Discussion

This study is the first to investigate the influence of using different TL methods during a cycling training program on the outcome parameters of the fitness-fatigue model (Banister). The main findings of this study were that, although the TL methods evolve differently over time, they produce a similar error margin when relating TL to performance and that despite this small error margin, the choice of TL-input does lead to a different timing with regard to the moment when training has the greatest positive influence and the timeframe wherein training should be avoided within an individual.

Subjects in this study improved their performance with 16.6 ± 3.0 %, with a considerably high variability in the timing and magnitude of improvement despite the theoretical equal TL for the subjects. Four subjects showed a small to large decrease in performance in the first week of the training period, with five subjects showing a small to large increase during that same period (figure 1). This individuality in training response is also reflected in the parameters (τ, k, t(n) and t(g)) of the fitness fatigue model, contributing to the idea that the application of such a model is only effective when these parameters are individualized. The authors acknowledge the fact that the training modalities used in the present study (i.e. a constant external TL in each session) are not the best way to optimally improve performance, however this approach was chosen in order to isolate the effect of the different TL quantification methods on the output of the model.

Despite keeping the external TL constant throughout the training period, the internal TL showed a clear drop over the course of the study. This drop was more pronounced during the first few weeks of the training period, which could be explained by an increase in blood volume during the first weeks of the study. An increase in blood volume is generally one of the first adaptations to a training program and in turn leads to a greater stroke volume. Given that a constant cardiac output is required for a given power output, the HR at this power output will decrease (Convertino 1991). But even within the HR methods there is a clear difference, with bTRIMP decreasing more than luTRIMP and eTRIMP during the first 4 weeks. This difference originates from a more methodological nature. bTRIMP uses the HRMEAN of a training and an exponential factor, which means that a small decrease in HRMEAN will lead to an associated exponential drop in TL. However, both luTRIMP and eTRIMP use training zones, implying that the HR will have to decrease enough and drop into a lower HR zone to be noticeable in the total TL. In previous studies strong correlations between TL methods were found, leading to the conclusion that the methods described in this paper are quite similar to each other (Van erp 2018, Vermeire 2020). However, this study clearly shows that the TL methods evolve differently over time, suggesting a different sensitivity of the methods to adaptations caused by training. A combination of external and internal TL methods as a tool in monitoring athletes, as proposed previously (Bourdon 2017), thus seems warranted.

Irrespective of the TL method used, the fitness fatigue model accurately related TL to performance with an average error of 1.73 ± 0.52 %, which seems an acceptable error to work with in the field. To our knowledge, only 2 studies previously investigated the influence of different TL methods on the output of the model in other sports (Wallace et al. 2014 & Mitchell et al. 2020). These studies also found no significant difference in the error of the model in relating TL to performance using different TL methods as input. However, these studies did not investigate the influence of the different methods as input on the outcome parameters (, k, t(g) and t(n)) of the model.

Despite the small error margin for all TL methods, using a different method as input for the model, leads to differences in the output parameters within a subject (table 2). Most interesting is the intra-subject variability in t(g) caused by a different input for the model. The mean range across the TL-methods in t(g) is 1.8 ± 1.2 days within an individual, although in some subjects the difference in t(g) across the TL-methods goes as high as 5 days (e.g., subject 8). This difference would lead to a different timing of the tapering period, despite the fact that the training sessions and the resulting performance are exactly the same. Thus it is clear that understanding the influence of the input used for the model on these parameters is crucial in interpreting the results derived from the modelling.

Also interesting is the intersubject variability in the model parameters with t(g) ranging from 0.5 to 19.0 days and t(n) from 0.0 to 6.1days, showing the ability of the fitness fatigue model in capturing the individual responses to training. So, the use of generic constants, as is typically done in online training platforms, is not warranted in guiding athletes to optimal performance. Moreover, the values found for both variables are lower than wat is mostly found in previous studies ( ± 40 days for t(g) and 15 days for t(n)), which are commonly used to advize taper periods (Morton 1990, fitz Clarke, hellard 2006, Mujika 1996). However, some studies using similar training modalities as the present study, also reported values that are in the same range (Busso 2002 & Wood 2005). This leads the authors to conclude that the commonly used duration of a taper period (i.e. 2 weeks) is excessive for recreational athletes typically training 3 times a week and that a taper period of 1 week or even less should be sufficient in order to obtain maximal performance.

Practical applications

For coaches and practitioners in the field, the authors suggest some guidelines when using TL in a modelling situation. The first being to choose a TL method that is, depending on the situation and regulations of the sport, most likely to register the required data correctly. If possible, the combination of an external and internal TL method is preferred. Next to this, it is important when using TL in a model as presented above, that the same TL measure is used over the whole period since the methods have a different order of magnitude and evolve differently over time. So when data is missing from a training session, it is preferred to make an estimated guess based on previous training data, than to use a different TL method within the same model, as is now frequently being done in the field (e.g. Performance Management Chart).