FIRSTBEAT

Understanding Athlete Stress and Recovery

Contents

A 360-Degree Understanding

Monitoring what an athlete does on the training field has been a major part of professional sports for years, and rightly so. But the importance of what happens away from the practice facility should not be underestimated.

Everything that occurs between one training session and the next - from what they eat, to how they sleep - impacts an athlete's ability to recover and perform at the level required. But every player's body reacts differently to physiological and psychological stressors.

Discovering the ideal stress-recovery balance for an individual has a significant impact on their ability to; handle training loads effectively, perform optimally, develop quickly and avoid injury.

Collecting personalized information over a full 24-hour period can reap real rewards and provide a full 360-degree understanding that **informs coaching decisions and educates players on their well-being.**

How can you do this?

Firstbeat Sports uses heart rate variability (HRV) to monitor stress and recovery on an individual level as it accurately measures the autonomic nervous system (ANS). This makes it possible to see how well, and when, an athlete is recovering during the day and overnight. Periods of stress can be identified through monitoring of the parasympathetic ("rest and digest") and sympathetic ("fight or flight") nervous systems.

"Professional athletes are training for around 25 hours a week so there are still 143 hours that are very important in recovery and, ultimately, performance."

Veli-Pekka Kurunmäki
Firstbeat Director of Sports Performance Products

Glossary

**24-HOUR STRESS AND
RECOVERY BALANCE SCORE**

Score represents how well the
necessary recovery periods are
balancing out the body's stress
reactions in a 24-hour period.

EXERCISE

Periods when oxygen consumption is
at least 40% of the personal maximal
level.

LIGHT PHYSICAL ACTIVITY

Periods when the body's metabolism
is increased from the resting level but
intensity is low.

OVERNIGHT RECOVERY SCORE

Score represents the level of recovery
overnight. Metric score is based
on HRV and sleep duration and is
individualized.

RECOVERY REACTIONS

A calming down of the body
characterized by parasympathetic
predominance of the ANS, individually
low heart rate and great HRV.

RMSSD

Root Mean Square of the Successive
Differences in RR-intervals. The most
used parameter to describe the level of
HRV at rest.

STRESS REACTIONS

An elevated activation level in the
body not caused by physical activity.
Stress is characterized by sympathetic
predominance of the body, and the
reaction can be positive
(e.g. excitement, happiness) or
negative (e.g. anger, anxiety).

Understanding the
Key Metrics

———————

Firstbeat Sports is built on over 20 years of scientific research and work in professional sports. Our metrics provide the most comprehensive internal load monitoring analyses to help you measure training and recovery effectively.

A Digital Model of the Body's Physiology

Firstbeat Sports measures the body's physiological responses using HRV, and body movements using acceleration signals. HRV reflects arousal of the autonomic nervous system - specifically the sympathetic and parasympathetic nervous systems - which is central in controlling the body's stress and recovery reactions.

By building a digital model of the body's physiology, Firstbeat Sports is able to reveal how the body is responding to different activities over time and to quantify moments of stress, recovery, exercise and light physical activity.

This is done using the Firstbeat Bodyguard 3, a professional grade monitoring device which automatically records each heartbeat via two electrodes attached to the chest, and body movements via a 3D acceleration sensor.

Monitoring and visually representing the body's physiological state over a 24-hour period helps the athlete to better understand their body and make informed daily choices which support athletic performance - ultimately helping to get the ideal balance between training and rest.

Σ

HRV indexes, respiration frequency, VO2, EPOC, energy expenditure, moving speed etc...

