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Re-thinking athlete training loads: would you rather have one big rock or lots of little rocks dropped on your foot?

Andrew Renfree[a], Arturo Casado[b] and Shaun McLaren[c]

[a]School of Sport & Exercise Science, University of Worcester, Worcester, UK; [b]Centre for Sport Studies, Rey Juan Carlos University, Madrid, Spain; [c]Department of Sport & Exercise Sciences, Durham University, Durham, UK

ABSTRACT
Determination of athlete training loads is of great interest to sport practitioners and is widely used in the prescription and monitoring of physical conditioning programmes. Although a number of methods of load quantification are used, a common feature is that total load calculations are the product of exercise intensity and duration. We argue that these methods may be limited, however, as they do not account for non-linearities in the biological response to stress, with the end result being that they fail to fully account for the load imposed by high-intensity or interval-based training sessions. We end with a call for sport scientists to develop novel method of training load quantification to better deal with this issue.

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Introduction

There is understandably great interest in the monitoring of athlete training loads. It is not the purpose of this brief commentary to explore in detail the various methods used in this process, but, in general, we refer to load as the net stimulus or "dose" of a training session, which is typically quantified as a single unit combining exercise intensity and volume (i.e., duration)(Impellizzeri et al., 2019). This can be thought of as an impulse-type metric; that is, not in a mechanical sense (nor is the term "load"), but as an analogy to describe the area under the curve represented by duration (x-axis) and exercise intensity (y-axis). The resulting "score" can be used to track training load over time and manage the training process. Two of the most common load metrics are session ratings of perceived exertion (sRPE., i.e., sRPE-TL) (Foster, 1998) and heart-rate-derived training impulse (TRIMP) (Bannister, 1991; Edwards, 1993).

Whilst recognizing the value of these methods, we propose to use this commentary to highlight a potential shortcoming that is seldom discussed. Nassim Taleb (2012) uses the term "Antifragile" to describe objects or systems that respond to stress not by breaking (as would a fragile object or system), but by adapting and becoming stronger. This is exactly the process an athlete takes advantage of, through a hormetic response whereby specific functional adaptations result in improved performance capacity. Taleb tells the story of the ancient king who, in a rage, decreed that his son must be punished for some misdeed

CONTACT Andrew Renfree a.renfree@worc.ac.uk School of Sport & Exercise Science, University of Worcester, Worcester, UK

and that the punishment would consist of having a boulder dropped on his head from a great height, an almost certainly fatal event. As the day of the punishment grew closer, the king started to regret his decision, but also did not want to be seen as "weak" by his subjects. However, his advisors developed an elegant solution to the king's dilemma – instead of dropping the boulder all in one go, it was broken into 1000 small pebbles which were dropped one by one. Through this method, the same total load was "applied" to the son but instead of a fatal outcome, the end result was mild discomfort. This story illustrates a key feature of the biological response to stress, that of non-linearity. Whilst the total load remained the same, the stress response depended on the way in which it was applied. Applying it all at once had a greater impact than spreading the load out over a longer period.

Discussion

We suggest the same principles hold true for physical training – that the manner in which a load is applied is equally or more important than the magnitude of the load. As a hypothetical example, a 30-minute bout of exercise at an sRPE of 5 arbitrary units (au) and a 15-minute maximal bout at an sRPE of 10 au both generate an sRPE-TL of 150 au. Similarly, two sessions consisting of 20 minutes at 80–90% maximum heart rate or 40 minutes at 60–70% maximum heart rate would each render an Edwards TRIMP of 80 au. However, using the argument outlined above, the shorter session imposes greater physiological stress. To further illustrate this problem, consider a typical pre-competition phase session for a middle-distance runner consisting of 2 × 400 m at maximal effort, with full recovery between repetitions. Although sRPE may be maximal, the short duration of the session (approximately 0.8 minutes per repetition) means the total load imposed by the repetitions is very small (16 au). This also means a very easy warm-down jog at the end of the session may produce a greater TRIMP than the main activity in what is a very difficult training session likely to produce a high signal for adaptation.

A similar issue exists when small-sided games are utilized as a conditioning modality for team sport athletes, in that use of overall sRPE or TRIMP fail to take into account the intermittent nature of the activity. We consider this of crucial importance as the result may be significant underestimation of the load imposed by high-intensity sessions relative to low-intensity sessions. This point is illustrated in Figure 1, using hypothetical training periods for endurance and team sports. Regardless of the method used, some days render identical training load scores (data labels) despite vastly differing combinations of intensity and volume.

