon should also be considered in talent scouting. Young athletes who run the 5,000-m or 10,000-m in track and field successfully but whose potential might not be sufficient for being successful on an elite international level, may still be able to excel in Olympic-distance triathlon and should therefore be convinced to switch from track and field to Olympic-distance triathlon.

Another aspect that should be considered within a team is how weaker runners could act strategically during the run in order to improve their team-mates´ chances of winning. The performance of a triathlon team does also depend on how effectively the coaches´ orders during the competition can be implemented by the athletes (e.g. good cyclists close a gap for the best runner etc).

Considering economic aspects it must be concluded that the common training programs for Olympic-distance triathlon should be reconsidered and thought over. Limitations of this study are the lack of precise information about the courses (details of the profile) and that transition times were not listed explicitly for all competitions. Another limitation is that there is no data available concerning the athletes` training strategies and personal records for each of the respective disciplines.

7. References

[1] G.J. Landers, B.A. Blanksby, T.R. Ackland, R. Monson. Swim positioning and its influence on triathlon outcome. *International Journal of Exercise Science*. 2008, **1**(3): 96-105.

[2] G.P. Millet, V.E. Vleck. Physiological and biomechanical adaptations to the cycle to run transition in Olympic triathlon: review and practical recommendations for training. *British Journal of Sports Medicine*. 2000, **34**: 384-390.

[3] G.P. Millet, R.B. Candau, B. Barbier, T. Busso, J.D. Rouillon, J.C. Chatard. Modelling the transfer of training effects on performance in elite triathletes. *International Journal of Sports Medicine.* 2002, **23**: 55-63.

[4] G.P. Millet, D.J. Bentley. The physiological responses to running after cycling in elite junior and senior triathletes. *International Journal of Sports Medicine*. 2004, **25**: 191-197.

[5] J. Brisswalter, C. Hausswirth. Consequences of drafting on human locomotion: benefits on sports performance. *International Journal of Sports Physiology and Performance*. 2008, **3**(1): 3-15.

[6] J.C. Chatard, B. Wilson. Drafting distance in swimming. *Medicine and Science and Sports and Exercise*. 2003, **35**(7): 1176-1181.

[7] C. Hausswirth, D. Lehénaff, P. Dréano, K. Savonen. Effects of cycling alone or in a sheltered position on subsequent running performance during a triathlon. *Medicine and Science and Sports and Exercise.* 1999, **31**(4): 599-604.

[8] V.E. Vleck, A. Brügi, D.J. Bentley. The consequences of swim, cycle, and run performance on overall result in elite Olympic distance triathlon. *International Journal of Sports Medicine*. 2006, **27**: 43-48.

[9] D.J. Bentley, G.P. Millet, V.E. Vleck, L.R. McNaugthon. Specific aspects of contemporary triathlon: implications for physiological analysis and performance. *Sports Medicine*. 2002, **32**(6): 345-359.

[10] P.D. Peeling, D.J. Bishop, G.J. Landers. Effect of swimming intensity on subsequent cycling and overall triathlon performance. *British Journal of Sports Medicine*. 2005, **39**: 960-964.

[11] D.R. Dengel, M.G. Flynn, D.L. Costill, J.P. Kirwan. Determinants of success during triathlon competition. *Research Quarterly for Exercise and Sport.* 1989, **60**: 234-238.

[12] E.J. Schabort, S.C. Killian, A.S.T. Gibson, J.A. Hawley, T.D. Noakes. Prediction of triathlon race time from laboratory testing in national triathletes. *Medicine and Science and Sports and Exercise*. 2000, **32**(4): 844-849.

[13] G.G. Sleivert, H.A. Wenger. Physiological predictors of short-course triathlon performance. *Medicine and Science and Sports and Exercise*. 1993, **25**: 871-876.

[14] G.G. Sleivert, D.S. Rowlands. Physical and physiological factors associated with success in the triathlon. *Sports Medicine*. 1996, **22**(1): 8-18.

[15] C. Hausswirth, J.M. Vallier, D. Lehénaff, J. Brisswalter, D. Smith, G. Millet, P. Dréano. Effect of two drafting modalities in cycling on running performance. *Medicine and Science and Sports and Exercise*. 2001, **33**(3): 485-492.

[16] G. De Vito, M. Bernardi, E. Sproviero, F. Figura. Decrease of endurance performance during Olympic triathlon. *International Journal of Sports Medicine.* 1995, **16**(1): 24-28.

[17] F. Vercruyssen, R. Suriano, D. Bishop, C. Hausswirth, J. Brisswalter. Cadence selection affects metabolic responses during cycling and subsequent running time to fatigue. *British Journal of Sports Medicine*. 2005, **39**: 267-272.

[18] G.A. Tew. The effect of cycling cadence on subsequent 10km running performance in well-trained triathletes. *Journal of Sports Science and Medicine*. 2005, (4): 342-353.

[19] T. Bernard, F. Vercruyssen, F. Grego, C. Hausswirth, R. Lepers, J.M. Vallier, et al. Effect of the cycling cadence on subsequent 3 km running performance in well trained triathletes. *British Journal of Sports Medicine*. 2003, **37**: 154-159.

[20] C.R. Abbiss, M.J. Quod, D.T. Martin, K.J. Netto, K. Nosaka, H. Lee, et al. Dynamic pacing strategies during the cycle phase of an Ironman triathlon. *Medicine and Science and Sports and Exercise*. 2006, **38**(4): 726-734.