Omegawave: Theory & Practice

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INTRODUCTION

The Omegawave Team System provides an innovative approach to athlete preparation, one that can be incorporated into any type of training program without radically changing the existing methodology or representing a threat to the coach's intuition. Omegawave's approach centers on the concept that the type, volume, or intensity of the training load should not be the primary focus, but rather the *timing* of when the load is applied (5).

Omegawave's technology is a synthesis of extensive research in the fields of neurophysiology, cardiovascular physiology, and exercise physiology. The concepts put forth by this manual are an extension of training theories established over 60 years ago, concepts which in their current application are meant to provide objective feedback for analyzing and predicting how athletes are adapting to their training sessions (4).

This manual is designed to answer the following questions for users of the Omegawave Team solution:

- **What foundation did modern training theory evolve from?**
- **What is the science behind Omegawave?**
- **What do all of these numbers actually mean?**
- **How do I use this information to help guide the training process?**

THE TRAINING PROCESS

TRAINING THEORY: HISTORICAL PERSPECTIVE

In order to understand Omegawave's approach towards athlete preparation, a quick overview of the historical evolution of modern day training theory can be helpful. Training theory has roots that stretch as far back as Ancient Rome; modern-day training theory, however, did not develop until post-World War II. The following represents a timeline of the evolution of training theory:

- **1945: End of World War II**
- **1948: Soviet Union creates committee dedicated towards research in physical work culture aimed at increasing athletic talent selection and systematic athletic development (6)**
- **1952: First Soviet Union Olympic appearance post-research initiative, with the country tying the USA in Olympic Games points (12)**
- **1956: Soviet Union increased medal count nearly 40% and surpassed the USA in total medal count (16)**
- **1959: Nikolai N. Yakovlev introduces *supercompensation theory*, the fundamental basis behind training theory (15)**
- **1964: Soviet Union professor Lev Matveyev publishes *The Fundamentals of Sport Training* (in Russian), the first introduction of training periodization (10)**
- **1981: First English language translation of *The Fundamentals of Sport Training* (9)**
- **1981: Foundation of the National Strength and Conditioning Association (NSCA)**
- **1982: Michael Stone and colleagues adapt Matveyev's periodization model for strength and power athletes in the United States (13)**
- **1982-Present: NSCA promotes training periodization in monthly research journals and training periodization becomes the preferred method for many strength and conditioning coaches nationwide**

Soviet scientists made invaluable early contributions to the fields of exercise physiology and athletic development. In practice, these training methods showed their effectiveness through the nation's considerable success in world sporting events; due to the Cold War and the Soviet Union's strict guidelines on international research collaboration, however, as the theories were developed they rarely reached beyond the Eastern Bloc countries. In fact, many of the seminal works of modern training theory remained untranslated until the 1980's. At that same time, a number of the training methods popular in the West were based on training as an art, an approach that prioritized intuition and experience over hard science. The development of the NSCA and the Journal of Strength and Conditioning Research promoted the efficacy of Soviet methods based upon the science and technology available in the 1960's. Supercompensation theory still remains the backbone of most training regimens, while periodization continues to be the gold standard of training methods utilized by strength and conditioning professionals.

TRAINING THEORY: CRITICAL REVIEW

While training periodization and supercompensation theory are still highly regarded and subject to a considerable body of research among strength and conditioning professionals, both are open to a fresh critical evaluation. The very backbone of training periodization may also be its biggest limitation.

