HEART RATE VARIABILITY FOR PERSONAL TRAINING—PART II: PRACTICAL APPLICATION

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This article is the last of a two-part series.

INTRODUCTION

The first article of this two-part series explored the physiological background of heart rate variability (HRV). This article will focus on the practical application of HRV testing for strength and conditioning professionals. HRV has many clinical and diagnostic uses, but strength and conditioning professionals are most likely to benefit from HRV testing in one of two ways: to assess the acute effect of changes in training load or to assess the chronic effect of training (e.g., fitness).

ASSESS TRAINING LOAD

The most common way that HRV is used, and probably the first way in which most people are introduced to HRV testing, is to use it to guide daily workouts. In this regard, it is a simple, reliable, and useful tool. Reminiscent of flexible non-linear periodization (which uses a daily metric of performance, such as a single vertical jump, as an indicator of recovery), a morning HRV assessment can serve a similar function in determining readiness to train.

HRV provides a window into the autonomic nervous system (ANS). The ANS, a branch of the peripheral nervous system which is responsible for managing all physiological function that operates under the level of conscious awareness (e.g., blood pressure and glucose regulation), is exquisitely sensitive to even the smallest of physiological changes to the internal environment. In this manner, HRV can serve as a barometer, measuring the amount of "reserve" that is available on any given day. For example, if an individual had a particularly intense workout (or a series of intense workouts over multiple days), their reserve might be depleted. Conversely, it would be expected that physiological reserve would be maximized following a period of recovery. In this way, a daily HRV reading can provide an objective measurement that is useful on a day-to-day basis and can provide an indication of physiological recovery, or "readiness to train."

Several studies have validated the usefulness of HRV-guided exercise programs in athletes as well as recreational exercisers. For example, Kiviniemi et al. investigated the difference between a traditional pre-defined training regimen and one that relied upon a morning HRV reading, which would dictate daily workout intensity, among male recreational runners (7). The HRV group determined whether they were going to do a low-intensity run (65% of maximal hear rate), high-intensity run (85% of maximal heart rate), or rest day, based on morning HRV readings. If their morning assessment showed a lower than normal reading, based upon interpretation of a rolling 10-day average, they would take a rest or low-intensity day. In contrast, the traditional training group performed one day of low-intensity exercise, two consecutive days of high-intensity exercise, and one non-exercise recovery day, which was repeated to give six training days per week. This training regimen was maintained for the duration of the four-week investigation. Both groups accrued a similar number of rest, low-intensity training, and high-intensity training days. Maximal running velocity increased for both groups; however, the HRV group increased to a significantly greater extent. While there was no significant difference in VO_2peak between the groups, only the HRV group improved VO_2peak significantly (7). This led the researchers to conclude that using HRV to guide daily workouts was an effective strategy to improve cardiorespiratory fitness.

A more recent investigation compared a traditional pre-defined training program versus HRV-guided training in both male and female recreational runners (16). The 12-week training study, which included a four-week preparatory period followed by eight weeks of intensive training, was largely running-based with cross-training and muscular endurance circuit training encouraged two days per week. Both groups performed weekly combinations of low-intensity, moderate-intensity, or high-intensity runs. Individuals in the HRV group performed daily assessments of HRV and used a rolling seven-day average to determine workout intensity. The results were noteworthy in that the HRV group significantly improved 3,000-m run-time, despite completing fewer moderate-intensity and high-intensity training sessions than the traditional group. Moreover, the individual differences in training adaptations were smaller in the HRV-guided group. This diminished variation potentially indicates a more accurate exercise prescription, suggesting that "the timing of moderate- and high-intensity sessions according to HRV is more optimal compared with the subjectively predefined training," (16).

ASSESS FITNESS LEVEL

Aerobic fitness can be described as physiological efficiency. A "fit" body is a physiologically efficient body. Consequently, high levels of HRV serve as a biomarker of physiological efficiency. Chronically decreasing HRV is an indicator that the body is sliding toward physiological inefficiency. Many chronic lifestyle-related diseases are a manifestation of physiological inefficiency. Type 2 diabetes, which is characterized by a diminished ability to regulate blood sugar levels, is a prime example of physiological inefficiency. A loss of HRV is associated with type 2 diabetes as well as pre-diabetes and is inversely associated with plasma glucose levels (14).

While there currently exists no normative data that can be used to predict or quantify fitness level directly from HRV, research is trending in this direction. For example, a recent study by Kiviniemi et al. investigated the ability of resting HRV measures to predict change in aerobic fitness during a short-term (two weeks), high-intensity training program in middle-aged sedentary males (8). The authors demonstrated that baseline measures of HRV in previously sedentary individuals were predictive of improvement in aerobic capacity following a short-term, high-intensity exercise intervention.

Moreover, a recently published study by Mankowski et al. provided validation for an exciting new application for HRV (10). In the study, which manipulated oxygen to normoxic, hyperoxic, or hypoxic (i.e., normal oxygen consumption, excessive oxygen supply, and inadequate oxygen supply, respectively) levels during an incremental stress test, researchers demonstrated a strong linkage between markers of HRV and the second ventilatory threshold (10). The incorporation of this method of ventilatory threshold assessment into commercially available fitness equipment could pave the way for significant improvements in exercise prescription in the future.

