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Research Article

The use of the Lamberts Submaximal Cycle Test in Triathlon; an exploratory study in young professional sprint triathletes

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Abstract: The Lamberts Submaximal Cycle Test (LSCT) has proven itself as an effective tool to monitor and fine-tune training prescriptions for trained to elite cyclists whilst also being able to reflect identifying early symptoms of fatigue and/or overreaching. Although considered a popular monitoring tool in cycling, it is not clear how well the design of the LSCT relates triathlon performance. Therefore, the aim of this initial study was to determine whether a relationship exists between the LSCT and actual sprint triathlon performance in six young professional triathletes. As part of the study all triathletes performed the LSCT 2 days before the Dutch National Championships, while the relationships with overall and split sprint triathlon times were studied. All triathletes successfully finished the National Championships, with 3 winning their age and gender category. A strong Spearman's rho correlation (rs) between between the power output during LSCT stages 2 and 3 and overall sprint triathlon finishing time (rs = -0.94, p = 0.017). As expected, based on the cycling nature of the LSCT, the best correlations with split triathlon time, were found between LSCT stages 2 and 3 power output and split cycling time (rs = -1.0, p <0.001 and rs = -0.99, p = 0.006, respectively). Slightly weaker relationships were correlations were found with split running time (rs = -0.94, p = 0.016) and swimming time (rs = -0.94, p = 0.017), while no relationships were found with heart rate recovery. Findings yielded by the initial study suggest that the LSCT relates well to both the overall as well as split triathlon performances of professional athletes. Although a larger sample study is needed to confirm and determine the accuracy of the LSCT in a more heterogenous group of triathletes, the findings of this initially study highlight the potential of the LSCT as useful monitoring tool for triathletes.

Keywords: athletic performance; swimming; bicycling; running; physiology; LSCT

1. Introduction

In an ongoing quest to gain the most from training sessions, and consequently to peak at the right time, athletes strive to maintain the optimal balance between training load and recovery. However, finding this elusive balance is often easier said than done as both training load and recovery are influenced by various factors. These variables include: duration, intensity and frequency of training sessions as well as athletes' psychological well-being, nutritional regime and quality of sleep (Jeukendrup, 2002; Kenttä & Hassmén, 1998; Lamberts et al., 2010). In most cases, training prescription and consequent fine-tuning are based on training data and verbal feedback provided by the athletes. In addition, a maximal performance test might be administered two or three times a year, as a more objective measurement of an athlete's training status (Lucía et al. 2000). In the triathlon, performance tests in all three triathlon disciplines (swimming, cycling and running) are thus required once or twice yearly. Although these tests provide coaches with valuable insights as to athletes' training status, their regular administration may interfere with athletes' daily training and/or racing programmes. Performance tests are therefore not wholly suitable as regular monitoring tools (Capostagno et al., 2016; Coutts et al., 2007; Lamberts et al., 2010).

The submaximal test design (Lamberts et al., 2011; Sassi et al., 2006; Sassi et al., 2008) provides a viable alternative to performance tests, especially considering the test's ability to track changes in training status over time. It is important that a submaximal test is reliable, that it relates well to a specific sport and that it is relatively easy to administer. The Lamberts Submaximal Cycle Test (LSCT) adheres to all these criteria. It has been shown to be reliable and it relates well to both peak power output (PPO) and 40-km time trial (TT) performance in trained to elite cyclists (Lamberts et al., 2011, 2014). In addition, the LSCT can be used to successfully monitor and fine-tune training prescriptions (Capostagno, Lambert, and Lamberts 2014, 2019) whilst successfully identifying early symptoms of fatigue and/or overreaching (Decroix et al., 2018; Hammes et al., 2016; Lamberts et al., 2010).

Based on its diagnostic success, as well as similarities between cycling and triathlon, including the high training load of athletes (Landers et al. 2000; Sultana et al. 2012), the LSCT has consequently gained popularity as a practical monitoring tool in the triathlon world. To the best of our knowledge, however, no study to date has investigated how well the LSCT relates to triathlon performance.

As conducting a large sample size study on the LSCT and field triathlon performance poses several logistical challenges, an initial exploratory study was set-up. This initial exploratory study aims to determine if relationships exists between the LSCT and overall and split sprint triathlon time in 6 young professional triathletes. Based on the cycling nature of the LSCT, we hypothesised to find the strongest relationship with split cycling time, while substantially weaker relationships would be found with split running and swimming time, as well as overall finishing time.

