Polar Orthostatic Test

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Polar Research and Technology

Content

1 Introduction

Orthostatic Test has a historical background in medical sciences , where it has been used to detect autonomic nervous system functions in various diseases. In sports this test was introduced over 30 yrs ago and Polar has had this test in products for over 20 years.[1] Orthostatic test is based on changes in heart rate (HR) and heart rate variability (HRV) and it reflects cardiac autonomic modulation. The test involves measurement of heart rate (HR) and HR variability (HRV) during supine rest, active standing up and quiet standing. During supine rest, HR is low and HRV high because cardiac parasympathetic modulation is dominant. When standing up, there is a temporary reduction in blood pressure and a rapid withdrawal of parasympathetic modulation together with an increase of sympathetic outflow, resulting in an increase in HR shortly after standing up. The phase 1-2min after standing up is characterized by an increase in diastolic blood pressure and a sympathetic HR increase and HRV decrease. During the years the Orthostatic Test has been developed by Polar and is one of the Polar Smart Coaching features.This document describes the content and validity of current Orthostatic Test in Polar offerings.

2 Why measure

Heart rate (HR) and heart rate variability (HRV) measured during orthostatic test are good indicators of disturbances in the autonomic nervous system. Several studies reported changes in HR and HRV during training overload, sleep deprivation, altitude or heat exposure, high mental and/or social stress and during disease. HRV measures are therefore very helpful to assess the training readiness of an athlete, considering all the challenges an athlete phases in his daily life, such as stress from training and stress from time outside training. The purpose of Orthostatic Test is therefore to offer a way to monitor and learn how the body responds to training and other stressors in daily life. It helps to find the right amount of training.

3 How does Polar measure

In Polar Orthostatic test RR interval data are recorded beat by beat during the orthostatic test procedure. RR interval recordings require the use of a HR strap as optical beat to beat interval recordings are currently not able to sensitively detect the physiological changes in blood pressure and thus beat to beat intervals occurring after postural changes. Before the calculation of results, the errors and extra beats are eliminated. The resulting time series is generally called NN interval time series, i.e. from normal to normal heart beat. The test is interrupted if there are too many rejected RR intervals. This is told to the user with an alarm sound and text.

The test result is based on changes in the NN parameters compared to the normal range. The normal range for each individual user is determined based on the calculation of the average of each parameter presented in table 1.

Table 1. Parameters calculated from the filtered RR interval data.

	DESCRIPTION	TIME OF CALCULATION
1) $AVNN_{supine}$	Average NN while lying down	60 – 120 s
2) NN_{min}	The shortest NN following standing up	121 – 150 s (1-30 s after standing up)
3) $AVNN_{stand}$	Average NN while standing	180 – 240 s (60 – 120 s after standing up)
1) $RMSSD_{supine}$	Square root of the mean squared difference of successive NN	60 – 120 s
2) $RMSSD_{stand}$	Square root of the mean squared difference of successive NN	180 – 240 s (60 – 120 s after standing up)

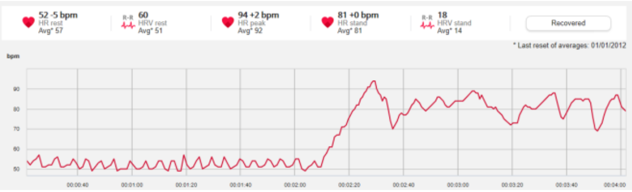

Figure 1. An example of orthostatic test result view on Polar Flow.

The final test result shown in figure 1 is a combination of numerical and visual feedback on the prevailing values compared to the user's usual values. $AVNN_{supine}$, NN_{min} and $AVNN_{stand}$ will be converted to HR values (HR_{supine}, HR_{peak}, HR_{stand}) and presented in comparison with the corresponding average values (avg_HR_{supine}, avg_HR_{peak}, avg_HR_{stand}). For the first 6 tests, this corresponding average is calculated from the previous values and the new value. From the 7^{th} test onwards, the average is calculated from the previous values not including the new value. Visual feedback is provided about the direction of the change in HR (lower, normal or higher) compared to the average. It is possible for the user to reset the continuously updated average to start a new calculation of the average values. Resetting the average values will start a new testing period.

Cardio recovery level (showing if the user is recovered or not recovered) is included in the orthostatic test result and described in more detail in 4.2. Training Load Pro and Recovery Pro white paper. In brief, Cardio recovery level requires at least 3 measurements in 28 days (min 2 for baseline + 1 for today). It compares the newest orthostatic test result with the individual RMSSD baseline, calculated from all measurements within 28 days. Depending on how much RMSSD of the new orthostatic test deviates from the individual baseline, the Cardio recovery level is automatically interpreted as recovered or not recovered.

4 Validity

Technical validity:

R-R detection with Polar H10[2] and Polar H7 heart rate monitor[3,4] were shown to be valid.

Physiological validity:

HRV recorded during orthostatic test has been shown to be altered during a state of overreaching and overtraining.[5–7] Training guided by feedback from Cardio recovery level led to similar improvements in 5 km running performance and VO_{2max} and better improvements in running economy compared to professionally designed training plans with significantly less training.[8]

5 Reliability and repeatability

HR and HRV from orthostatic test were shown to be reproducible both at rest and after orthostatic challenge in healthy subjects[9] and in patients with a history of acute coronary syndrome.[10]

6 Advantages of use

User can learn and understand how (s)he responds to training load and other aspects of life that may disturb the cardiac autonomic nervous system activity (e.g. sleep, stress, nutrition, environment etc.).

7 How to interpret values/results

As the training season progresses, the user can follow the effect of an increased training load or other life aspects on HR and HRV results by monitoring the difference between averages and new results. Newest peak, stand and rest values and how much they differ from average values are shown. If one or more of these results fall below or rise above averages and don't normalize during recovery weeks when training load is lower, it's possible that the user is developing an overtraining syndrome. However, HRV is only one indicator of overtraining. It is always recommeded to monitor other changes as well, such as changes in performance and general feelings of fatigue.

The user also has the possibility to follow automatic interpretation of orthostatic test by Polar Cardio recovery level Smart Coaching algorithm (showing if user is recovered or not recovered).

Cardio recovery level is also used as input in Polar Recovery Pro. Polar Recovery Pro measures the Cardio recovery level and user's readiness for cardio training and combines measured and subjective long-term recovery data with long-term training load (Cardio load) to give daily training recommendations. Polar Recovery Pro is described in more detail in the white paper Training Load Pro and Recovery Pro.

8. Limitations

Normal NNI is required for the calculation of HRV. Therefore, people with abnormal RR intervals are not getting a result. Further limitations are the requirement of highly standardized conditions to make results comparable. It is therefore recommended that the test should always be taken in standardized conditions to get the most reliable results. Orthostatic test results are very individual, and the test is meant to be used continuously. It is therefore difficult to interpret results when measurements are not taken regularly.

9. Patents

US 8,082,030, European patent EP1852062 (validated in Germany, France and Great Britain) and Finnish patent FI119618.

10. References

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