Using Heart Rate to Quantify Relative Exercise Intensity

I know you already think you know a bit about this topic based on your own exercise experience, or simply from watching television. However, there is a true science to understanding the use of heart rate to quantify exercise intensity, and some of this research goes way back to the 1950s. In fact, this early research was so important that it still frames the approaches still used today to understand exercise intensity.

Heart rate has and remains a useful measure from which to quantify exercise intensity. However, such an application requires knowing the maximal heart rate (HRmax), which as previously described, is not a simple measurement to make, or one that can be measured with tremendous confidence due to the exercise mode and protocol specificity of HRmax. In addition, estimates of HRmax are known to be highly inaccurate, so any use of heart rate as a relative (to HRmax) gauge of exercise intensity is prone to error, with this error increasing drastically if HRmax is estimated vs. measured.

Despite these shortcomings, heart rate measurement is now very affordable to the average citizen due to the use of heart rate monitors than can be as cheap as AUS$25. Furthermore, most exercise equipment in the gym setting is equipped with heart measurement features, so understanding the good and the bad about heart rate measurement is a necessity for the exercise physiologist to ensure correct explanations of the public.

There are two main methods for heart rate quantification of exercise intensity; the Karovonen method, and the % HRmax method.

**Karvonen Method**

This method was devised by Karvonen in 1957. For the *Karvonen method*, both a resting heart rate (RHR) and maximal heart rate (HRmax) values are needed to calculate a heart rate reserve (HRR), as shown in Equation 1.

\[
HRR = HR_{\text{max}} - HR_{\text{rest}} \quad \text{Equation 1}
\]

The HRR reserve is then adjusted by a percent value, and added to the resting heart rate as shown in Equation 2.

\[
60\%HRR = 0.6 \times (HR_{\text{max}} - HR_{\text{rest}}) \\
60\%HRR \text{ Intensity} = HR_{\text{rest}} + (0.6 \times (HR_{\text{max}} - HR_{\text{rest}})) \quad \text{Equation 2}
\]

The Karvonen method is the preferred method to use for heart rate based exercise intensity as it closely resembles the %VO\text{2}\text{max} measure of relative exercise intensity. It is a relative intensity because the actual exercise heart rates are influenced by individual differences in physique and training/health status. A 60% HRR intensity expressed in absolute units of Watts, VO\text{2}, or running speed would be far higher for a trained athlete than a sedentary person.
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Another application of the %HRR intensity method is to compute a heart rate range from which to prescribe a range of exercise intensities for a given individual to exercise train. For athletes, the range is typically between 75 to 90%HHR, with intensities closer to 90% being preferred, especially during interval training. Conversely, for untrained subjects, a range between 60 to 80% HRR is prescribed. As will be discussed in the clinical section, for individuals with exercise-induced heart arrhythmias or angina, the HRmax component of the equation is replaced with the heart rate at the onset of the symptom.

% HRmax

The %HRmax relative intensity is as simple as it appears. Heart rate is expressed as a % of HRmax, whether HRmax is measured or estimated. As this heart rate expression covers a larger heart rate range than the heart rate reserve of the Karvonen method (i.e. not adjusted for resting heart rate), %HRmax intensities are higher than each of %HRR intensity and %VO2max.

Comparisons To %VO2max

As previously mentioned, the Karvonen method is touted as being a close approximation of increments in the %VO2max relative intensity. However, prior research has not adequately expressed relationships between the Karvonen and %HRmax methods. This has been due to only a small number of investigations on this topic, and my readings and observations have revealed different versions of these relationships in different prior textbooks. Consequently, I have used data from a random collection of maximal incremental exercise tests from my past research so that I could compare between the relative intensity expressions of %VO2max, %HRR intensity, and %HRmax. Figure 1 presents the data from a representative subject for this analysis from a cycle ergometry incremental protocol. The data clearly show that the %HRR intensity expression is closer to the %VO2max intensity across all submaximal (< 100 %VO2max) exercise intensities. For this subject, the consistent error in this expression between %VO2max and %HRR was 7.5 beats/min (at 100% HRR, %VO2max = 92.5%). However, there is considerable variability in these responses between individuals, as shown for another subject from a treadmill incremental protocol (Figure 2). As such, the data of Figure 2 represent a composite from the data of several subjects for each %VO2max-%HRmax and %VO2max-%HRR relationship for incremental exercise.
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At this time, the best approximation of these relationships is based on the composite data of Figure 3 and Table 1. However, be aware that this topic requires further research.

\[ \%HRR = (0.9118(\%VO_2\text{max}) + 9.259 \]
Equation 3

\[ \%HRmax = (0.525(\%VO_2\text{max}) + 45.3 \]
Equation 4

Table 1. Data from a representative Subject for different expressions of exercise intensity.

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\[ \%HRR=0.9118(\%VO_2\text{max}) + 9.259 \]
\[ \%HRmax=0.525(\%VO_2\text{max}) + 45.3 \]

Glossary Words

Karvonen method is the method for calculating heart rate values for exercise intensities close to the same % of VO₂max.