2. Materials and Methods

Six professional triathletes, 3 male (19 years [18-19]) and 3 female (20 [18-21]) with a median world ranking position of 516 [314-785] or at 52% [34-86%] of the professional field were included in the study. All six participants were members of the Dutch national selection and either competed in the under 23 or junior race category. Consent from all triathletes, as well as the national head coach, was attained via a signed informed consent from. Ethical approval for the study was granted by the Health Research Ethics committee of Stellenbosch University (C18/10/015). In addition, the study was performed in accordance with declaration of Helsinki (2013)and the international research standards as described by Harris et al. (2019).

Research design

As part of this study, all six triathletes completed the LSCT two days before the Dutch National Sprint Triathlon Championships on 2nd of June 2018 in Rotterdam, Netherlands. All triathletes were familiar with the LSCT as this forms part of their standard training and monitoring protocol. Overall and split finishing times during the Dutch National Sprint Triathlon Champion-ships were downloaded from the organisers' website:
(http://nl.mylaps.com/evenementen/uitslagen/2018).

The Lamberts Submaximal Cycle Test, better known as the LSCT, contains of three stages. During the test athletes were required to: cycle for 6 minutes at 60% of HRmax, 6 minutes at 80% of HRmax and 3 minutes at 90% of HRmax as per Figure 1 (Lamberts et al., 2011, 2014). Power output and cadence heart rate were captured during the test whilst a rating of perceived exertion (RPE) was recorded at each stage. Heart rate recovery was captured directly after the LSCT stage 3, as previously described (Lamberts et al., 2011, 2014, Capostagno et al., 2016).

The LSCT was performed on the triathlete's own bicycle which was mounted on a Tacx cycle ergometer (Tacx Neo Smart T2800). Data were analysed with Training Peaks (TrainingPeaks, USA). Based on the work of Lamberts and Davidowitz (2014) and as the data of the male and female were expressed as absolute values the data could be combined for correlation analyses.

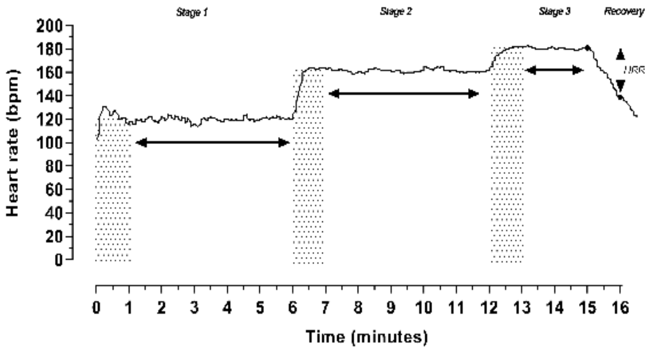

Figure 1. Graphical representation of the LSCT.

The Dutch National Sprint Triathlon Championships were held on 2 June 2018 in Rotterdam, Netherlands. The head coach (LD) instructed all triathletes to perform to the best of their personal abilities.

Statistical analysis

The data were analysed with STATISTICA 13.0 (StatSoft Inc., Tulsa, OK, USA). Based on the small sample, data are expressed as median [interquartile ranges]. Relationships between the LSCT and overall as well as split sprint triathlon times were, in line with the median and median and interquartile ranges (small sample size), analyzed with a Spearman's rho correlation (rs). The following criteria were adopted to interpret the magnitude of the correlation(r) between the measures: < 0.3 weak, 0.3-<0.5 moderate, 0.5-<0.90 good, 0.90-<1.00 strong, and 1.0 perfect. Significance was accepted at $p < 0.05$.

3. Results

All six professional triathletes successfully completed the Dutch National Sprint Triathlon Championships (750m swim, 20km cycle and 5km run). Three of the athletes (50%) won their race and gender category and were crowned Dutch National Champion. Of the other three triathletes, two finished fifth and one finished in twelfth position.

A strong correlation between the triathlete's peak power output (312 W [246-360]) and sprint triathlon performance (rs= -0.83, p = 0.049) indicates that all athletes performed to the best of their ability, as per the national triathlon coach's instruction.

All LSCTs were performed under stable environmental conditions (21.0˚C [20.8-21.0]), two days prior to the National Championships. Median power output and RPE during stages 1, 2 and 3 of the LSCT were 111 [81-128] W (RPE: 8 [7-9]), 204 [138-258] W (RPE: 13 [13-14]) and, 246 [159-324] W (RPE: 16 [15-17]), respectively. Median 60 seconds heart rate recovery after stage 3 was 55 [35-79] bpm.

