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Assessment and Applications of Heart Rate Variability

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Abstract

The purpose of this article is to present a brief overview of the applications and assessment of heart rate variability. Researchers, clinicians and other health practitioners may find value in this index of autonomic regulation. Attaining heart rate variability using a heart rate monitor is described as barriers of cost and expertise do not limit this technique. **Health & Fitness Journal of Canada 2010;3(2):39-43.**

Keywords: heart rate, variability, autonomic regulation, cardiovascular health

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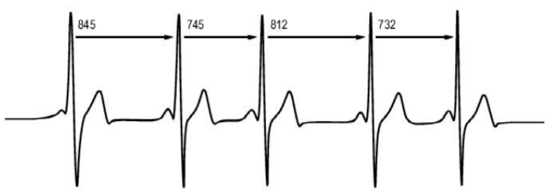
Background

The autonomic nervous system (ANS) plays a pivotal role in cardiovascular control (Hainsworth, 1998). An increased activity in the sympathetic branch of the ANS increases heart rate and constricts blood vessels, whereas an increase in parasympathetic activity opposes these actions (Pumprla et al., 2002). Baroreflex activity is closely linked to this activity. as changes in blood pressure influence the level of activity from these two pathways (Aubert et al., 2003). Thus, the ANS is a key component of cardiovascular control. Heart rate variability is one means of assessing autonomic nervous system function (Aubert et al., 2003) and has been shown to be related to all cause mortality and sudden cardiac events (Tsuji et al., 1994, 1996).

Heart rate variability (HRV) concerns the beat-to-beat variation in heart rate and is commonly used as a measure of autonomic health or function (Aubert et al., 2003). Specifically, HRV reflects the time intervals between the peaks in the electrocardiogram (ECG; Figure 1) or normal-to-normal (NN) intervals. The variations in heart rate may be evaluated by time domain or frequency domain (spectral) measures.

The time domain measures are derived from either direct measurements of the NN intervals or from the differences between NN intervals and spectral measures reflect how power (variance) distributes as a function of frequency (Electrophysiology, 1996). The low frequency band (LF = 0.04 - 0.15 Hz) is suggested to reflect both sympathetic and parasympathetic control of the heart, with the high frequency band (HF = 0.16 – 0.4 Hz) representing parasympathetic influence only (Aubert et al., 2003; Barron and Lesh, 1996). Increased vagal tone, or parasympathetic activity, is considered to be protective against cardiac events, whereas increased sympathetic activity is associated with higher risk of perturbing the heart (Barron and Lesh, 1996; Farrell et al., 1991). Women have been shown to have enhanced parasympathetic input to cardiac regulation compared to men (Evans et al., 2001), which may provide protection against arrhythmias and the development of coronary heart disease (Ramaekers, et al., 1998). HRV typically declines with age (Reardon et al., 1996; Tasaki et al., 2000); however, sustained endurance training over many years may attenuate this decline (Muster et al., 1999; Yataco et al., 1997).

Figure 1. An example ECG tracing showing consecutive RR intervals and an illustration of the varying interval length between them.



Applications:

Clinicians may use HRV as a simple and non-invasive measure of health. Athletes typically display higher HRV values than sedentary individuals. Normative data is provided in Table 1. HRV has also been used to assess one's response to a physiological stress such as weightlessness (Eckberg and Fritsch, 1991), changes in central blood volume through lower body negative pressure (Cooke et al., 2008) or immediately following exercise (Kaikkonen et al., 2008; Martinmaki and Rusko, 2008).

Following exercise, parasympathetic activity is reduced, however, slow parasympathetic recovery may indicate autonomic imbalance (Cole et al., 1999). In athletic populations, monitoring of parasympathetic activity using HRV appears to indicate the state of recovery. When athletes are overreaching or overtrained, parasympathetic activity is reduced compared to baseline values (Hynynen et al., 2006; Uusitalo et al., 2000). Therefore, coaches may choose to decrease an athlete's training load when parasympathetic nervous system is reduced, allowing a full recovery and reducing the chance of burnout.

Table 1. Typical time and frequency domain values for endurance trained and sedentary individuals.