Segmenting the data to physiologically coherent periods

Does the segment contain signs of physical activity and how intensive the activity is?
— YES, LIGHT → Light physical activity
— YES, AT LEAST MODERATE → Exercise
— NO ↓

Is parasympathetic activity dominating?
— YES → Recovery
— NO ↓

Is sympathetic activity dominating?
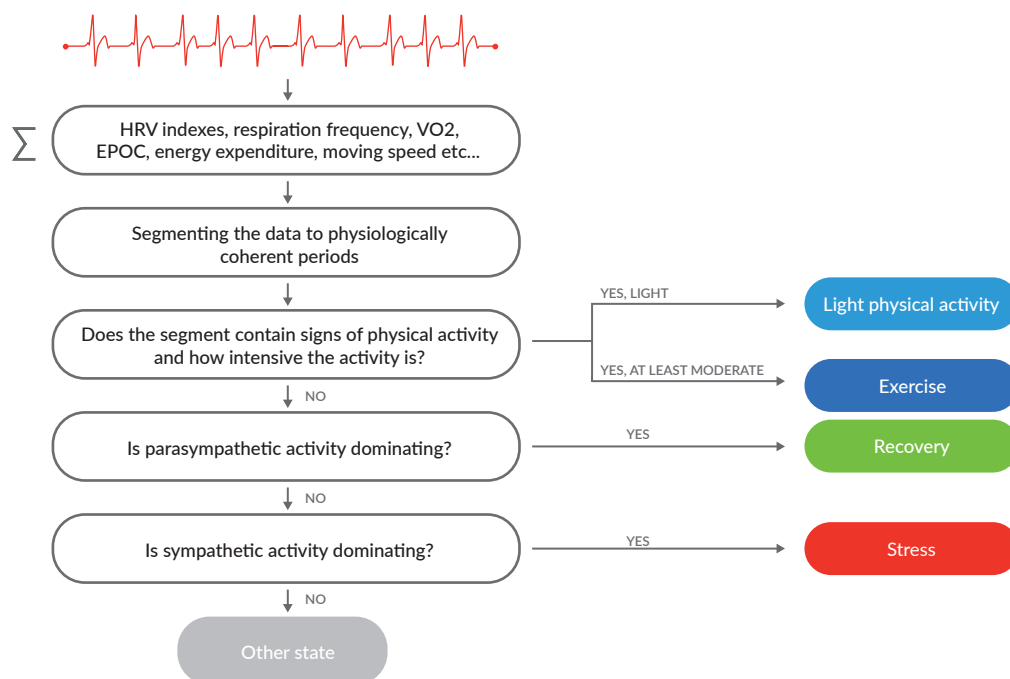— YES → Stress
— NO ↓

Other state

Fig 1. The process of building a digital model of the body's responses over time. The HRV and acceleration sensor data is transformed into information relating to various physiological processes which are then used to define the physiological status of the body.

24-Hour Stress and Recovery Balance

Increased sympathetic or diminished parasympathetic activity leads to the physical manifestation of stress during daily life. Stress reactions are natural and required in order to react and operate effectively in daily life, but prolonged, excess stress without effective recovery leads to fatigue and limits the body's capacity to perform. For athletes especially, it is vital to allow the body to regularly relax and unwind, and, in doing so, facilitate recovery to compensate for hard training.

Finding the Balance

Using the physiological modeling of the body's reactions detailed on page 5, the Firstbeat Sports system assesses the balance between stress and recovery to estimate whether the body's resources have accumulated or been consumed.

It isn't uncommon to see stress reactions present during a large proportion of the daytime. The most important thing is to get enough recovery to compensate. So, what exactly is 'enough'? Firstbeat Sports provides reference values for 'Good', 'Moderate' and 'Poor' amounts of stress and recovery. These values have been defined using data from hundreds of thousands of 24-hour HRV measurements during real-life situations.

A single, easy to understand score is created based on the amount of stress and recovery that has taken place, and is displayed on a 0-100% scale. The score indicates how well the stress reactions have been balanced out by recovery during the 24-hour period. The crucial role of recovery is highlighted in the score.