Individual finishing times and power output during stage 2 and 3 of the LSCT are shown in Figure 2.

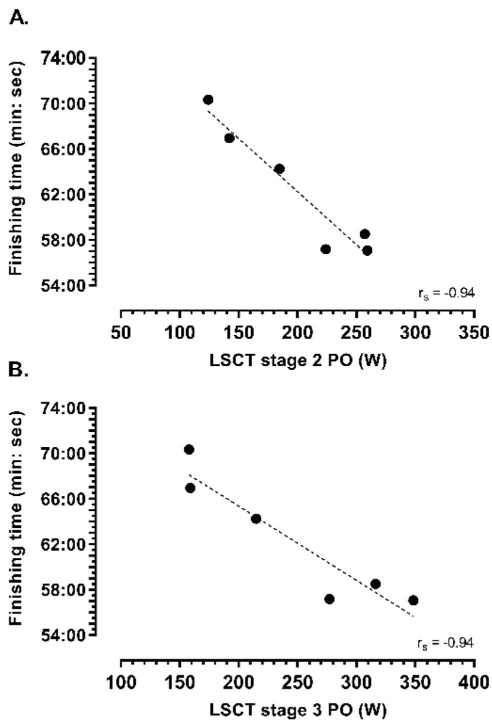

Figure 2. Individual finishing times and LSCT power output during stage 2 (A.) and stage 3 (B.).

Strong relationships were found between median power output during LSCT stages 2 and 3 and overall sprint finishing times (rs = -0.94, p = 0.017), as shown in Table 1.

Within the different triathlon disciplines of swimming, cycling and running, the strongest correlations were found between LSCT stages 2 and 3 power output and split cycling time (rs = -1.00, rs = -0.99, respectively). Lower correlation values were found between power output during LSCT stages 2 and 3 and split run (rs = -0.94, p = 0.017). In line with split running time, similar correlations were found between LSCT stages 2 and 3 and split swim times (rs = -0.94, p = 0.017), as also shown in Table 1.

No relationships were found between HRR and overall finishing times (rs = 0.26, p = 0.658) or split swim (rs = 0.26, p = 0.658), run (rs = 0.26, p = 0.594) or cycle (rs = 0.31, p = 0.658) times.

Table 1. Spearman correlations between LSCT stages 2 and 3 median power output and overall and split sprint triathlon finishing times.

	r_s	p-value
Split swim time		
Stage 2 PO (W)	-0.94	0.017
Stage 3 PO (W)	-0.94	0.017
Split cycle time		
Stage 2 PO (W)	-1.00	<0.001
Stage 3 PO (W)	-0.94	0.017
Split run time		
Stage 2 PO (W)	-0.94	0.017
Stage 3 PO (W)	-0.94	0.017
Overall time		
Stage 2 PO (W)	-0.94	0.017
Stage 3 PO (W)	-0.94	0.017

PO; power output

4. Discussion

Although previous studies investigated correlations between the LSCT and the performances of trained to elite cyclists (Lamberts et al., 2011, 2014), no study up to date has investigated if relationships exists between the LSCT and triathlon performance. In line with the LSCT cycling studies, in which the initial study was done on a small sample size (Lamberts et al., 2009) and later on a large sample size (Lamberts, 2014), the aim of this first exploratory study was to establish relationships between the LSCT and triathlon performance exists in a small sample size of young professional triathletes. In contrast with the cycling studies (Lamberts et al., 2009, 2011, 2014), which studied relationships between the LSCT and laboratory based performance tests, the current study looked at the relationships between the LSCT and field performance data.

The first finding of this study was that a strong Spearman correlation existed between PPO and overall sprint triathlon time (rs = -0.83), which is an indication that all triathletes seem to have performed to the best of their personal capacity. The correlation strength between PPO and sprint triathlon performance is in line with findings by Schabort et al. (2000) who reported a correlation of r = -0.86 between PPO and overall Olympic distance triathlon time in 5 male and 5 female triathletes. In addition, Papavassiliou et al. (2019) reported similar correlations between sprint triathlon finishing time and VO2max during a maximal cycle (r = -0.81) or run (r = -0.76) test.

