Polar Team Pro System

Polar Research Center

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1 Introduction

Team sports evolve constantly. Considering soccer, where data from a wide variety of performance tracking sources is available, the game is now filled with more high intensity action than ever.[1–3] . As the game evolves, training tools have to evolve also.

Players' heart rate (HR) responses have been monitored already for 40 years. To also obtain information about movement, global navigation satellite systems (GNSS) have supplemented HR monitoring.

Although training monitoring devices were first adopted by individual athletes, it didn't take long for teams to follow. In 2015, teams surveyed in Europe, the United States, and Australia showed that monitoring heart rate and player movement during all training sessions was becoming the norm.[4]

Polar Team Pro contains state-of-the-art heart rate monitoring, movement tracking, and comprehensive training load solution, including internal and external training load, in one kit.

By managing training load with Team Pro, athletes can continue development, maintain match day readiness, and ensure that training load is in line with today's game standards. As the system itself is portable, it's not tied to one training location, but can be carried to any training site.

2 Polar Team Pro System

Polar Team Pro player tracking system consists of three elements: 1) a heart rate belt or Team Pro shirt and wearable sensor module, one pair for each player, 2) a recharging dock, and 3) cloud-based player performance analytics software available on iPad for real-time monitoring, and as a connected web service for post-session analysis. (Note: iPad on figure "Team Pro system" is sold separately).

TEAM PRO SYSTEM. Wearable sensors and a recharging dock are connected to an iPad for synchronization to the web service.

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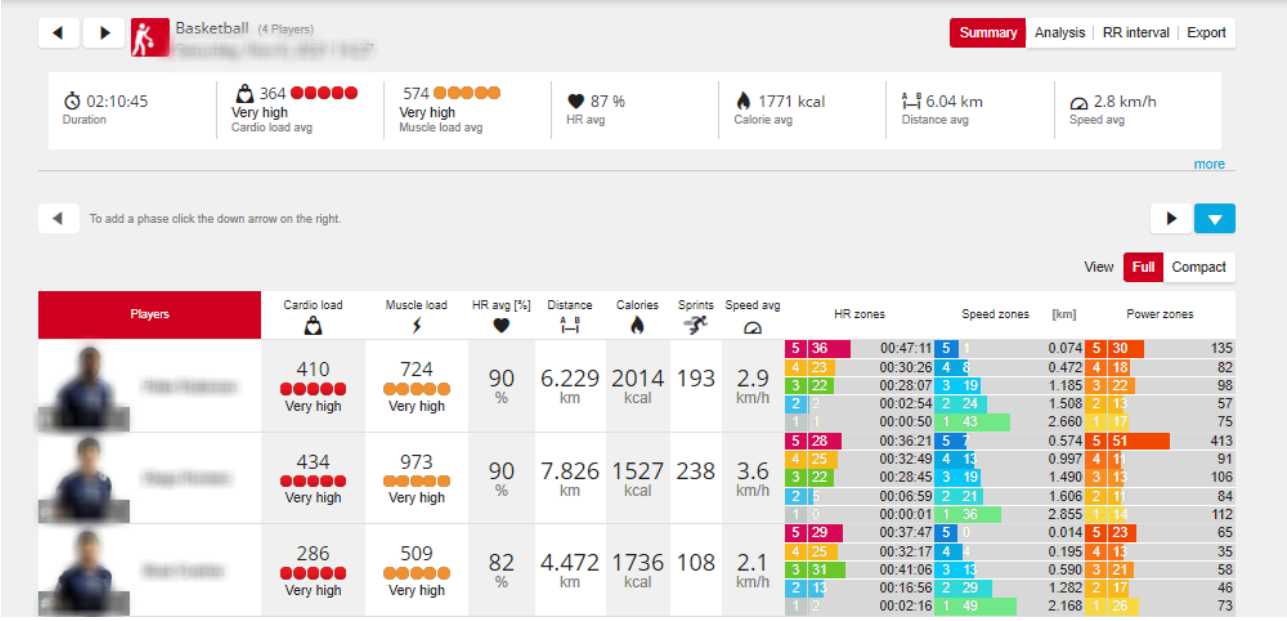
SESSION OVERVIEW. HR, speed and power zones are displayed by color codes (see text for explanation).



The operating principle of Polar Team Pro system is very simple. During each training session or game, players wear dedicated wearable sensor modules that measure physiological data as well as information about the player's movement on the field.

