WHOOP

CASE STUDY // THE SCIENCE AND APPLICATION OF HEART RATE RECOVERY

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JANUARY 9, 2017

Introduction

The WHOOP physiological monitoring platform provides continuous, actionable physiological assessments and training recommendations based on proprietary and extant scientific research. One area of focus is on analyzing a user's physiological response to exercise. An example is the measurement of heart rate recovery (HRR) after workouts. This case study reviews the theory and literary support for HRR as an important post-exercise metric, and then provides examples using WHOOP data of how the relationship between our predictions of readiness to adapt to strain (the WHOOP Recovery metric) and same-day post-workout HRR is individualized.

HRR in Research

HRR is generally defined as the decrease in heart rate (HR) caused by parasympathetic reactivation while resting immediately following near-maximal exercise.[1,2,3] No single standardized HRR formula has been established by the scientific community, although they are all variations on the same common theme: measuring HR's decrease post-exercise. Here we use the percentage decrease in HR in the 30 seconds following the point of exercise cessation. We note that in relevant academic literature, recording lengths ranging from 30 seconds to 5 minutes are used.[4] **Figure 1** shows examples of both slower and faster 30-second HRR.

Figure 1. An example of slow (top) and fast (bottom) 30-second HRR at the end of a workout. The dotted black line represents the end of a workout, and the gold shaded area highlights the drop in HR during the 30 seconds after the end of the workout.

Research has shown that HRR is affected by several factors. It has been shown that greater fitness leads to greater HRR following exercises of the same intensity[5,6,7]; this faster decrease

[1] Borresen and Lambert, 2007
[2] Lamberts et al., 2009
[3] Shetler et al., 2001
[4] Daanen et al., 2012
[5] Bunc et al, 1988
[6] Short and Sedlock, 1997
[7] Dimpka, 2009

has been observed in both endurance-trained and strength-trained athletes.[8] There has also been research suggesting that changing HRR reflects the state of the autonomic nervous system (ANS) and that HRR can be used to monitor fatigue.[9,10,11] It has also been suggested that changes in HRR post-workout can be extremely useful when examined alongside an athlete's training phase, perceived fatigue, and workout performance.[12]

WHOOP Recovery and HRR

One of the essential components of the WHOOP system is the proprietary Recovery algorithm, which provides physiologically-relevant and scientifically-grounded training recommendations based on heart rate, heart rate variability, and sleep quality.[13,14,15] The relationship between Recovery and 30-second HRR is demonstrated in Figure 2 for five different WHOOP users. For each workout, 30-second HRR (expressed as a percent decrease) was calculated after high-intensity running workouts followed by a rest period. All athletes included in the analysis below logged at least 20 running workouts between June 1st, 2016 and December 1st, 2016.

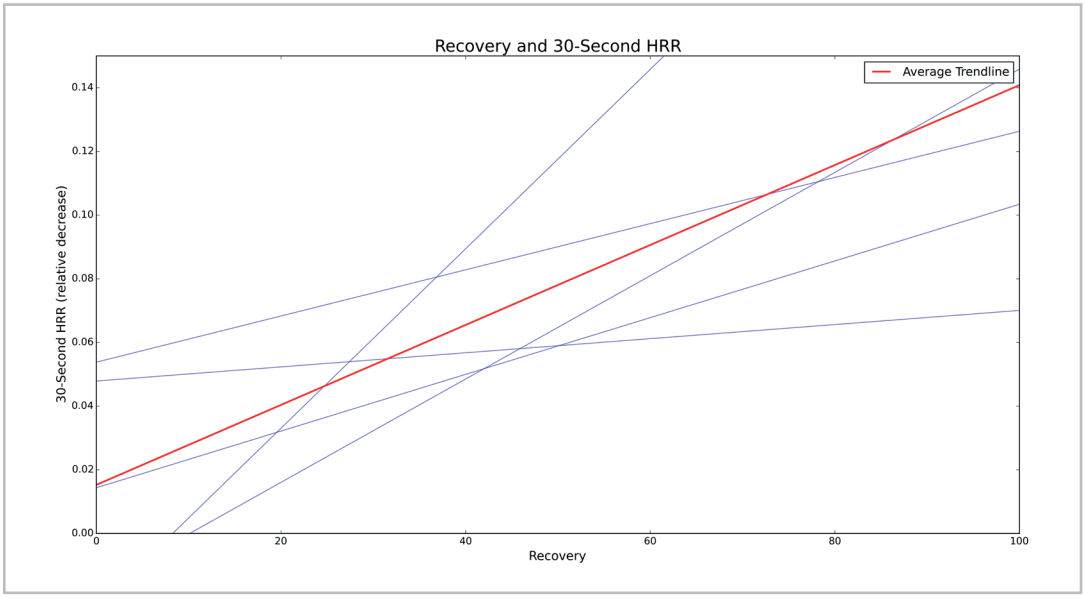

Figure 2. The relationship between Recovery and 30-second HRR after running workouts between 6.01.2016 and 12.01.2016 for five WHOOP users. A linear regression of the day's Recovery on HRR was fit for each user and plotted in blue. The red line represents the population average.

[8] Otsuki et al., 2007
[9] Borresen et al., 2007
[10] Lamberts et al., 2010
[11] Daanen et al., 2012
[12] Aubry et al., 2015
[13] Allen et al., 2016
[14] Breslow, 2016
[15] Breslow, 2016

The figure above illustrates that on days when a user is more recovered, 30-second HRR post-workout is faster than on days when a user is less recovered. However, interestingly, different athletes appear to be differently sensitive to changes in Recovery, likely suggesting that additional factors not captured in Recovery create meaningful differences in HRR.

Implications

Research has indicated that the rate of decrease in heart rate following a hard workout is affected by a variety of factors, including but not limited to decreased fitness, accumulation of fatigue, and higher workout intensity. The analysis of HRR post-workout presented above emphasizes that the relationship between these factors and readiness to adapt to a training load is individualized. The notion that each individual responds to training impulses differently is one of the most important ideas behind the “Always On” mentality at WHOOP. By engaging with the WHOOP system’s continuous stream of actionable data, the user can realize how specifically his or her adaptation to training varies with different stressors and behaviors. In other words, the user can learn how long he or she takes to recover after certain workout loads and types and how the things they do between workouts help or hurt the recovery process. Armed with this knowledge, the user can then determine how to individually optimize training to unlock peak performance.

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