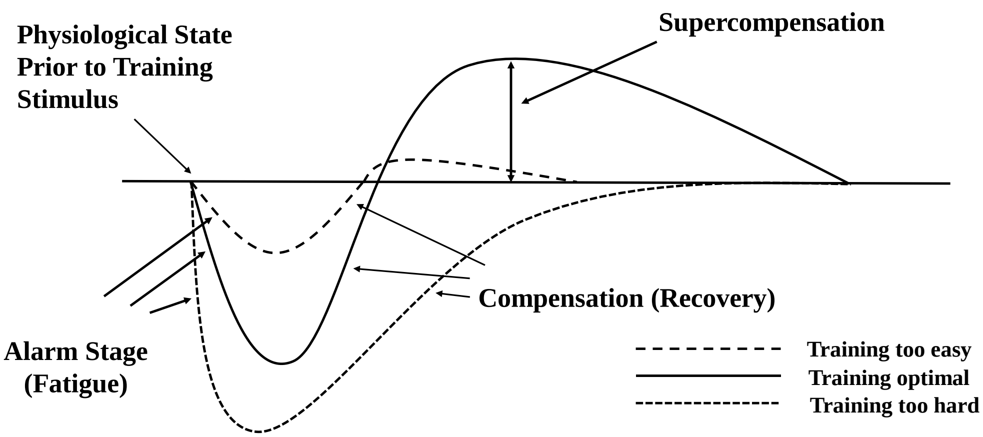


Figure 1. Supercompensation Theory in Response to Training Load

Supercompensation Theory: Limitations & Contentions

1. Limitation in scope

The supercompensation model implies that the human organism will uniformly adapt to all training stimuli regardless of training type (cardiovascular, strength, power, etc.). In this model, the only factors that can influence the rate of supercompensation are the volume and intensity of the training session. This theory portrays the human system as a whole, failing to recognize the individual systems that are depleted during a given training session. In reality, supercompensation is better illustrated by the following figure:

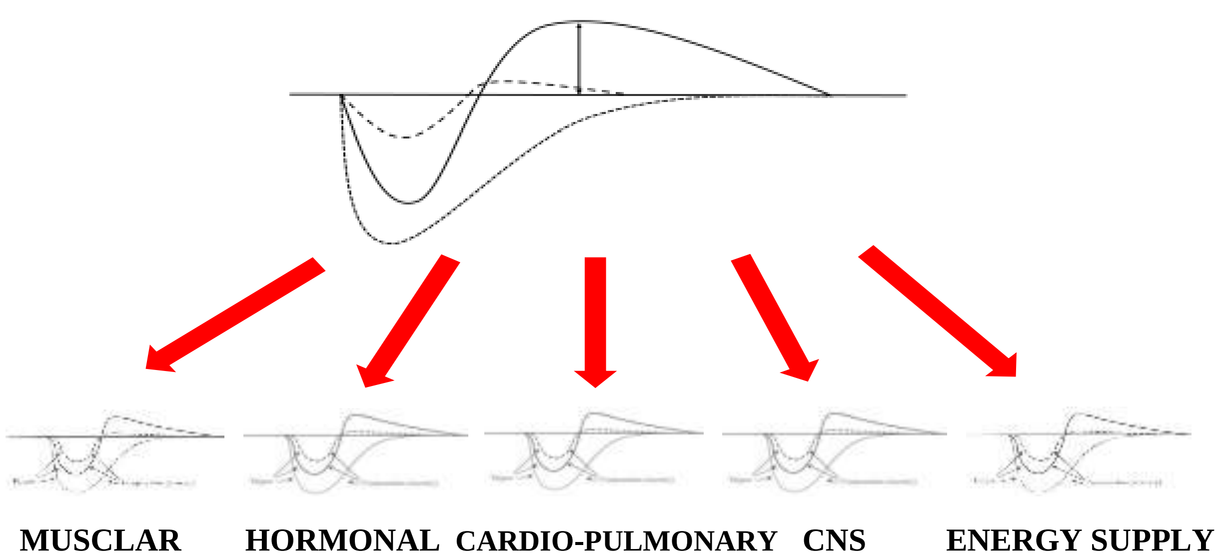


Figure 2. Multi-System Supercompensation Model

2. **Not all slopes are created equal**

The standard supercompensation curve is simple, straightforward, and linear. However, due to the unique genetic makeup of each athlete and the differing situational stressors present at the time of a training stimulus, the curves and durations of supercompensation can vary drastically between individuals. Likewise, one system may achieve supercompensation while at the same time others may fail to do so. For example: A student-athlete completes a high intensity, power-speed workout on Monday, which stresses their central nervous system. According to supercompensation theory, this athlete should be able to receive a similar type of training stimulus 24-48 hours later. Assume, however, that the original workout was followed by two important exams, with the tests scheduled during the recovery time frame. The subsequent mental stress from the exams can disrupt supercompensation of the CNS, hormonal, and muscular systems, delaying the timing in which the athlete can sufficiently train and adapt to a similar training load.