The issue of interval training is further complicated by the requirement to consider the influence of recovery time between high-intensity bouts. Manipulation of session density through changes in the duration of recovery periods can influence total session duration. If, in order to account for total exercise duration, activity during recovery periods are included in total load calculations, we can envisage a situation whereby increasing duration of recovery actually increases calculated session load, even if the physiological stress imposed is lower. Additionally, the mode of activity between bouts of high-intensity exercise must be considered. An active recovery may impose lower metabolic stress than passive recovery between repetitions of sprint interval training (Wahl & Mathes, 2020), despite a higher average heart rate during recovery periods. Here then, we have another

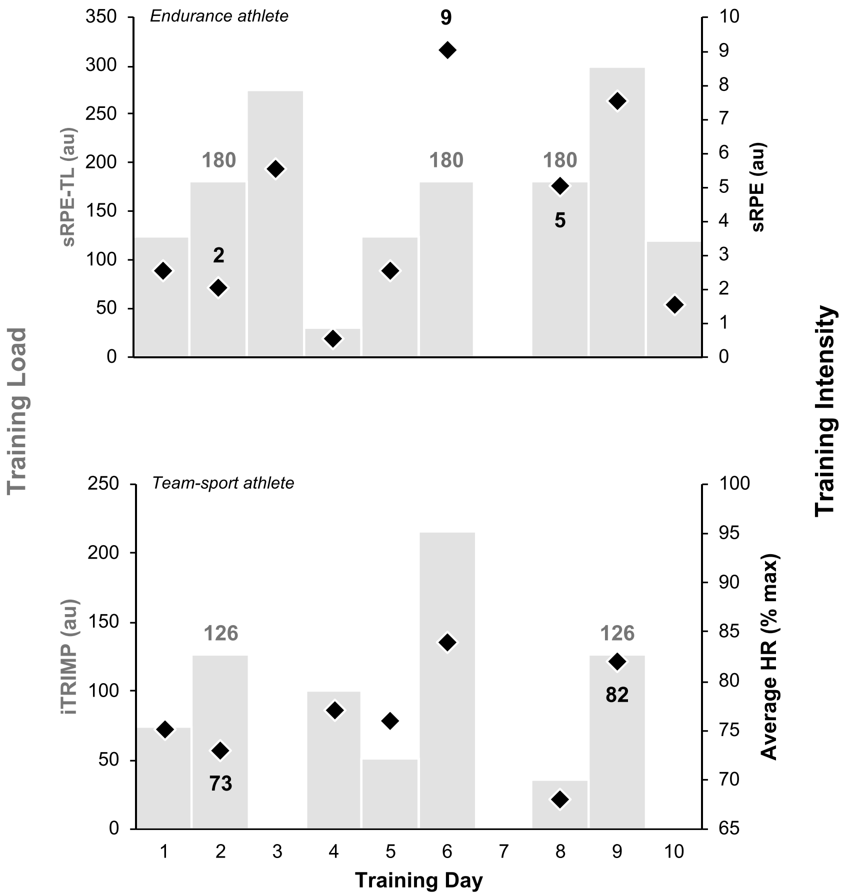

Figure 1. Hypothetical training load quantification over a 10-day period in an endurance athlete (via sRPE and sRPE-TL) and a team-sport athlete (via heart rate and iTRIMP).

situation whereby a training load calculation using TRIMP results in a higher loading score for a session that may be expected to produce less physiological stress.

Advancements in training load quantification over the past two decades have seen the advent of several different methods to improve its precision: the use of category-ratio scaling – and in particular the CR100® (centiMax) scale (Borg & Borg, 2001) – to account for the non-linear exercise–response relationship when measuring sRPE and individualized TRIMP (Manzi et al., 2009), which includes an exponential weighting coefficient based on an athlete's maximally graded HR–blood-lactate association. However, despite these sophistications, there will always exist a situation whereby two sessions consisting of vastly differing combinations of intensity and volume will render almost identical load values (Figure 1). Furthermore, we acknowledge that while the examples we provide focus on single load measures, a multitude of data sources are clearly needed for effective decision-making. Nevertheless, we maintain that the fundamental issues we identify will persist, a point recently made by Gamble et al. (2020) who emphasize practitioners should be "data-informed" rather than "data-driven". Unfortunately, it is not within the scope of this brief commentary to speculate in regard to solutions to this issue. However, we feel it is important enough to highlight in this forum and we conclude by encouraging sport scientists to consider how current methods of training quantification might be further improved to allow for a more accurate (yet simple) reflection of training load and its associated stress in order to allow coaches and practitioners to make better informed training decisions. To exemplify this, we refer to Figure 1 as a seemingly straightforward but powerful visualization strategy that could help coaches and practitioners better understand the nature of (internal) training load.

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Arturo Casado http://orcid.org/0000-0001-7668-6844
Shaun McLaren http://orcid.org/0000-0003-0480-3209

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