



Editorial

To vary or not to vary? Interpreting heart rate variability in soccer players

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Within-measure variability

Heart rate variability (HRV) is becoming one of the most widely used physiological variables to quantify the stress and recovery of soccer players. At rest, cardiac vagal modulation can be inferred by the logarithm of the root mean square of successive R-R interval differences (lnRMSSD), and it has been shown that higher values are related to higher training status (Proietti et al., 2017). Low variability within a measure relative to baseline may reflect inadequate recovery from previous exertion (Bricout et al., 2010; Muñoz-López, in press) or heightened stress. Reduced lnRMSSD may also be observed near or on match-day due to pre-competitive arousal (Ayuso-Moreno et al., in press). Thus, high variability between consecutive RR intervals within a measure, resulting in a high single day lnRMSSD measure is generally good.

Weekly mean variability

For monitoring purposes, it is necessary to perform at least 3-5 daily HRV measurements per week (Flatt & Esco, 2015), with the calculation of weekly averages that are compared over periods of preparation and competition (Flatt et al., 2017; Nakamura et al., 2020). Ultra-short-term measures (2 min) (Esco & Flatt, 2014) and apps (Esco et al., 2017) have facilitated the use of HRV within the work routines of professional teams. A significant reduction in the average lnRMSSD from one week to another may indicate a sudden change in training loads

and an increase in fatigue (Flatt et al., 2017a). To avoid prolonged accumulation of excessive loads, weekly HRV can give warning signals for practitioners to manage training and promote recovery strategies. It has already been demonstrated that functional overreaching is not a viable strategy to induce so-called “supercompensation” (Aubry et al., 2014); therefore, HRV can be used to guide and regulate training loads on an individual basis to avoid this undesirable state. In contrast, a low variation between the values of successive weekly average lnRMSSD, mainly with a tendency to increase in the medium term (e.g., 4 weeks), is likely associated with positive adaptations to training (i.e., increased fitness) (Flatt & Esco, 2016; Nakamura et al., 2020). Hence, maintained or gradually improved weekly average lnRMSSD is generally good, especially when perceived fatigue and general stress are low.

Inter-day variability

Multiple weekly records of lnRMSSD can also result in measures of inter-day variation in vagal cardiac activity and disturbance of autonomic activity within each week. For this, the coefficient of variation of the lnRMSSD values (lnRMSSD_{cv}) has been used. In soccer players, it has been shown that a high value of lnRMSSD_{cv} is associated with low levels of aerobic fitness (Boullosa et al., 2013) and higher perceived fatigue (Flatt et al., 2017b). In addition, the reduction in lnRMSSD_{cv} over preparatory training was



positively related to the increase in aerobic fitness of futsal players (Nakamura et al, 2020) and women's soccer players (Flatt & Esco, 2016). As the perceived loads over the weeks did not change significantly, the reduction in $\ln\text{RMSSD}_{\text{cv}}$ was interpreted as an accommodation of athletes to training stimuli, indicating the positive physiological adaptations (Nakamura et al., 2016). This leads us to believe that persistently high variability of the $\ln\text{RMSSD}$ values within each week is generally not good.

Conclusion

The available research indicates that throughout preparatory soccer training, a desirable $\ln\text{RMSSD}$ pattern involves a progressive increase in weekly average values, concurrent with reductions in daily fluctuations ($\ln\text{RMSSD}_{\text{cv}}$) (Boullosa et., 2013; Flatt & Esco, 2016; Flatt et al., 2017a,b; Nakamura et al, 2016; 2020). Thus, modifying workloads for players deviating from this pattern may help avoid fatigue accumulation and support training adaptations. During the season, $\ln\text{RMSSD}$ appears to be primarily impacted by competition (both pre- and post-match) (Bricout et al., 2010; Muñoz-López et al., in press; Rabbani et al., 2019). Thus, adopting strategies aimed at managing pre-competitive anxiety as well as facilitating post-competition cardiac-parasympathetic recovery may be beneficial.

Conflicts of Interest: The authors declare no conflict of interest.

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