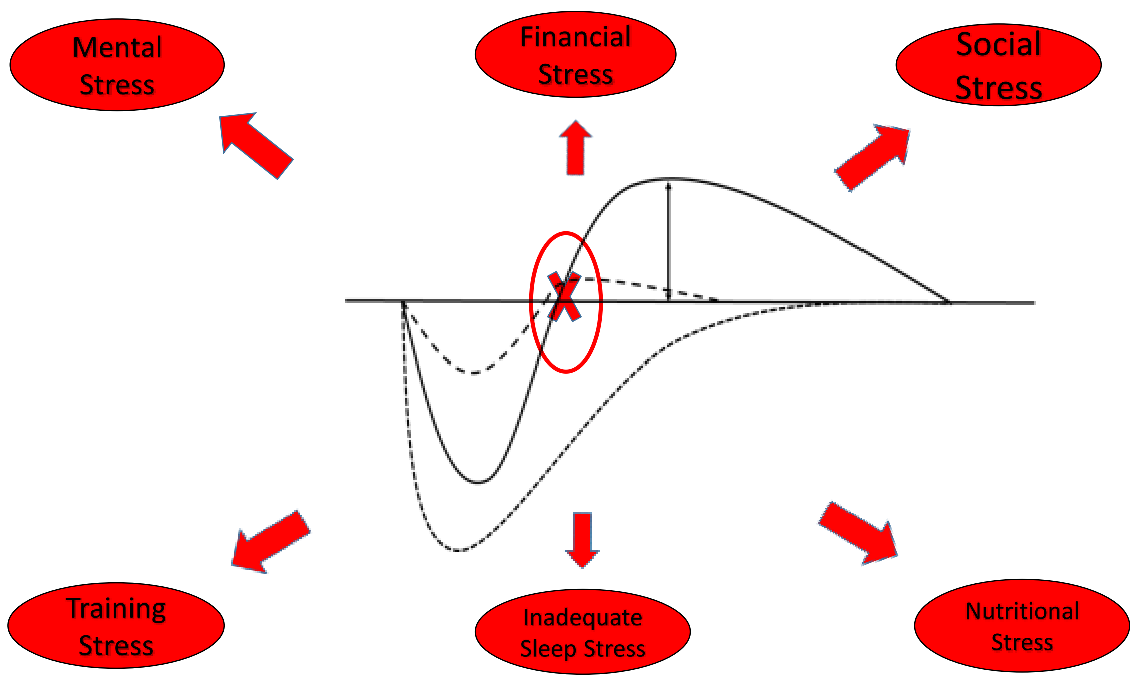


Figure 3: Factors Affecting Time to Supercompensation Following Training Stimulus

3. **Changing Times: Modern athletes train with different conditions and oversight**

Soviet scientists made pioneering discoveries in the fields of exercise physiology and athletic development, laying the foundation for many of the training theories prevalent today. Their methods were revolutionary, leading to regular podium slots and high medal counts at the

Olympic Games. Many scholars, however, suggest that athletes behind the “Iron Curtain” owed part of their success to financial incentives, pharmaceutical enhancements, and—most importantly—lifestyles dedicated exclusively to training and recovery. The training theories advanced by Soviet scientists, therefore, were based upon an ideal training environment, one where the training process was subject to complete control. Environmental factors that might limit supercompensation were minimized, while natural recovery was potentially enhanced by pharmaceutical agents (which at that time were still legal).

Today’s competitors are exposed to a multitude of environmental stressors that did not exist for those athletes studied over 60 years ago. Social media alone places both collegiate and professional athletes under a ceaseless microscope, with a constant demand from both fans and media outlets. Competitive seasons have grown longer, and the amount of travel has multiplied significantly. While athletes face an increase in environmental stressors and time demands, which vary widely from one individual to the next, the training process has remained consistent, regardless of the athlete’s functional state.

Traditional periodization places the training volume and intensity as the point of control, regardless of the athlete’s functional state. In contrast, Omegawave’s approach situates the athlete as the object of control, adjusting their workout to accommodate their daily functional state. Due to the vast genetic and environmental variability between athletes, it is crucial that the training process remain fluid rather than fixed. The following figure represents the conventional training approach, contrasted with our method of athletic development (5).