After the monitored session is over, all wearable sensors are attached to the dock for data synchronization to the iPad. From the iPad, the data is transferred wirelessly to the Polar Team Pro web service via the iPad's built-in Wi-Fi or cellular connection.

The Polar Team Pro system provides coaches with extensive data on the following areas: HR, location map, distance, velocity, acceleration, and power.

The accompanying wearable sensors are equipped with Bluetooth technology that enables continuous data transfer with a range of up to 200 meters. This enables live monitoring of each player during the training session on the coach's iPad. The wearable sensor module also comes with internal memory capable of storing 65 hours of training data, which ensures that no data will be lost due to bad connections.

Advanced training analysis and reports are available in the Polar Team Pro web service. Coaches can analyze each player separately or run reports on the whole team. They can also compare session data to earlier training sessions to get information about the effectiveness of the training and to identify signs of injuries or overtraining. Each individual player can also access their data if they have a Polar Flow web service account.

3 Technology

The wearable module of Polar Team Pro includes a heart rate and GNSS receiver and an inertial measurement unit (IMU). In the following sections a description is given of how these basic measurements are processed to provide detailed information about the athlete's performance on the field.

3.1 Heart rate

Polar Team Pro presents heart rate in absolute terms, as beats per minute [bpm], and in relative terms, as percentage of the individual maximum heart rate [HR%].

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By default, the maximum heart rate is calculated as HR_{max} = 220 – age, but it is recommended to take the maximum heart rate value from a high intensity training, game or test (e.g. intermittent yo-yo test) to reflect the maximum HR of an individual player more accurately.

Polar Team Pro uses a five-step default categorization of HR% to divide the intensity into respective HR zones. Zone 1 is the easiest in terms of load while Zone 5 is the hardest one. The default values of each zone are: Zone 1 = 50…60%, Zone 2 = 60…70%, Zone 3 = 70…80%, Zone 4 = 80…90%, Zone 5 = 90…100%. These limits can be adjusted by the user if needed.

The benefit of using HR zones instead of absolute HR values is that they are comparable between athletes. Training with the intensity at Zone 3 is evenly strenuous for each athlete no matter how high or low their maximum heart rate is. Team Pro uses color coding in the graphical views to represent each HR zone: 5 Red, 4 Yellow, 3 Green, 2 Blue, and 1 Gray. This makes it easy for the coach to see how much time each player has spent in each intensity level (see “Session overview”).

3.2 Movement

Player movement tracking is an integral part of any team sport training system providing information about player’s location on the field and quantitative measures of player’s horizontal acceleration, speed and distance travelled.

In the Polar Team Pro system, player location during a training session or a game is visualized as a heat map that integrates the coordinates of players over the whole session on a map representing the playing field. The “hot” areas (red color) show the location where the player has spent most of his or her time.

The Polar Team Pro sensor uses several adaptive data source and filtering algorithms for player acceleration, speed and distance calculation. The sensor selects the source automatically based on the available data and the quality of that information. Outdoors, where the GNSS sensor can acquire satellite signals, GNSS is the primary method for tracking. Polar Team Pro uses 10 Hz GNSS due to its validated accuracy in measuring instantaneous velocities.[5] Indoors the GNSS data is not available and all movement data is calculated from the information provided by the Inertial Measurement Unit (IMU) consisting of acceleration, gyroscope and magnetometer sensors. The implementation of the algorithms relies rather heavily on 9D Polar Electro proprietary sensor-fusion technologies.

The heat map is not available indoors as inertial sensors cannot provide exact coordinate information.

3.3 Running power

In 2018, Polar introduced the first wrist-based Running Power solution without need for additional sensors.

The original wrist-based Running Power feature followed the speed at which the runner moves and the gradient at which the runner ascends or descends making it a great tool for hill training. In addition, power responds rapidly to changes in intensity, as opposed to HR that responds much more slowly. As a result, power data is ideal for high-intensity interval training.

The next generation of Running Power for Team Pro was launched in 2021. This new Running Power doesn’t consider gradient as gradient is constantly zero on a flat court. Instead, Team Pro considers player’s acceleration, in addition to speed, when determining the power at which player is moving.

A striking example of the contribution of acceleration on power is seen in sprinters. Instead of supplying highest power during the maximal speed phase, the sprinter’s power output tops immediately after leaving the starting blocks when the acceleration reaches its peak value, but the speed is still relatively slow.