71%
GOOD

Stress **49% of time**

| ≥ 60% | 59-50% | ≤ 50% |

Recovery **31% of time**

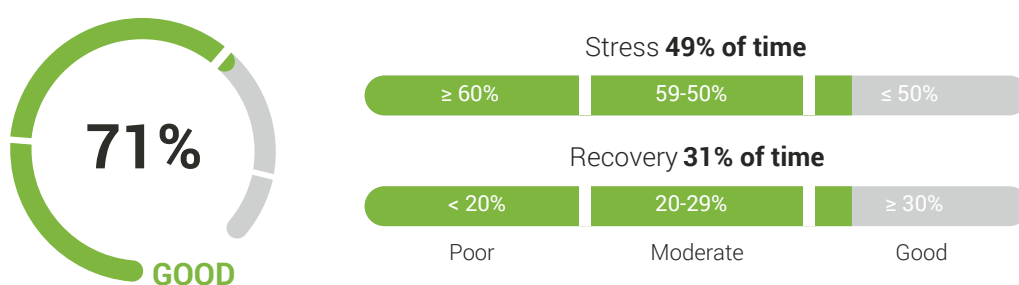| < 20% | 20-29% | ≥ 30% |

| Poor | Moderate | Good |

Fig. 2. The 24-hour Stress and Recovery Balance score combines information on the magnitude of stress and recovery reactions in the body during the measurement.

Overnight Recovery

Sleep is the body's active and dynamic process to recover. A night's sleep is the definitive resting period which should support an individual's long-term health and performance levels.

The **Overnight Recovery Score** describes the level of physiological overnight recovery in an individual and is represented as a percentage. It is defined by two factors:

1. Recovery Index - The quality of relaxation in the body via analysis of personally calibrated HRV levels
2. Sleep Duration - The quantity of sleep obtained on a given night

Quality of Relaxation (Recovery Index)

The quality of relaxation is measured by analyzing HRV and heart rate levels during a night's sleep. Because sleep has different dynamically changing stages which also affect cardiovascular reactions, we have standardized the analysis on the most stable period of sleep. This means the Recovery Index value is derived from a 4-hour period that begins 30-minutes into sleep. Using this period of time - where deep sleep usually occurs and where physical recovery such as protein synthesis and growth

hormone secretion takes place - provides reliable and consistent results.

The level of HRV is a highly individual characteristic. As a result, Firstbeat Sports takes personal measurement history into account to accurately define the quality of relaxation. Color-coding of these personal scales show the user their score in relation to the absolute Recovery Index value. When formulating the personal scaling the 'smallest worthwhile change' method is used to assess how much an athlete's HRV values typically change from one night to another.

Quantity of Sleep (Sleep Duration)

Regular adults are recommended to sleep between 7-9 hours-per-night. However, demanding physical training increases the need for recovery and scientific studies have found that athletes benefit from longer than average sleep. Thus, in Firstbeat Sports, 8-9+ hours is defined as 'Good' sleep duration. 6.5-8 hours is 'Moderate', and fewer than 6.5 hours is 'Poor'. The importance of getting enough sleep is highlighted by the fact that it is impossible to get a good Overnight Recovery Score when sleeping for short periods.
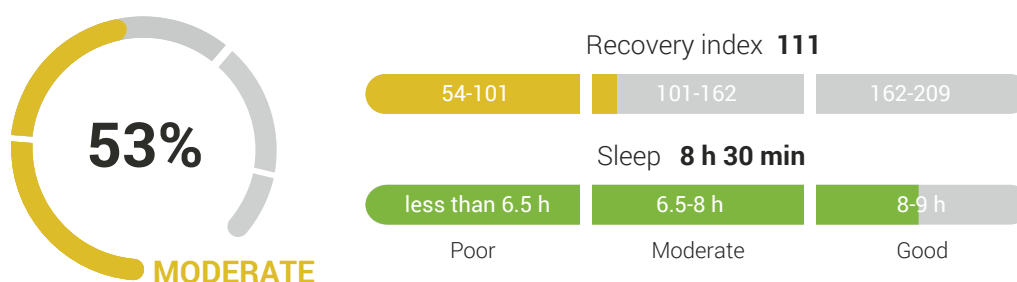

Fig. 3. The 0-100% Overnight Recovery Score takes into account the personally calibrated, HRV-based Recovery Index and Sleep Duration to provide a follow-up metric highlighting how sleep is supporting long-term performance improvements. This serves as a tool when making training decisions.

