Polar Recovery Pro

November 12,2019

Polar Research and Technology

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1 Introduction

Training is typically prescribed based on literature, general recommendations, experience of coaches, and assumptions about an athlete's current training and recovery status. These recommendations aim to improve sports performance by finding the right balance between training load and recovery. However, it is well known that adaptations to training are individual. The same training program causes different responses in individuals, even if they have a similar training background. In addition, even within an individual, the amount of training load that can be tolerated can vary, as capacity to recover also depends on what is going on in the person's life outside of training (stress, sleep, nutrition, environment etc.). Therefore, training and recovery need to be monitored individually and not based on population norms, and should also take into account the athlete's 24/7 life.

The purpose of Polar's Recovery Pro is to measure recovery in order to find the ideal timing for key training sessions and to evaluate how much total training can be tolerated for optimal training benefits, taking also into account stressors from 24/7 life and not just the training itself.

2 Why measure

Simply monitoring Cardio load status, as described in the white paper Training Load Pro, will not take into account numerous important factors outside of training that have significant influence on recovey time. Known factors include environment (e.g. climate, altitude), health status, mental stress, energy balance, hydration status, sleep, physical activity outside of training, recovery strategies and personal characteristics (e.g. age, gender, fitness level). Therefore, Polar Recovery Pro includes a recovery test that takes into account most stressors of a user's life, including stress from training and stress from outside of training.

It should also be noted that not all environmental/mental stessors can be measured with technical devices, at least not easily with a user friendly way in everyday life. With questionnaires, some of these can be taken into account.

Recovery Pro consists of a short-term and long-term recovery feedback and a training recommendation (Figure 1) .

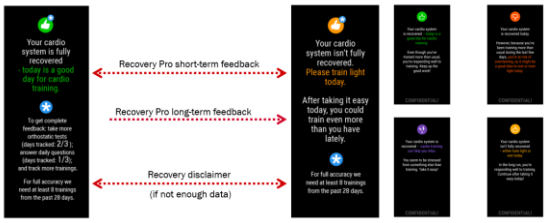

Figure 1. Recovery Pro, existing of short-term and long-term feedback and training recommendation.

3 Advantages of use

- User can measure the actual (not estimated) individual recovery status
- User gets a recovery status which is taking into accout the effects of total

lifestyle (sleep, stress, nutrition, environment etc.)
- User can see how much training can be tolerated in relation to his/her resources to recover from it.
- User can follow his/her readiness for the next cardio training session.

4 Description of Recovery Pro

4.1 Recovery Pro short-term recovery feedback

Description

Recovery Pro short-term recovery feedback tells how recoverd the cardiac autonomic nervous system activity is and is calculated based on heart rate variability (HRV) analysis from RR recording. Several studies reported changes in 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, taking into account all the challenges an athlete faces in his/her daily life as stress from training and stress from time outside of training.

Studies reporting HRV in athletes were measuring HRV at rest, during exercise, post-exercise or during night.[1] The selected method to assess recovery of the cardio system is short-term HRV measurements at rest and under standardized conditions, since they currently tend to be the best practice for athletes.[2,3] Due to the shorter recording time requirement, the better reproducibility and the numerous scientific publications using the square root of the mean squared differences of successive RR intervals (RMSSD) to monitor training adaptations in athletes, RMSSD is the selected HRV parameter to calculate from RR recordings.

At rest, measurements in supine position and sitting are the most convenient. However, in athletes with a resting heart rate below 60 bpm, a saturation effect of cardiac parasympathetic receptors is likely,[1] making it difficult to track training adaptations. Some studies using the orthostatic test only observed changes in RMSSD with overload in standing and not in supine position, suggesting that the standing after orthostatic challenge is the best method to monitor training status.[4,5] However, the orthostatic test has frequently been reported to be an inconvenient test to take on a daily basis. Several research attempts have been made at Polar to figure out whether information from the orthostatic test can also be obtained from daily routine activities. Until now, none of them turned out to be reliable or valid.[6] However, recording length of the orthostatic test can be reduced from 3min to 2min in supine and standing position each,[7] making the test more user-friendly.

Advantages of use

- User can see how recovered the cardiac autonomous system activity is, taking into account all loads, not just from training, but also from outside of training.
- User can test readiness for cardio training in order to optimize the right timing for key training sessions.

Calculation and interpretation

The newest orthostatic test result is compared to the individual normal RMSSD range of the user. The individual normal range is calculated from the individual mean and standard deviation of the test results from the past 4 weeks. In order to get an interpretation on the result, at least 3 measurements are required within 28 days, whereof 1 measurement needs to be from current day. It should be noted that the accuracy of the test result becomes more accurate the more measurements are done.

If the new measurement is within the normal range, it is considered to be normal and following message will be shown to the user:

Your cardio system is recoverd – today is a good day for cardio training.

If the new measurement is outside the normal range, it is considered to be abnormal and following message will be shown to the user:

Your cardio system isn't fully recovered – either train light or rest today.

If enough data is available for long-term feedback (see 4.3), training advice can slightly differ from the two illustrated examples based on the long-term recovery results.

Note that abnormal measures can come from significantly higher or lower than usual RMSSD in the orthostatic test. This is because both, increase[8,9] and decrease[10–13] in RMSSD were observed during extremely strenuous training loads. Figure 2 illustrates how this works with the example or RMSSD in supine position.

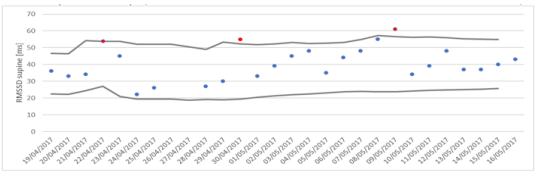

Figure 2. Example of how orthostatic test data from supine position is considered normal or abnormal. Same principle is also applied for data from standing after orthostatic challenge.