An even better correlation was noted between power output during LSCT stages 2 and 3 and overall sprint triathlon finishing time (both rs = -0.94). This stronger correlation can likely be explained by multiple factors such as, the similar high submaximal load during races as well as the race characteristics on the day (e.g. sometimes there is one main cycling group, while in other races there are multiple small groups of 3 to 5 riders). In addition, the fact that we recruited a small homogenous group of young elite athletes likely contributed to very high Spearman's correlations values (Swart et al. 2009).

In addition to overall sprint triathlon performance, strong correlations were also noted between split cycling time and LSCT stages 2 (rs = -1.00) and 3 (rs = -0.99) power output. The strength of these correlations are in line with those of the initial cycling study which reported strong correlations between 40-km time trial time and mean power output during LSCT stages 2 (r = -0.84) and 3 (r = -0.92) (Lamberts et al., 2011).

Surprisingly, but in line with the findings of Papavassiliou et al. (2019), strong correlations were noted between median PO during the LSCT and split running time (both rs = -0.94). In line with the correlations between median PO and split cycling time, these were slightly higher than the relationship between running VO2max and sprint triathlon performance (r = -0.76) reported by Papavassiliou et al. (2019).

Due to the essential differences that exist between swimming and cycling, we expected to find a low correlation between median PO and split swimming time. These correlations were, however, surprisingly high (rs = -0.94 for both stages 2 and 3 median PO). These high correlation values can likely be attributed to the low sample size and inclusion of both male and female triathletes.

In contrast to median power output during LSCT stage 2, no correlations were noted between HRR and overall sprint finishing time and/or any of the split times, as per Table 2. This can likely be explained by the homogeneity of the population group. Although HRR in a heterogeneous group of people has shown to be indicative of training status (Capostagno et al., 2016; Daanen et al., 2012; Lamberts et al., 2010), the relationship disappears in a homogenous group of similarly trained individuals (Decroix et al., 2018; Lamberts et al., 2011). In addition, Hautula et al. (Hautala 2006) has shown that HRR is dependent on the polymorphism in acetylcholine receptor M2 and, therefore, partially genetically determined. Although HRR does not seem to be a good predictor of training status and performance in a homogenous group of well-trained athletes, it does seem to be a sensitive marker which reflects changes in training status and/or a state of functional and non-functional overreaching (Decroix et al., 2018; Hammes et al., 2016; Lamberts et al., 2010; Siegl et al., 2017).

Although the findings are in line with other studies with a small sample size (Lamberts et al., 2011; Schabort et al., 2000) and larger sample size (Lamberts, 2014; Papavassiliou et al., 2019), the findings of this study should be interpreted with care. The small sample size and inclusion of both male and female triathletes has likely contributed to the relatively strong relationships. Therefore, the relationships reported in the study should be mainly seen as strong indicators that the LSCT has great potential as a useful monitoring tool for triathletes, rather than overinterpreting the actual relationship values. A larger sample size study, which will Pearson's correlations can be performed, and the associated error of the estimate can be determined, will provide accurate insight into the actual predictive strength of the LSCT for triathlon performance.

However and although it is important to show that a submaximal test has a strong relationship with a specific sport for which it is used (e.g. triathlon), monitoring and fine-tuning of training should be based on the actual submaximal values and not the predicative performance values. In addition, a multi-factorial approach should be used when monitoring athletes as shown and proposed by Lamberts in multiple papers (Decroix et al., 2018; Hammes et al., 2016; Lamberts et al., 2009,2010; Siegl et al., 2017).

In conclusion, this study is the first to indicate that the LSCT relates well to sprint triathlon performance in young professional athletes and, as such, it holds great potential as an effective monitoring tool for triathletes and their coaches.

5. Practical Applications

Although future research would require a larger and more heterogenous sample, the findings of this initial study support the use of the LSCT within the triathlon domain. The potential of this test lies in its capacity to effectively monitor triathletes whilst guiding the fine-tuning of training prescriptions and the detection of symptoms of overreaching.

Currently the LSCT is already is being used by quite a few triathlon organizations and, at least 3 national triathlon federations. The outcomes of the current study support the use LSCT in by triathletes, based on the strong correlations that were found with sprint triathlon performance. Although future research is needed on larger sample sizes, different triathlon distances and how best training prescription within the three disciplines can be guided based on the LSCT, the potential to assist coaches with optimizing training prescription in triathletes by using of the LSCT seems very promising.

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