Conducting follow up measurements of both the overall 24-Hour Stress and Recovery Balance and Overnight Recovery score helps you identify trends and track progress over time.
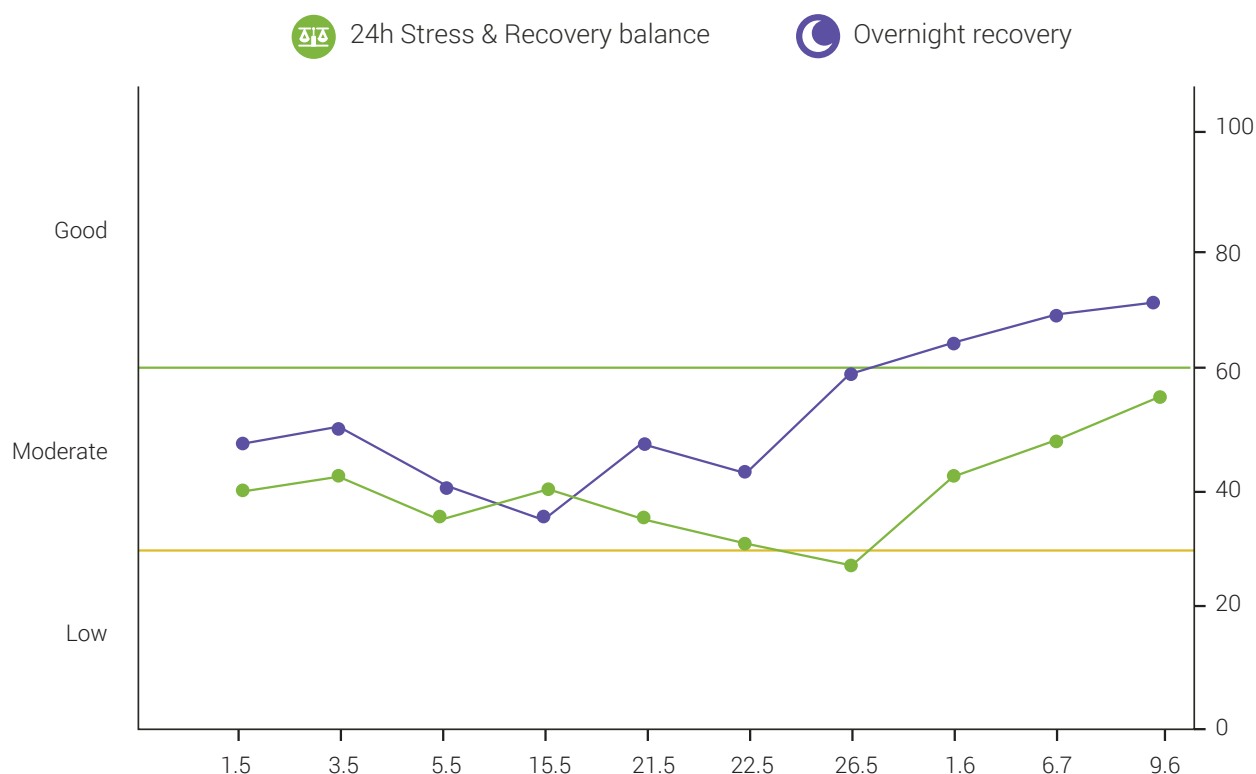

Fig. 4. A follow-up chart for the two scores describing recovery.

Did you know...

Increased sleep quality and quantity has been shown to increase reaction times, improve wellness, boost physical recovery and reduce injury risk.[1]

52% of athletes monitored in the Firstbeat Sports database were found to be getting fewer than eight hours sleep.

[1] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6112797/

Getting Results

Firstbeat Sports allows you to monitor stress and recovery in athletes
over a 24-hour period using the Firstbeat Bodyguard 3. This gives you a
full picture of an athlete's situation and helps inform decisions.
To do this effectively, it is important to understand how the data
can be put to practical use.

Leisure Time and Behavioral Decisions

On average, a player at the elite level is training for approximately 25 hours each week. That leaves a lot of time throughout the rest of the week which can affect their stress levels, recovery and, ultimately, impact performance.

Alcohol consumption, time of training/exercise/games, diet and blue light emitted by smartphones, TVs and tablets are amongst the things that can influence the onset of recovery during sleep. Meanwhile, failing to find time for daytime recovery can lead to a stress imbalance as players struggle to wind down and relax.