Thanks to its high-frequency sampling, Team Pro can obtain both speed and acceleration data with high precision. As a result, users can now enjoy wider power measurement range than ever (see comparison below). This range is enough to accurately capture even the most intense bursts of actions during a game.

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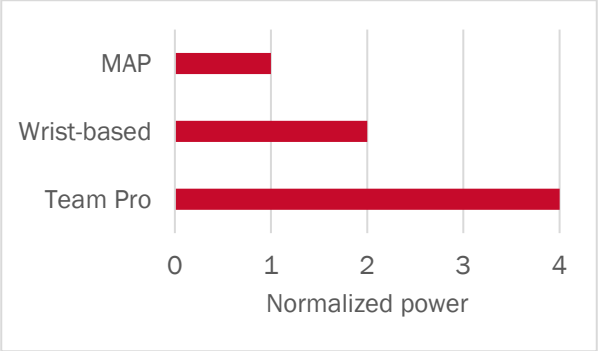
MORE RANGE. Comparison of range that can be obtained with wrist-based and Team Pro specific power in relation to maximal aerobic power (MAP), which equates to unity.



In Polar devices, we use a five-step categorization of power zones, just like we do with HR. The default power zones are: Zone 1 = 70%…85%; Zone 2 = 85%…100%; Zone 3 = 100%…130%; Zone 4 = 130%…180%; and Zone 5 = over 180% of maximal aerobic power (MAP). Users can freely update zone limits.

Maximal aerobic power, which we use to define power zones, can be assigned in two ways. First, by updating a player's maximal aerobic speed in player settings, system will convert that to MAP. Second, players can take the Running Performance Test with a wrist-worn device (such as Polar Vantage V2) to determine MAP. This requires that the player's individual Polar Flow account is synchronized with the Team Pro account.

As the unit of power, watts (W), implies, Running Power depends on the player's weight. Therefore, it's crucial to keep weight data updated to receive correct power readings.

3.4 Training load

The management of training load has been at the core of Polar's research for many years. As a result of continuous development, Team Pro users can now choose between several methods to analyze and display training load.

Training Load Score belongs to the previous generation of the training load feature, which combines several data sources such as heart rate, calorie consumption, mechanical impact and duration of the exercise, and translate it into an easily understandable format. Alternatively, Training Load Score can be presented as **recovery time,** an estimate of the time needed to recover from the training. Recovery time can range from mild exercise needing only one hour recovery to extreme requiring at least 48 hour recovery. These functionalities are not under development, but are still available in Team Pro.

Cardio Load and **Muscle Load** are part of the Training Load Pro feature. This is the most recent generation of player load management tools. As these functionalities will be further developed, they warrant closer attention and are therefore described in distinguished section "Player load management".

4 Team Pro Validity

4.1 Heart rate

Team Pro relies on Polar's heart rate measurement technology that has been rigorously validated over the years. In a recent study, Polar's flagship heart rate monitor Polar H10 was compared against Medilog AR12plus ECG Holter monitor. The difference between Polar H10 and the criterion measure was (0.0 ± 4.4) % over a wide range of movement intensities. Polar H10 came out exceptionally strong at high intensities, when its signal quality exceeded ECG Holter monitor (Polar vs. Medilog = 99.4% vs. 89.8%). As a result, the authors recommended Polar H10 as the "golden standard" of heart rate variability measurement during exercise.[6]

4.2 Movement

Team Pro's preferred method of movement tracking is GNSS although also IMU-based tracking is used indoors. Here, we consider only the validity of GNSS as this situation is considered the most common.

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The real-world GNSS positioning accuracy that a user attains depends on environmental conditions, availability of satellites and building infrastructure (open field vs. blocked by buildings). Thus, the user experience may differentiate from the results acquired by a research group.

In a recent study, the standard error of distance was always 1% or less over a linear locomotion path (length = 100 m). When multi-directional locomotion path (length = 120 m) was used instead of a linear one, the distance error did not exceed 2%. The error of maximal speed during sprinting task was 3% and 5% over linear and multi-directional paths, respectively.[7]

4.3 Running power

Running power has several definitions and therefore its comparative analysis is not straightfoward.[8] As the definition of running power is out of the scope of this paper, we recommend readers to seek more information on Polar's website and read the white paper dedicated to Running Power.

