Polar Recovery Pro

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Polar Research and Technology

CONTENTS

1 Introduction

Training plans and workouts are typically prescribed based on scientific literature, general recommendations, coaching experience, and assumptions about an athlete's current training and recovery status. These guidelines aim to optimize sports performance by balancing training load and recovery. However, training adaptations are highly individual. The same training program can produce different responses, even among athletes with similar training background.

Additionally, an individual's ability to tolerate training load can fluctuate, as recovery capacity is influenced by factors beyond training, such as stress, sleep, nutrition, and environment conditions. Therefore, training and recovery should be monitored individually on a personalized basis rather than relying solely on population norms. A holistic approach that considers the athlete's entire 24/7 lifestyle is essential for optimal performance and well-being.

The purpose of the Polar Recovery Pro feature is to assess recovery in order to determine the optimal timing for key training sessions and evaluate the total training load an athlete can tolerate for maximum benefit. It also considers stressors from daily life, not just those related to training..

2 Why measure

Simply monitoring cardio load status, as described in the Training Load Pro white paper, does not account for many important factors outside of training that significantly influence recovey time. These factors include environmental conditions (e.g., climate, altitude), health status, mental stress, energy balance, hydration, 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 considers most stressors in a user's life, including those from both training and external factors.

It is important to note that not all environmental and mental stessors can be easily measured with technical devices in a user-friendly way for everyday use. However, some of these factors can be assessed through questionnaires.

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

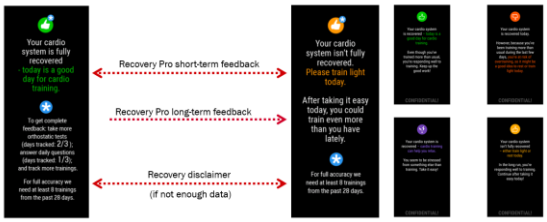

Figure 1. Recovery Pro, short-term and long-term feedback and training recommendation.

3 Advantages of use

- Users can measure their actual (not estimated) individual recovery status

- Users receive a recovery status that accounts for the effects of their overall lifestyle, including sleep, stress, nutrition, and environmental factors.
- Users can assess how much training their body can tolerate based on their ability to recover.
- User can track their 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 estimates how well the cardiac autonomic nervous system has recovered. It is calculated based on heart rate variability (HRV) analysis from RR recordings.

Several studies have reported changes in HRV during training overload, sleep deprivation, altitude or heat exposure, high mental and/or social stress, and illness. Therefore, HRV measurements are a valuable tool for assessing an athlete's training readiness, as they consider both training related stress and external life stressors.

Studies examining HRV in athletes have measured it at rest, during exercise, post-exercise, or during night.[1] The preferred method for assessing cardiovascular system recovery is short-term HRV measurement at rest under standardized conditions. This is currently considered best practice for athletes for athletes.[2,3]

Due to its shorter recording time, better reproducibility and the widespread use in scientific research, the square root of the mean squared differences of successive RR intervals (RMSSD) is the selected HRV parameter for calculating RR recordings and monitoring training adaptations in athletes.

At rest, measurements in the 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 observed changes in RMSSD due to overload only in standing and not in supine position, suggesting that standing after an orthostatic challenge is the best method for monitoring training status.[4,5] However, the orthostatic test is often reported as an inconvenient method for daily use.

Polar has conducted several research attempts to determine whether orthostatic test information could be obtained from daily routine activities, but none have proven to be reliable or valid so far.[6] However, the recording length of the orthostatic test can be reduced from three minutes to two in both supine and standing positions,[7] making the test more user-friendly.

Advantages of use

- Users can see how well their cardiac autonomic nervous system has recovered, considering both training-related and external stressors.
- Users can evaluate their readiness for cardio training to optimize the timing of key training sessions.

Calculation and interpretation

The latest orthostatic test result is compared to the user's individual normal RMSSD range, which is calculated based on the mean and standard deviation of test results from the past four weeks.

To obtain an interpretation of the result, at least three measurements are required within 28 days, with at least one measurement from

current day. It is important to note that the accuracy of the test result improves as more measurements are taken.

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

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

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

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

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

Note that abnormal measurements can result from significantly higher or lower than usual RMSSD in the orthostatic test. This is because both, increases[8,9] and decreases[10–13] in RMSSD have been observed during extremely strenuous training loads. Figure 2 illustrates this concept using RMSSD in the supine position as an example.

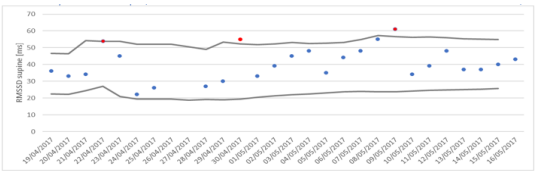

Figure 2. Example of how orthostatic test data from the supine position is considered normal or abnormal. The same principle applies for data measured at standing position after an orthostatic challenge.