Selectively monitoring stress and recovery reactions throughout a certain day, or overnight, is an important educational tool. It helps players understand how and why certain behavioral decisions, or periods of their leisure time, are impacting their performance or ability to handle training load.

With Firstbeat's illustrative reporting, athletes can be guided to look after their well-being in their 'civil life' as well as support the concept of being a 24/7 athlete.
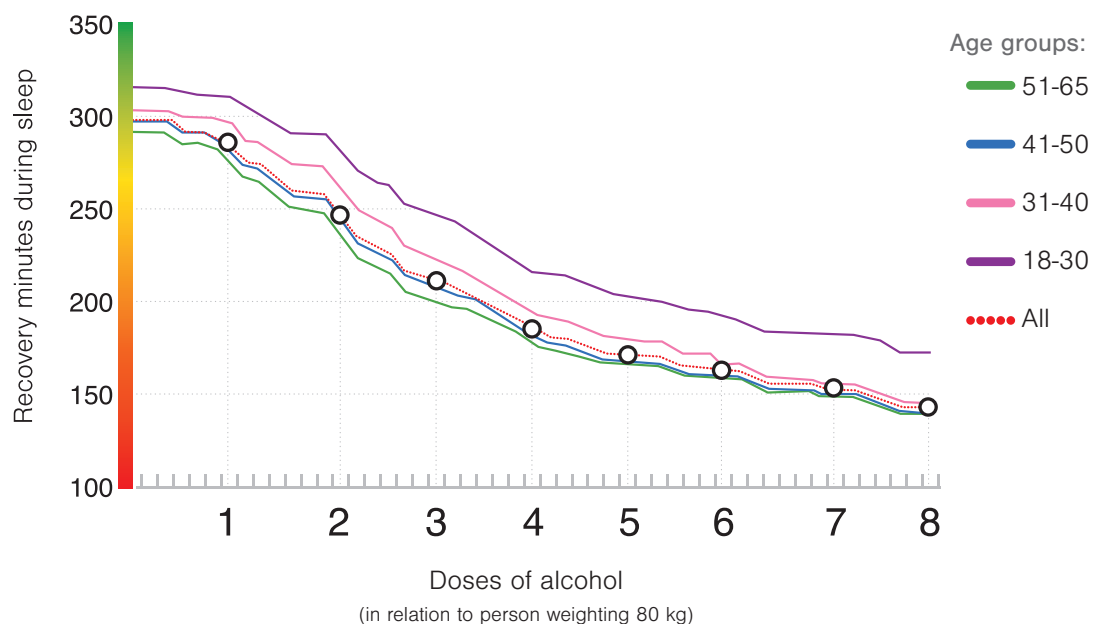

Fig. 5. The impact of alcohol on recovery in different age groups in the Firstbeat data. There is a dose-response relationship between the doses of alcohol and reduced recovery. Alcohol is a significant factor disturbing the body's recovery process and sleep.

Typical uses:

Follow-up Assessments:

Individual follow-up assessments help track whether behavioral changes have had the desired effect on stress and recovery levels. They can also flag up if any new personal developments have impacted an individual.

'Known Situation' Assessments:

Conduct a new assessment when there are known changes to an individual's lifestyle/ personal situation. For instance, a newborn baby can impact sleeping patterns and, thus, recovery. An assessment can help you plan for this situation correctly and aid the player as best as possible.
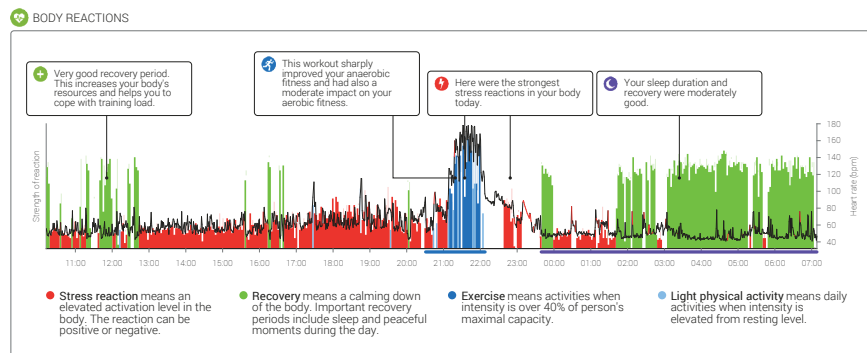