Time Domain of HRV

	MeanNN (ms)	SDNN (ms)	rMSSD (ms)	pNN50 (%)
Sedentary Control	800	70	40	20
Aerobically Trained	1100	95	70	40

Frequency Domain of HRV

	Total Power (ms2)	LF (ms2)	HF (ms2)
Young Sedentary	1200-4000	200-900	250-600
Elderly Sedentary		200-500	200-300
Young Athletes	1200-5000	800-1200	500-2500
Elderly Athletes		600-1100	400-1000

MeanNN=Normal to normal (RR) intervals; SDNN=the standard deviation of the RR intervals; rMSSD=the square root of the mean squared successive differences between adjacent RR intervals; pNN50=percentage of successive interval differences larger than 50 ms; LF=low frequency; HF=high frequency

Methods:

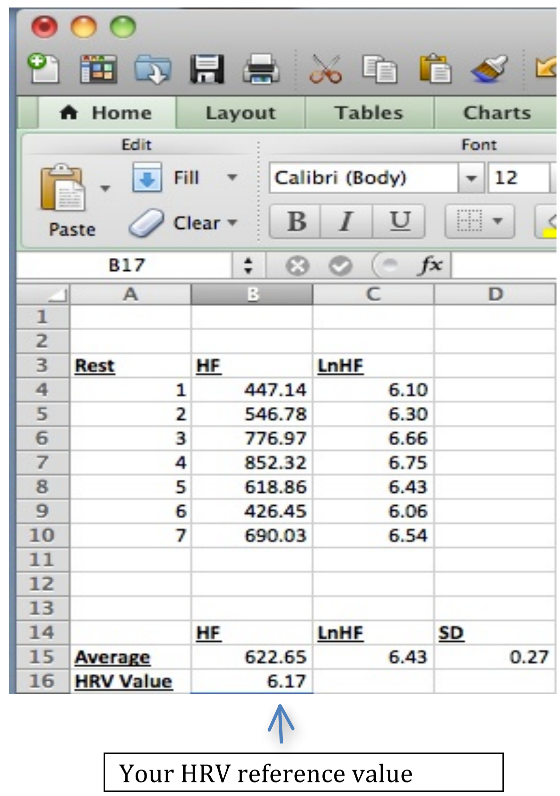
Clinical assessment of HRV is commonly performed using specialized software capable of analyzing the ECG. However, recent advances in heart rate monitors have resulted in the ability to obtain HRV data using a chest strap transmitter and wrist receiver that records R-R intervals such as the Polar RS800 series, or S810 series. In addition the Polar Precision Performance SW 4.0 software (www.polar.fi) and a spreadsheet package such as Microsoft Excel are needed.

Prior to using HRV to guide training, one should collect resting data for seven to ten days to establish a typical baseline for that individual under similar conditions and for a similar duration (ideally 5 minutes) each day (Aubert et al., 2003). If using HRV analysis to monitor training, the resting data should be collected while standing to allow for comparisons to exercise data.

Step-by-Step

1. On the Polar watch unit; Select Settings > Features > RR data > On / Off
2. Using the RR data function consumes the memory of the polar unit, therefore the remaining recording time is shown on the display when the RR function is turned on,
3. Once the RR data option is turned on, attach the HR transmitter device to the strap. Fit the strap comfortably around the chest, just below the pectoral muscle. Ensure electrode areas are firmly against skin, and that the HR transmitter device is positioned in the center of the chest. Applying water to the contact points may aid signal transmission. Press start on the watch and the data collection will begin.
4. After collection, import the data into the Polar Precision Performance SW 4.0 software. Choose to display the data as a 'curve of the HR values' and then click display 'curve properties' by right clicking on the curve. Click on the HR tab, select 'RR Intervals'.
5. Next, select the entire exercise log under the edit menu, Right click on the graph and select 'Error Correction'. Select 'OK', Right click on the graph and choose 'Selection Info'. The value that you are recording here is the 'HF (0.15 – 0.40 Hz)' value.
6. Next, calculate the logarithm (Ln) of the HF value. This can be done by entering your HF value into Microsoft Excels command '=Ln (your value; Figure 2). [example: if HF value is 447.14 use the following Microsoft excel function '=ln(447.14)', resulting in a log HF value of 6.10ms^2]
7. After calculating the logarithm, calculate the standard deviation of these values in Excel by typing '=STDEV' and selecting all the HF Ln values from the rest period. Finally, calculate the average of the HF Ln values and then subtract this from the standard deviation.

Figure 2: An example of data output as per Steps 6 and 7.



	A	B	C	D
1				
2				
3	Rest	HF	LnHF	
4	1	447.14	6.10	
5	2	546.78	6.30	
6	3	776.97	6.66	
7	4	852.32	6.75	
8	5	618.86	6.43	
9	6	426.45	6.06	
10	7	690.03	6.54	
11				
12				
13				
14		HF	LnHF	SD
15	Average	622.65	6.43	0.27
16	HRV Value	6.17		

Conclusion

Measurement of HRV is a simple non-invasive means of monitoring autonomic function and has the potential to be a versatile tool for athletes, coaches and sports scientists. HRV appears to be helpful in identifying overreaching states as well as autonomic imbalance in disease as well. Thus, practitioners of many health disciplines may find the measurement of HRV a useful and practical tool.

Authors' Qualifications

The author qualifications are as follows: Anita Cote MSc, CSEP CEP, CSEP CPT-CC; Adam Ivey, BSc, CSEP CEP.

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