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

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

Several studies have shown that training based on daily HRV-based recommendations based leads to greater performance improvements compared to professionally designed training plans.[14–16]

In a Polar study conducted in Würzburg, a group following an orthostatic test-guided training program—modified according to short-term recovery feedback—achieved similar improvements in 5 km running performance and VO_2max, along with greater improvements in running economy, compared to professionally designed training plans..[17] Notably, the orthostatic test group achieved these results with significantly less training. This suggest that HRV-based training can help individualize training programs for optimal performance improvements tailored to each athlete.

Limitations

A key limitation is the requirement for highly standardized conditions to ensure comparable results. Furthermore, as described previously, while HRV measures are widely accepted as an objective stress marker, they do not identify the specific source of stress.

Additionally, research indicates that heart rate and HRV measures are not sensitive in assessing neuromuscular, metabolic or psychometric disturbances,[1] which may be due to the fact that HRV reflects only the cardiac autonomic nervous system.[18]

4.2 Recovery questions

Description

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

Advantages of use

Users can track subjective recovery, which may help identify stressors that cannot yet be objectively measured.

Calculation and interpretation
To minimize the effort required from users to report subjective feelings, the following three questions—based on expert recommendations—have been selected (Figure 3):

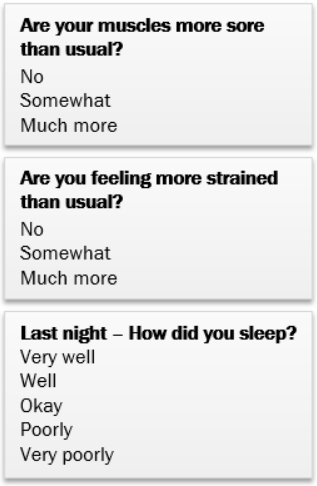

Figure 3. Recovery questions

Limitations
The timing of a user's response may influence the results. Ideally, the questions should be answered 30 minutes after waking up for the most accurate assessment. Additionally, the selected questions may not be equally sensitive to detecting fatigue in all users.

4.3 Recovery Pro long-term recovery feedback

Description
The core concept is to combine long-term data—a rolling average of the past seven days—from objective measurements (orthostatic test) and subjective assessments (perceived recovery questions) with training history to evaluate the balance between training load and recovery and provided personalized guidance to the user.

The use of HRV measurements alongside daily training logs and subjective questionnaires is recommended in scientific literature as a comprehensive approach to monitoring athlete training and recovery.[20,21]

Advantages of use

- Helps users determine their optimal individual training load (not too little, not too much).
- Helps user monitor their training responses and adaptations.
- Helps users prevent overtraining.
- Helps users avoid unplanned detraining.
- Helps users identify whether potential stress stem from from training or external factors.

Calculation and interpretation
The following variables inform the algorithm:

- Average score from recovery questions over the past seven days. This score is calculated based on the recovery questions described in Section 4.2.
- Seven-day rolling average of HRV from the orthostatic test, relative to the user's individual normal HRV values from the past four weeks. The individual limits depend, among others, on the user's training background (Buchheit 2016, unpublished data) and are set in the user settings. Changing training background in the settings may therefore alter the results. The seven-day period was chosen based on a recommendation by Plews et al.[22], while the four-week baseline aligns with the chronic training load timeframe (referred as Tolerance in Polar terminology). Additionally, the four-week period accounts for training periodization effects on heart rate and HRV, particularly in athletes using heavy periodization cycles, as well as for average hormonal fluctuations in menstruating women.

- Training history using Strain, Tolerance and Strain to Tolerance ratio.

To receive long-term recovery feedback, a minimum of three objective measurements (orthostatic test) and three subjective assessments (recovery questions) per week are required.

The Recovery Pro long-term feedback will provide users with an interpretation of their training load, indicating whether it has been too much, too little, or optimal in recent weeks. Additionally, the long-term feedback will alert users if excessive stress originates from sources other than training or if they are at risk of overtraining.

Limitations

It is unclear whether a time span shorter than 7 and 28 days would be more appropriate for assessing long-term recovery.

5 Validity

Since there is no gold standard measurement for recovery, Recovery Pro cannot be scientifically validated. However, its algorithms have been developed based on up-to-date scientific recommendations. Polar has also tested the algorithms on several athletes and received positive feedback.

6 Limitations

Even though Polar Recovery Pro takes a unique holistic approach, it does not assess all aspects of recovery. To date, no comprehensive solution exists to evaluate both physiolocial and psychological recovery in full.

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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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