5 Player load management

Injuries are the nemesis to all athletes. In team sports, the consequences of injury fall on whole team instead of a single athlete as injury rates correlate negatively with team success.[9]

To speak in numbers, the current mean injury rate in professional soccer is 27 injuries per 1000 hours of play. This result to 12% of players being unavailable at any given moment and around 50 injuries per team over a season.[10]

To avoid injuries, it has been suggested that factors such as training load, playing style, and the continuity of medical and technical staff should be considered and further investigated.[10]

Research has shown that both high and low acute training loads can predispose athletes to injury. The strongest advisor seems to be the acute:chronic load ratio, defined as the training load from the past week divided by the training load from the last four weeks. So far, the best estimate that scientists can agree upon is that athletes should maintain acute:chronic training load within the range 0.8–1.3 to gain positive training adaptation and still stay free of injuries.[11]

What parameters should be included in successful training load management? A consensus statement from the International Olympic Committee recommends using at least one internal and one external training load measure to distinguish between body's internal response to exercise and how body interacts externally with environment.[11]

Examples of internal training load measures are HR and subjective feeling, whereas examples of external measures are speed, distance, power, and work.

Training load variable can also be categorized as cumulative or non-cumulative. Cumulative training load means that time is factored into the equation: the longer the duration, the higher the load. In practice, most training load parameters are cumulative, like distance and work.

Distance has been widely used as an external training load parameter. This approach has limitations, though. Distance takes into account only the speed at which player travels, but not how often player changes speed. As a result, some teams have started to follow traveled distance and accelerations together to gain information on external load. This is laborious and potentially futile.

Running Power merges acceleration and speed into a single number what allows to determine external load without a lot of hassle. Therefore, the primary method to measure external load in Team Pro is Muscle Load, which is based on Running Power.

Training Load Pro is the latest generation of training load innovations from Polar and has now been integrated into Team Pro. Here we describe shortly the main components of Training Load Pro and how they are interpreted. More detailed information can be found from Training Load Pro white paper from Polar's website.

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5.1 Cardio load

Cardio Load uses heart rate information to quantify internal (or cardiovascular) load that player experiences. Cardio Load is computed using Bannister's TRIMP (training impulse) formula and it is cumulative training load measure.

5.2 Muscle load and power zones

Muscle Load quantifies external (or neuromuscular) load that a player experiences. Muscle Load is cumulative training load measure as it is calculated by integrating Running Power over time. Muscle Load can be interpreted as positive mechanical work done by an athlete during training or game. Therefore, unit of Muscle Load is the same as for energy and work, that is, joule (J) or, practically, kilojoule (1 kJ = 1000 J).

Muscle Load is divided into five power zones (see chapter 3.3 for limits) to help users distinguish high-intensity work from total work. High-intensity work is likely to be a good indicator of match-readiness. It has been shown that a team's usual starting line-up accumulated more load over a season as compared to fringe players, but only if comparison was made for high intensities.[12]

Power zones differentiate from HR zones in one fundamental way. Whereas HR zones show accumulated time in each zone, power zones show the accumulated Muscle Load in each zone.

Muscle load and power zones are activated for all running-based outdoor sports. For indoor sports, users must manually activate Muscle Load, in which case the device uses IMU as the speed source in power calculations. Muscle Load is not available for ice hockey and volleyball.

5.3 Training load level

Training load level is assessment of the load from the current training session as compared to mean load from all training sessions within last 90 days.

The training load levels shown in Team Pro are: 1) Very low; 2) Low; 3) Medium; 4) High; and 5) Very high.

The training load level is determined separately for Cardio and Muscle Loads (see "Session overview").

5.4 Training load status

Training load status is four-step verbal assessment of acute:chronic load ratio.

Overreaching = Load much higher than usual
Productive = Load slowly increasing
Maintaining = Load slightly lower than usual
Detraining = Load way lower than usual.

In addition, user might be warned about increased risk of injury.

Training load status is available for Cardio and Muscle Loads.

5.5 Strain and tolerance

Strain implies acute and **tolerance** chronic training load. Strain is computed as average training load within last 7 days, whereas tolerance is computed as average training load within last 28 days. Together, strain and tolerance determine Training load status.

Strain and tolerance are available for Cardio and Muscle Loads.

6 Summary

Polar Team Pro is an easy-to-use player load management system that provides the team coach and the team members a versatile and extensive set of information about both training sessions and games. Team Pro system promotes players to stay free of injuries and develop or maintain match fitness at level that top performance in game demands.

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