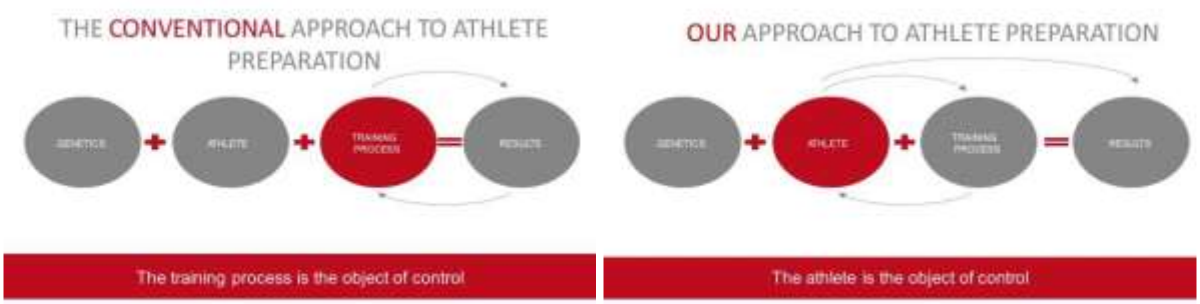


Figure 4. Traditional Approach (A) & Omegawave’s Approach (B) to Athlete Preparation.

CONCLUSION

Periodization and supercompensation are valid theories that have produced great athletes and helped earn numerous Olympic medals, but the environment in which athletes are trained has changed over time. Additionally, advances in science and technology have allowed us to examine each athlete's specific, individualized response to training loads.

It is not our intention to discredit the training theories established by the trailblazing scholars and scientists who came before us. Instead, we seek to build upon this sturdy foundation and better serve the athletes we train today. To borrow from Sir Isaac Newton (with a twist), "What the Soviet Union's scientists did was a good step… if we have seen farther, it is by standing on the shoulders of Giants."

FUNCTIONAL SYSTEMS THEORY

Functional System – a dynamic, self-regulating structure of biological components that work in unison to achieve a useful adaptive result for the athlete (5)

The human organism is designed with one overpowering purpose: survival. That organism doesn't seek to win medals or earn recognition as a world class champion; instead, it works to become the most efficient machine possible, accomplishing this innate goal by formulating functional systems to reduce the physiological costs of external stressors.

Example: Let's take an untrained individual, a blank canvas, who is seeking to become an endurance athlete. The training process elicits the following physiological reaction, with the creation of a specific functional system.