Fig. 6. An example report showing one player's actions during a 24-hour period. In this example, a late night workout has delayed recovery. This information should be used to plan optimal recovery strategies that maximize the rate of recovery.
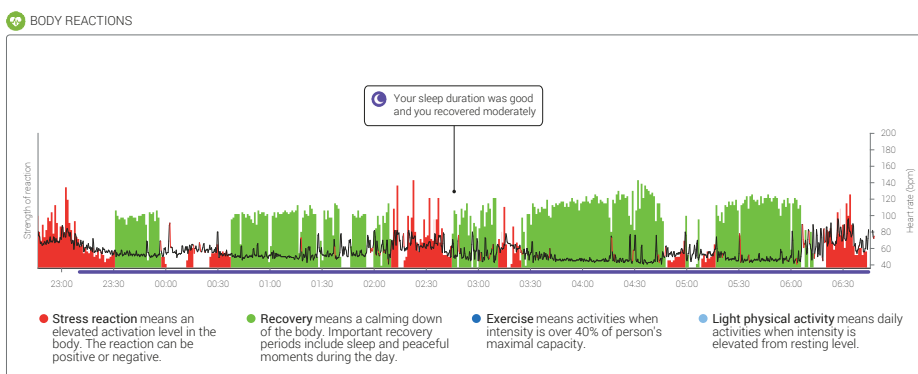

Fig. 7. Example: The athlete's sleep is being monitored after a new baby was born to a family. Stress reactions during the night are due to waking up when the baby is crying. Momentarily disturbed sleep & recovery is then taken into account in training prescriptions.

Travel Schedule

Successfully navigating a hectic fixture schedule is important when seeking to reduce injury risk and ensuring players can perform at their peak. Getting the travel schedule correct is a vital part of this in order to manage stress and ensure necessary recovery takes place.

Teams across the world are taking steps to provide the best environment for players on the road. This includes choosing specific hotels, mattresses, flight times and planning on-the-road nutrition with recovery in mind. Monitoring stress and recovery lets you see how travel affects individuals and, as a result, adopt and adapt practices that promote the recovery process.

Typical uses:	
New Environments: Travelling for fixtures can mean changes to the standard routine and new environments for players. Monitoring Stress and Recovery Balance allows you to see how players are reacting to these new environments and make adjustments accordingly.	**Away Fixtures:** Studies show the start of recovery can be delayed by up to three hours following away games compared to home fixtures. Knowing the exact data for each player helps inform when to travel to, and back from, road fixtures and when to begin a training session the day after travel has been completed.

BODY REACTIONS

OVERNIGHT RECOVERY

Your sleep was too short and your recovery was very poor.

27% POOR

Recovery index 25
0-29

Sleep 6 h 21 min
less than 6.5 h

Poor   Moderate   Good

Stress reaction means an elevated activation level in the body. The reaction can be positive or negative.

Recovery means a calming down of the body. Important recovery periods include sleep and peaceful moments during the day.

Exercise means activities when intensity is over 40% of person's maximal capacity.

