Heart rate variability in an elite female alpine skier: A case study

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ABSTRACT

Backgound: Previous research on heart rate variability (HRV) focused on male endurance athletes. The study purpose was to assess HRV during off-snow and on-snow training in an elite female alpine ski racer recruited from the Canadian Alpine Ski Team (25 years old; 175.6 cm; 69.9 kg). **Methods:** HRV was calculated from resting morning heart rate values using the natural logarithms of the root mean square of the successive differences of R-R intervals (lnRMSSD), and the coefficient of variation of lnRMSSD ($lnRMSSD_{CV}$). Regression analysis of daily $lnRMSSD_{CV}$ over time was conducted to predict improvement or declination in athlete's performance. **Results:** Major depressions in lnRMSSD were observed over the recording period. The regression analysis of daily $lnRMSSD_{CV}$ over time had a positive slope of 0.001 ($R = 0.0029$). **Summary:** An inverse relationship was identified between the extreme values for lnRMSSD and sRPE. Two of the major depressions in lnRMSSD coincided with peak sRPE values. Subsequent recovery of lnRMSSD to normal levels following the depression was indicative of adaptation to the training load. Regression analysis was not predictive of future performance.

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INTRODUCTION

To maximize performance, elite athletes perform highly structured, periodized training regimens which include periods of functional overreach (FR)[1]. If the athlete is unable to adapt to the training load they will enter a period of non-functional overreach (NFR), which if prolonged will progress to overtraining (OT). It is difficult to objectively distinguish between FR, NFR and OT [2]. Autonomic dysregulation has been suspected in the pathogenesis of overtraining [3]. Heart rate variability represents an objective measure of an individuals autonomic nervous system's health[4].

The primary purpose of this study was to investigate the feasibility and application of longitudinal HRV monitoring in an elite female alpine ski racer in real-world, high-performance training environment.

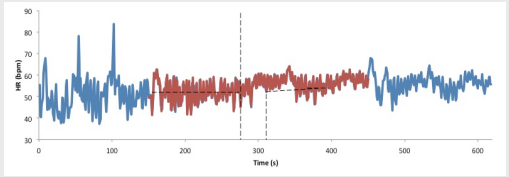

Figure 1. Example of daily heart rate recording taken upon waking. Blue represents entire recording. Red represents middle five minutes used for HRV analysis

METHODS

Using a case study design, a single elite female alpine ski racer (25 years old; 175.6 cm; 69.9 kg) was recruited from the Canadian Alpine Ski Team. Study period was 257 days, which encompassed dryland and on-snow training period and a competition period. Training load was obtained using the sessional rating of perceived exertion method (sRPE), and a weekly sum was calculated using all training loads in a calendar week. HRV was collected via R-R intervals measured by a Polar RS800cx heart monitor (RS800cx; Polar Electro, Kemple, Finland). The R-R intervals were recorded immediately upon the athlete waking from sleep. HRV was calculated using the natural logarithms of the root mean square of the successive differences of R-R intervals (lnRMSSD), and the coefficient of variation of lnRMSSD ($lnRMSSD_{CV}$).

ANALYSIS

Due to the skewed nature of HRV measures, the RMSSD values were log transformed using the natural logarithm (ln) [5]. $LnRMSSD_{CV}$ was calculated as a percentage. Linear regression was used on daily $lnRMSSD_{CV}$ values leading up to the athlete's competition season (day 180) to predict improvement or declination in performance. The magnitude of the relationship between time and $lnRMSSD_{CV}$ was assessed using the modified criteria of Cohen [6].

RESULTS

Over the study period, HRV recorded on 19.53% of total days (257 days). Compliance had a general negative trend with a sharp drop at the beginning of competition period. The weekly lnRMSSD had a mean (±SD) of 4.70(±0.40), with three noticeable depressions at weeks 8, 17 and 33 as shown in Figure 2. Largest depression in weekly lnRMSSD occurred during Week 17 (lnRMSSD=3.32). This measurement was the only HRV recording taken during this week, and did not coincide with a significant increase in the training load. However, at the morning training session on the same day the athlete suffered an injury (shoulder dislocation) during a routine strength training exercise. Regression analysis performed on the daily $lnRMSSD_{CV}$ for the 17 weeks leading up to the competition period found a positive general trend of 0.001% per day over the training period. A small magnitude relationship existed between time and $lnRMSSD_{CV}$ ($R = 0.0029$). The athlete had underperformed during the competition period relative to her past performance and these results are presented in Figure 3.

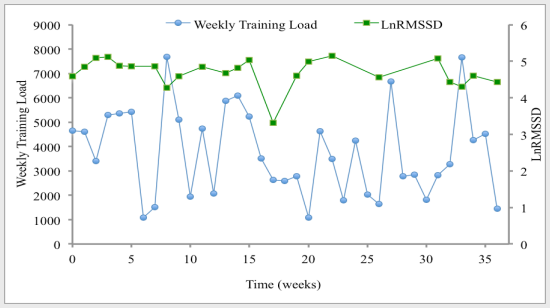

Figure 2. Weekly average LnRMSSD (mean = 4.695 ± 0.397) and weekly training load (mean = 3744.5 ± 1807.7) recorded over entire 36 week study period.

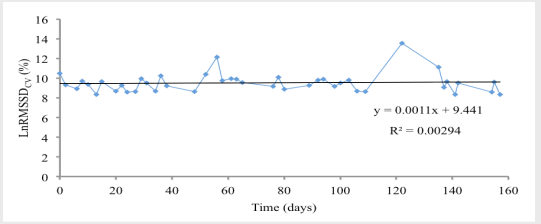

Figure 3. Regression analysis of daily $LnRMSSD_{CV}$ during training period leading up to competition period (day 180).

DISCUSSION

Compliance represents a possible downfall in the efficacy of using HRV during an average off-snow training period and competition period. An inverse relationship was identified between the extreme values for lnRMSSD and sRPE. Depressions in HRV mark increased sympathetic modulation of the heart rate [7]. Subsequent recovery of HRV to normal levels indicate the athlete was able to adapt to the training load [8].The largest depression in week 17 occurred on the morning before the athlete suffered a shoulder dislocation during a routine training exercise. To our knowledge, no previous research has been published regarding decreased HRV and risk of injury. Regression analysis of $lnRMSSD_{CV}$ leading up to competition period was not predictive of future performance. HRV was sensitive enough to detect changes in the athlete's training status, specifically when athlete entered periods of functional overreach and subsequent recovery.

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