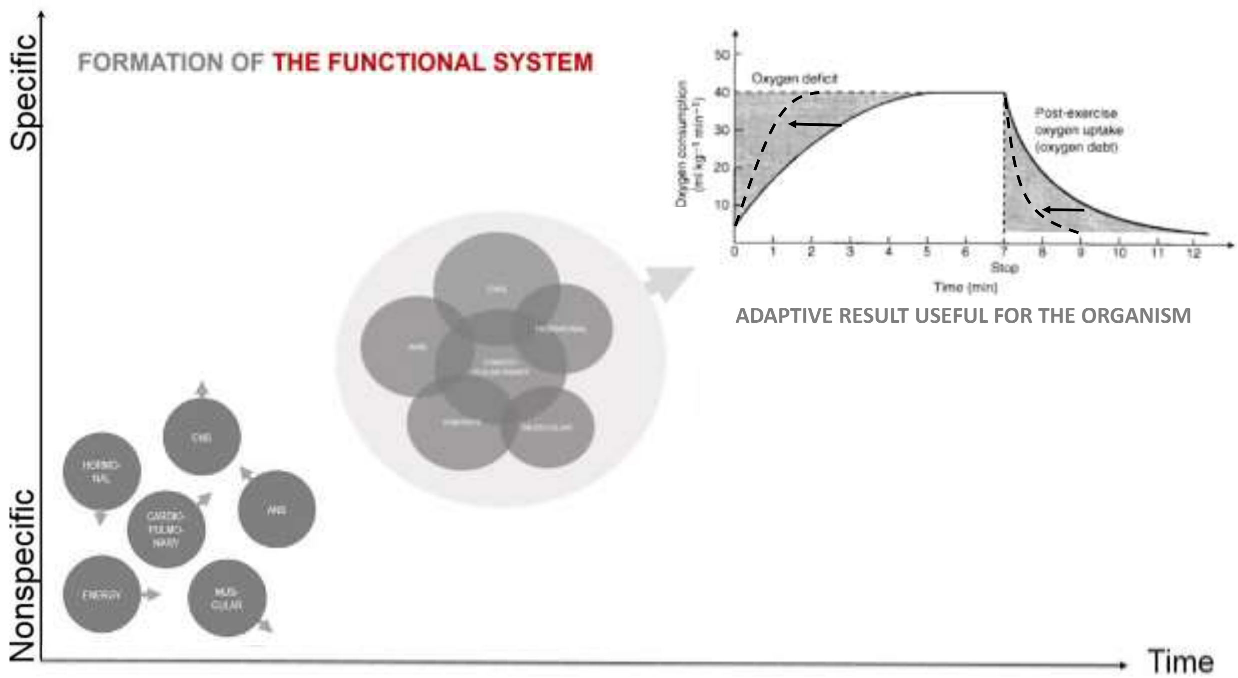


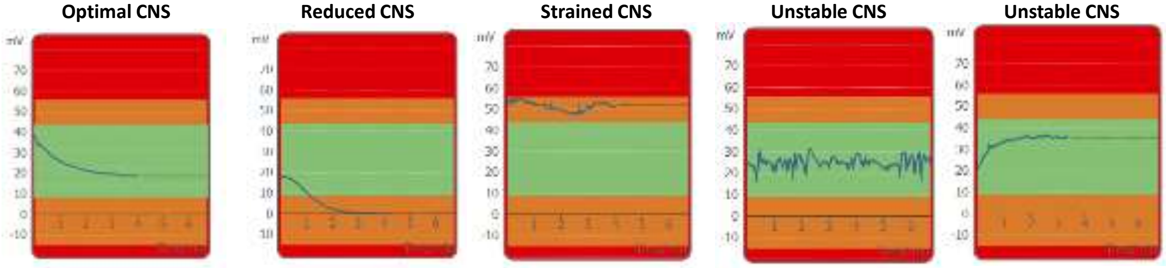
Figure 5. Formation of Functional System in Response to Aerobic Training Load (adapted from Fomin, Nasedkin 2015)

Classic anatomy and physiology texts suggest that each biological system acts in isolation in response to training demands; functional systems, however, recruit and bind subordinate systems and individual organs to act as a single mechanism, reducing the physiological cost of exertion and increasing the efficiency of the organism (2). In our example, the coordination and collaboration of the selected biological systems decrease the time to aerobic stabilization; which, in turn, decreases the reliance on glycolytic resources and thus decreases the overall physiological costs (5).

DIRECT CURRENT POTENTIAL: THE BASICS

Direct Current (DC) Potential of the Brain – brain biopotentials within a frequency range that is lower than the EEG range (0-0.5 Hz), also referred to as the Omega potential (8).

DC potential is an integrative indicator of the functional state, representing the cumulative activity of all functional systems in the central nervous system (8). The above example (of our novice endurance runner) is just one of the thousands of functional systems a human organism can display. Functional systems exist for skill acquisition and execution, such as learning and performing a squat, or completing a high velocity change of direction. Additionally, functional systems are responsible for learning, memory, psychological responses to stress and adversity, and—most importantly—the adaptive capability of the organism. Thus, when the direct current potential is in a reduced state, the athlete's ability to learn, complete complex movements, and adapt are limited. Training in such a reduced state can lead to maladaptation or even injury. The following represents a range of DC potential readings and the corresponding functional state.