If the new orthostatic test result is within the normal range (within grey line), user is considered to be recovered and ready for cardio training.

If the new orthostatic test result is outside the normal range, user is considered not to be recovered and not ready for cardio training.

Several studies showed that training according to daily recommendations based on HRV caused better performance improvements compared to professionally designed training plans.[14–16] In a Polar study conducted in Würzburg, an orthostatic test guided training (group followed training program modified according to short-term recovery feedback from orthostatic test) led to similar improvements in 5 km running performance and VO_{2max} and better improvement in running economy compared to professionally designed training plans.[17] Importantly, the orthostatic test group achieved these results with significantly less training. It therefore seems that HRV can help to individualize training programs to get the best performance improvement for each individual.

Limitations

Limitations are the requirement of highly standardized conditions to make results comparable. Furthermore, as described previously, HRV measures are an accepted objective stress measure but, based on the HRV measures only, it is not possible to identify the stress source. It has also been reported that heart rate and HRV measures are not sensitive to assess neuromuscular, metabolic or psychometric perturbations,[1] which may be related to the fact that HRV is only a marker of the cardiac autonomic nervous system.[18]

4.2 Recovery questions

Description

A recent systematic review highlighted the importance of subjective measures to determine acute and chronic changes in athlete well-being in response to training load.[19]

Advantages of use

User can follow subjective recovery, which may cover stressors that cannot be objectively measured yet.

Calculation and interpretation

In order to minimize the effort of users to report subjective feeling, following three questions based on recommendations from experts in this area are selected (Figure 3):

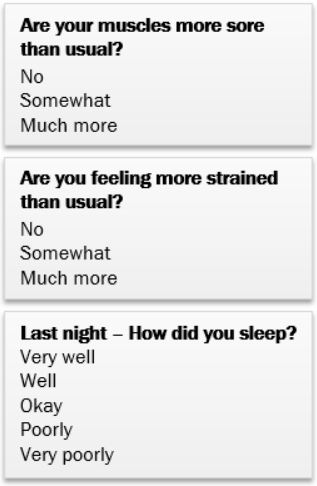

Figure 3. Recovery questions

Limitations

The time when user answers the question may influence the response. Ideal would be to answer the questions 30 minutes after waking up. It might also be that the selected questions are not sensitive to fatigue in all users.

4.3 Recovery Pro long-term recovery feedback

Description

The basic idea is to combine long-term (rolling average of past 7 days) objective (orthostatic test) and subjective (perceived recovery questions) results with training history to determine the balance between training load and recovery and to guide the user accordingly. The use of HRV in combination with daily training logs and subjective questions are recommended in scientific literature to offer a complete solution to monitor training in athletes.[20,21]

Advantages of use

- Helps user find best individual training load (not too little, not too much).
- Helps user to monitor individual training responses and adaptations.
- Helps user to prevent overtraining.
- Helps user to prevent unplanned detraining.
- Helps user to identify whether potential stress source is coming from training or from something else outside of training.

Calculation and interpretation

Following variables are input for the algorithm:

- Average score from recovery questions of past 7 days. This score is calculated from the recovery questions described in 4.2.
- 7 days rolling average of HRV from orthostatic test in relation to the user's individual normal HRV values from the past 4 weeks. The individual limits are, among others, dependent on the training background of the user (Buchheit 2016, unpublished data) and are taken from the user settings. Changing training background in the user settings may therefore change results. 7 days were selected based on the recommendation by Plews et al.[22] Four weeks were selected as baseline to be in line with the time-span from chronic training load (=Tolerance in Polar terminology) and because 4 weeks should average the effect of training periodization on heart rate and HRV in those athletes using heavy periodization cycles and average changes in heart rate and HRV due to hormonal effects in menstruating women.
- Training history using Strain to Tolerance ratio.

In order to receive long-term recovery feedback, both, a minimum of 3 objective (orthostatic test) and subjective (recovery questions) measurements are required per week.

The interpretation will be communicated to the user by the Recovery Pro long-term feedback including information on whether training was too much, too little or just right recently. The long-term feedback also warns when there was too much stress from something else than training or when the user is at risk for overtraining.

Limitations

It is unclear whether a shorter or longer time span than 7 and 28 days would be more appropriate to assess long-term recovery.

5 Validity

As there is no gold standard measurement for recovery, we cannot scientifically validate Recovery Pro. However, the algorithms are developed according to up to date scientific recommendations. Polar also tested the algorithms in several athletes and got positive feedback from them.

6 Limitations

Even though Recovery Pro uses a unique holistic approach, it does not assess all aspects of recovery. Up to date, there is no complete solution available to assess all aspects of physiolocial and psychological recovery.

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8 Glossary

Table 1. Polar Terminology related to Training Load Pro and Recovery Pro

Polar Terminology	Definition
cardio system	The circulatory system, also called cardiovascular system.**; Example:** E.g. the Orthostatic test gives a test result "Your cardio system is not fully recovered" and " Your cardio system is recovered.
cardio training	In cardio training you use large muscle movement over a sustained period of time and keep your heart rate to at least 50 % of its maximum. Cardio training gives your heart, lungs and circulatory system a good workout.
recovery feedback	Recovery Pro gives you daily feedback on cardio system recovery and provides training tips, which help you balance your recovery and training. To get recovery feedback, you should answer daily questions and take the Orthostatic test at least 3 times per week.
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