Light physical activity means daily activities when intensity is elevated from resting level.
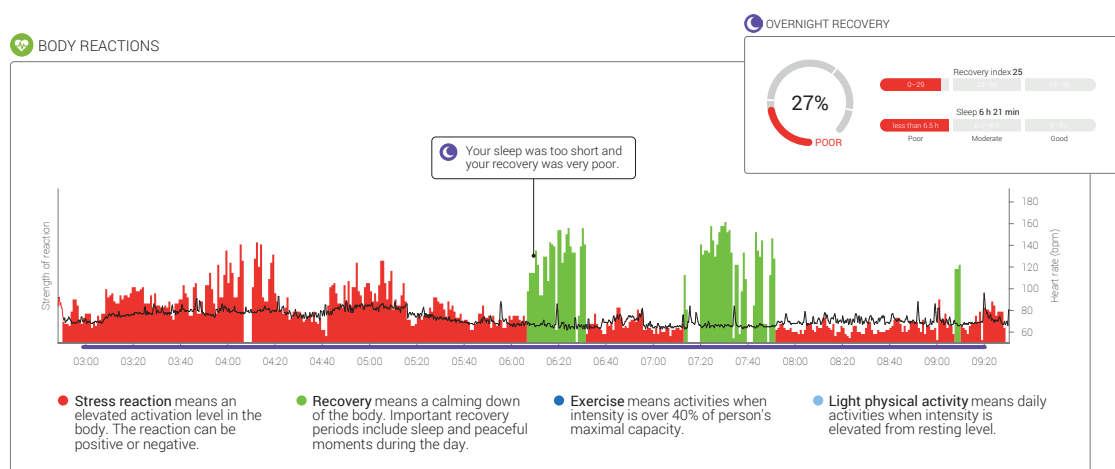
Fig. 8. Feedback report shows a player's overnight recovery after a game. The data shows significant disturbance in both sleep duration and sleep quality, leading to a poor Overnight Recovery score.

The follow-up chart in the same player's report (see below) shows that recovery typically returns to the baseline after a few days. However, travelling from away games back home can delay reaching baseline recovery until four days after the game. It also shows the player's typical level of recovery leading up to an away game is reduced compared to a home fixture. This is the impact of travel and new environments.
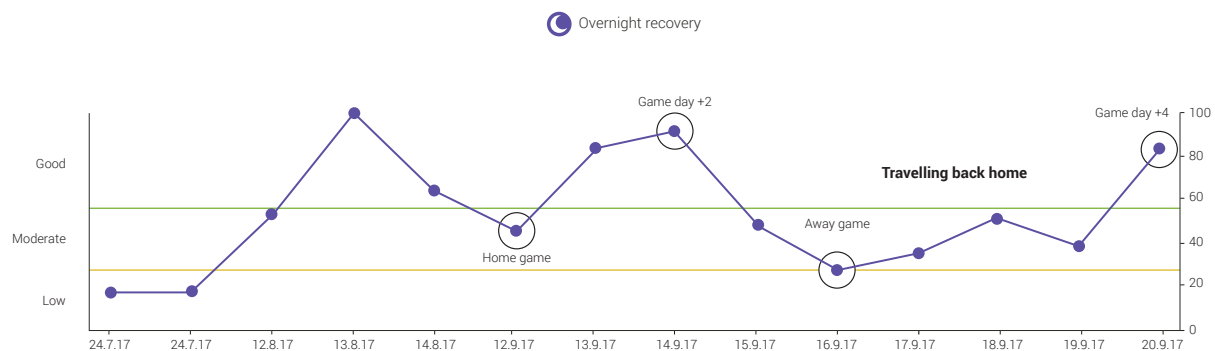

Fig. 9. An individual player's follow-up report showing their ability to recover during the season.

Putting it to use

Team GB ski coach Jai Geyer monitored recovery and stress data for skier Dave Ryding in the run up to the 2018 Winter Olympics. Ryding went on to achieve Team GB's best alpine finish in 30 years at the Games.

"We used the Bodyguard to see how long-haul travel and changes in time zones can affect the athlete's recovery. We wanted to see how long it takes to re-establish the 'norms'. The information we received informed some of the decisions surrounding when we went to Pyeongchang for the Winter Olympics."

Jai Geyer
Team GB Ski Coach

Overnight Recovery and Training Periodization

Sleep and recovery go hand in hand. It is the most effective time for the body to replenish energy levels. As such, collecting data overnight is the best and most accurate time to analyze whether effective recovery is taking place in the aftermath of a game or training session. Meanwhile, poor overnight recovery can negatively impact athletic performance and lead to exhaustion or injury.

Typical uses:

Post-Game Recovery:

Use the Firstbeat Bodyguard 3 to monitor true overnight recovery following games. For example, an athlete self-reporting they had eight hours sleep would suggest good overnight recovery. However, Firstbeat data shows exactly when recovery began within this eight hours - providing more accurate information on the recovery state of an individual.