Optimal CNS

Characteristics:
- DC potential initiation and stabilization within optimal ranges
- Time to stabilization within 1-3 minutes

Significance:
- Optimal level of adaptive capabilities
- Optimal level of skill acquisition and execution

Reduced CNS

Characteristics:
- DC potential stabilization below optimal range

Significance:
- State of exhaustion
- Reduced ability to execute adaptive processes
- Reduced ability to learn and execute previously learned movements

Strained CNS

Characteristics:
- DC potential stabilization above optimal range

Significance:
- State of tension
- Reduced ability to coordinate functional systems
- Think of a computer with a lot of applications running and you trying to open one document (Slow and Difficult)

Unstable CNS

Characteristics:
- DC potential failure to stabilize

Significance:
- State of tension
- Reduced ability to coordinate functional systems
- Typical of individuals with high levels of anxiety
- Prevalence of psycho-emotional stress

Unstable CNS

Characteristics:
- DC potential inversion

Significance:
- State of tension
- Reduced ability to coordinate functional systems
- Typical of individuals with spontaneous levels of anxiety
- Prevalence of psycho-emotional stress

Figure 6. Direct Current Potential Curve Analysis

These curves represent a few of the DC potential readings your athletes will present. There may be variations of the above curves, but there are several consistent factors to consider when interpreting the DC potential curve.

1: Shape of the curve – The curve should initiate from an optimal value (45mV and higher) and progress smoothly to stabilization within the optimal range.

2: Time to stabilization – Optimal time to stabilization should occur between 1-3 minutes

3: DC resting potential – Resting potential should stabilize within 9-45 mV

HEART RATE VARIABILITY: THE BASICS

Heart rate variability (HRV) has become a widely used tool for evaluating the autonomic nervous system (ANS) and assessing the functional state of athletes on a daily basis (3). With its two branches (sympathetic and parasympathetic), the ANS regulates the homeostatic functions of the body. Since human beings are in a perpetual cycle of homeostatic disturbance (sympathetic input), homeostatic restoration (parasympathetic input), or homeostasis (autonomic balance), an analysis of the ANS through HRV can be an effective method of monitoring the training status of your athletes. This simple, non-invasive measurement provides information regarding the state of the autonomic nervous system by using a mathematical analysis of the beat-to-beat, QRS complex (R-R) intervals as shown below.

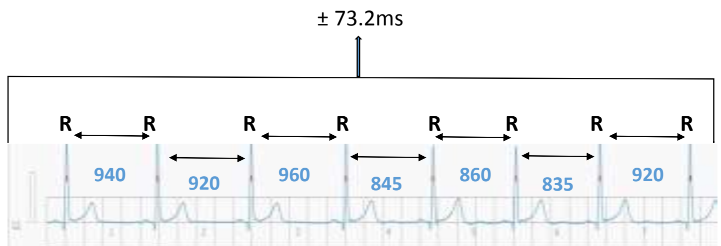
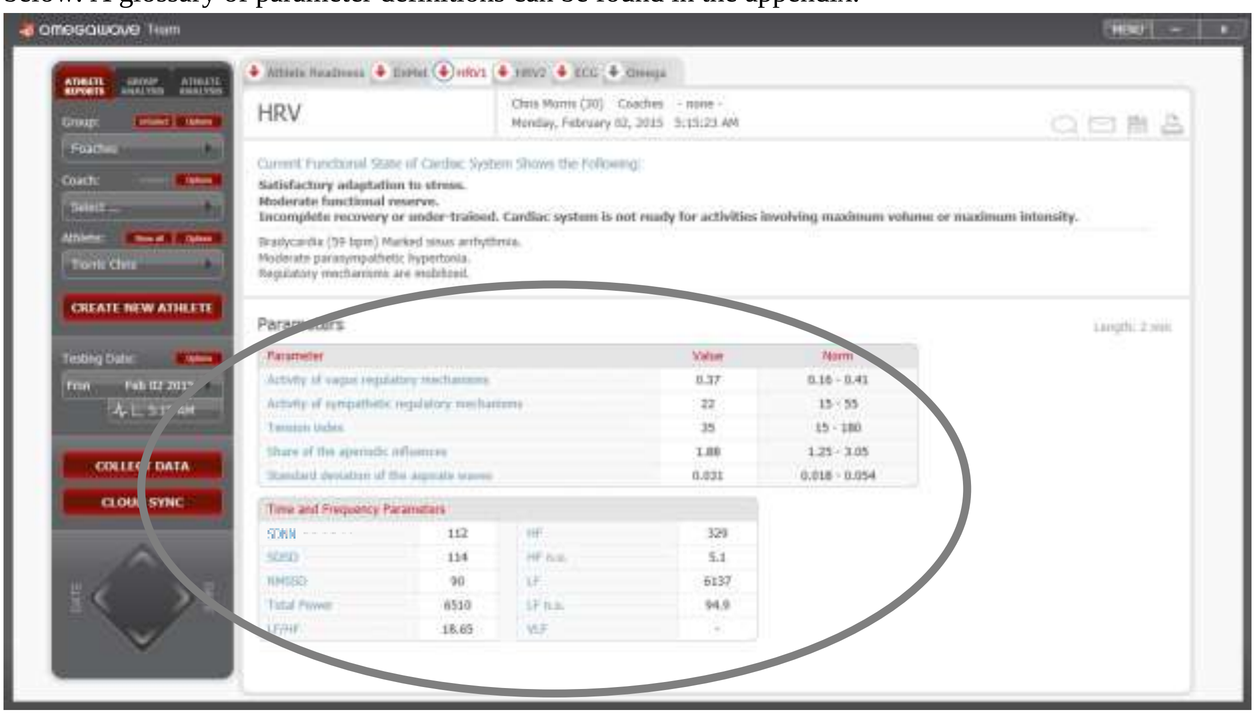