The effect of significant aerobic exercise training has consistently demonstrated improvements in HRV, particularly in parasympathetic markers (e.g., root mean square of successive differences [RMSSD] and high frequency power) of autonomic control (2). The literature, however, is somewhat equivocal in regards to the effect of resistance training on HRV. For example, Berkoff et al. found no significant mean differences in HRV between elite aerobic and power athletes, suggesting that both styles of training affect HRV in a similar fashion (1). Moreover, a recent review of the effect of resistance training on HRV found the majority of studies reporting no significant change (6). At first glance, these results may seem contradictory, but training adaptations are specific to the imposed demand of exercise. Since traditional resistance training does not place as great of a demand on cardiac function as aerobic training, and HRV is derived from cardiac dynamics, it follows that aerobic training should exert the greater effect on HRV.

Even though it is not yet possible to directly predict or quantify fitness level with HRV at the commercial level, regular HRV readings can serve the strength and conditioning professional as a biomarker of health, fitness, and readiness to train, while also providing important insight into specific populations, such as athletes and those with chronic health conditions. Many studies across a diversity of populations have demonstrated the efficacy of exercise training, particularly aerobic exercise training, in increasing HRV (3,8,13,17). Therefore, HRV can be used as a biomarker of change in aerobic fitness level. Furthermore, while reduced HRV is a predictor of carotid artery atherosclerosis, type 2 diabetes, and all-cause mortality, high HRV is associated with faster cognitive processing speed in older individuals and healthy longevity (5,9,14,15,18).

QUICK START GUIDE FOR HRV TESTING

There are dedicated HRV testing solutions on the market; however, this is a very expensive and inconvenient way to incorporate HRV into a health and fitness assessment. Moreover, technological advances are occurring at such a rapid pace that it is not advisable for the strength and conditioning professional to invest a large sum of money into a technology that may quickly become obsolete. It is recommended that strength and conditioning professionals consider these three basic rules:

1. **Pick the Device** – The simplest and most cost-effective way for the strength and conditioning professional to incorporate HRV testing is via a Bluetooth-enabled heart rate monitor (HRM). With Bluetooth capability, a chest strap HRM will be able to communicate directly with an application (app) on a smart phone or tablet. Plethysmography is another option for measuring changes in volume within an organ that result from changes in blood or oxygen. Devices for plethysmography vary and may be considerably more expensive than HRM options.

2. **Get the App** – A variety of apps are available for both iPhone and Android devices, and can be downloaded in seconds. It is recommended that the strength and conditioning professional invest some time in researching the capabilities of several apps, as each app has its own advantages and disadvantages. For a beginner to HRV testing, it is recommended to consider using a free app, such as Elite HRV or HRV +.

3. **Start Collecting Data** – Prior to beginning the first reading, it will be necessary to sync the Bluetooth HRM to the app (this can typically be done through the "settings" feature of the app).

TESTING ISSUES AND RECOMMENDATIONS

Because HRV is so exquisitely sensitive to a multitude of internal and external stimuli, it is imperative that testing parameters be as consistent as possible to obtain the most accurate measurements. For most health and fitness-related applications, the following guidelines are recommended:

- HRV testing should be done in a fasted state, immediately after waking in the morning, and while lying in bed.
- Morning recordings should be regular (i.e., daily).
- While research-based measurements range from five minutes to 24 hours, the recommended recording time for health and fitness purposes is one minute. One minute readings are typically standard on HRV apps and a resting one-minute reading has been validated in comparison to the research standard of five minutes (4).
- There are many meaningful measures of HRV; however, for health and fitness purposes, the primary metric is the RMSSD. Most apps will report either the raw or log-transformed RMSSD. Additionally, some apps (e.g., ithlete) will report a single transformed HRV "score." This is typically the RMSSD, which has been log-transformed and multiplied by a value of 20 to yield a score which is conveniently represented on a 0 – 100 scale (very high readings may exceed 100).

INTERPRETATION OF HRV READINGS

As HRV is susceptible to many internal and external stimuli, the strength and conditioning professional should be cautious of altering an exercise prescription based solely on a single low reading. Individual HRV measurements should be interpreted in the context of each individual. For example, if an individual reports a single low reading, it would be best to consult with the client to determine if there is an alternate source of stress that is acutely depressing the HRV reading (e.g., recent significant bout of alcohol consumption, abnormally high life stress, acute sleep deprivation, etc.).

Normative data for many metrics of HRV do exist; however, caution is advised in regards to methodological differences, as well as inherent issues with HRV testing, as these differences may render the data ineffective for client comparison. As there can be a great amount of inter-individual differences in HRV readings, the best use for strength and conditioning professionals will be to use intra-individual comparisons over time. This will give the strength and conditioning professional a trend-line for each client, serving to inform exercise prescription, as well as tracking fitness levels. Nevertheless, as a point of reference, consider the following:

- In a study of track and field athletes, Berkoff et al. demonstrated mean RMSSD values of 75.6 and 69.4 in elite male and female runners, respectively (1). Values for male and female power athletes were similar (and not significantly statistically different), at 76.3 and 77.7, respectively (1).
- Melanson reported RMSSD values among males (25 – 49-years old.), stratified into three groups according to amount of weekly aerobic exercise, as 42.3, 92.7, and 87.3, for low (< 1,000 kcal·wk), moderate (1,000 – 2,000 kcal·wk), or high aerobic activity (> 2,000 kcal·wk), respectively (11).
- In a meta-analysis of HRV readings in healthy adults, Nunan et al. reported an overall RMSSD value of 42 (12).

CONCLUSION

The "bread and butter" of the personal training world is to deliver consistent positive change for clients. Technological advances over the last decade, combined with an explosion of HRV-related research, have opened up HRV testing to the average strength and conditioning professional. Continued advances in both technology and research promise to make the utility of HRV testing and assessment an indispensable tool for the strength and conditioning professional. Given the broad scope of related research and its association with so many facets of disease, health, and fitness, HRV will prove to be an invaluable biomarker for the strength and conditioning professional.

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