Coping with Training Load:

Finding the right training load balance is important so that athletes can be pushed when they need to be, and peak when it matters most.

More frequent Overnight Recovery measurements are recommended during harder training periods, whilst players with the highest and lowest Training Effect value in team training are suggested to be monitored.

Training Periodization:

Measure how long it generally takes individuals to recover from games or training and apply this information when planning training periodization. Seeing how athletes cope with an ongoing training schedule helps plan for important periods of the season, and provides insight into why a player's performance levels have altered.

"In the past, we would go off coaching intuition, watch the player walk in and make a judgement based on what you are seeing or feeling from that player. A lot of times it's hard to get a kid to open up with such subjective feedback.

With Firstbeat, we have actual data that can validate some of that intuition and create an opportunity to get a player to open up and talk about what is going on."

Frank Wintrich,
Director of Football Performance, UCLA

Measurement Protocols

Stress and recovery monitoring is, first and foremost, an education tool for players themselves and coaches to help get the most from individuals. Applying the correct measurement protocols helps unlock this potential. Putting the right protocol in place also helps avoid players feeling they are being over-monitored.

Each team is different. However, for the following scenarios we recommend certain protocols:

Typical Squad Management:

Conduct a full stress and recovery assessment for each member of the squad at the beginning of the season. This gives you a 'typical level' for each athlete and allows future assessments to be measured within the appropriate context. It helps you highlight trends or potential red flags.

Players will receive their individual feedback report privately, allowing them to identify areas in their own lifestyle/situation which could be adapted.

Return to Play:

When a player is returning from a period out injured the load placed on them will inevitably increase. Monitoring their ability to recover - both in the hours following a session and overnight - lets you know how hard to push them during training and helps reduce the chance of reinjury.

Remote Monitoring:

Having players use the Bodyguard 3 device for periods during the offseason, or whilst away from the squad on international duty, lets you keep track of their situation even when not in immediate, daily contact. Players away from the team can collect and upload data remotely, meaning you can see the impact of situations beyond your control and react accordingly.

Impromptu Situations:

A player may self-report that they are having trouble sleeping, or they believe an issue is affecting their everyday life. Tracking their stress and recovery levels for a 'one-off' 24-hour period can provide objective data when seeking to find a solution to the problem.

"I use the system with the injured players to help them return safely to the line-up. The first two weeks after injury is the most critical time to see how they are responding to the increased training load."

Julen Masach

Strength and Conditioning coach, Arsenal

Previously PSG, Hannover 96, Turkey national team

The Next Step

To perform at the top level consistently, every moment counts. Being able to understand and appreciate what is happening away from training or practice can help inform the decisions made during it.

Get the Full Picture

Firstbeat Sports' Stress and Recovery Monitoring allows you to get the full picture of an athlete's physiological condition. This 360-degree understanding helps you:

- Get an in-depth picture of overnight recovery beyond just sleep duration
- Help players find their ideal stress-recovery balance and boost well-being
- Fine-tune training plans based on objective data previously unavailable
- Put your players in the best position to achieve peak performance levels

FIRSTBEAT BODYGUARD 3

**For 24-hour heart rate monitoring –
An insight into daily life, sleep and exercise**

The **Firstbeat Bodyguard 3** is a reliable R-R interval recording device for short and long-term measurements. It is designed for 24-hour heart rate monitoring for insights into daily life, sleep and exercise.

How do I learn more?

Visit firstbeat.com/sports-coaching/user-stories to read success stories from teams like Detroit Red Wings, Hertha BSC, UCLA football and Saracens Rugby.

Listen to the Firstbeat Sports Podcast to hear from leading coaches and sports scientists about the latest in performance monitoring: firstbeat.com/en/podcasts/.

To learn more about how you can implement Firstbeat Sports technology into your set-up and start benefiting from Stress and Recovery Monitoring, contact us at:

sports@firstbeat.com
firstbeat.com/sports

1000+	25%	26	100+	>50%
Elite Teams	of Champions League Soccer Teams	National Teams	NCAA Programs	of NHL teams

Advanced Performance Analytics

FIRSTBEAT