Figure 7. Mathematical Analysis of R-R intervals Shown in Milliseconds

The Omegawave Team system provides a comprehensive analysis of HRV parameters, including five parameters established by Russian scientists and the ten standard “time and frequency” parameters established by the European Society of Cardiology and the North American Society of Electrophysiology (4). These parameters can be found on the HRV1 tab of the team system and are highlighted in the picture below. A glossary of parameter definitions can be found in the appendix.



From a global perspective, the autonomic nervous system is responsible for maintaining the body's homeostatic environment. Any external influence that disrupts homeostatic equilibrium—at any level—will activate the sympathetic nervous system, which in turn mobilizes resources to fulfill the metabolic need. Once the need is satisfied, the parasympathetic nervous system slows down the metabolism and brings the body back to its baseline. Both of these systems work together to act as the gas (sympathetic) and brake (parasympathetic) pedals in supplying the body's metabolic fuel.

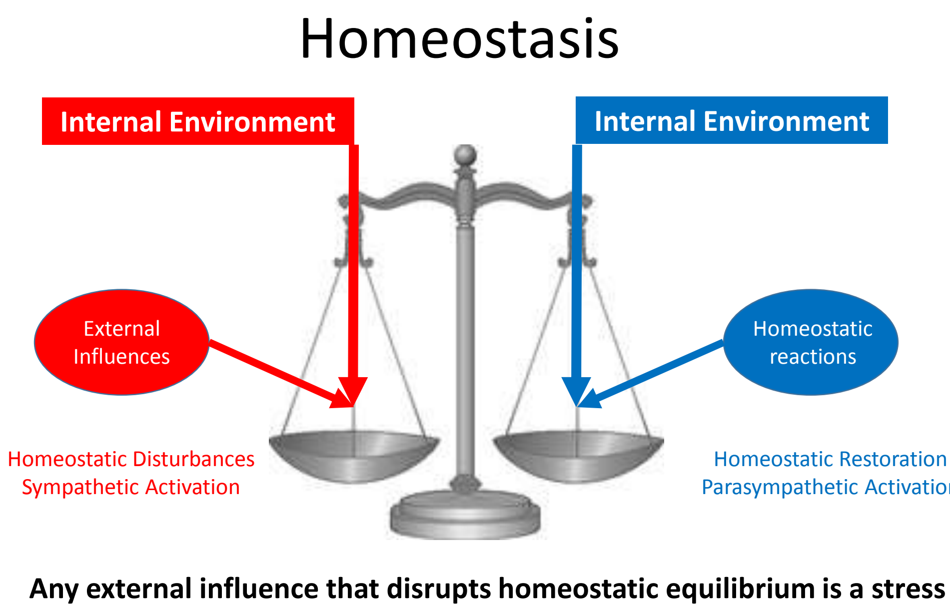


Figure 8. Homeostatic Equilibrium in the Internal Environment

In a perfect world, environmental stressors would be kept to a minimum while sleep, nutrition, and training would be the predominant focus for all of our athletes. Following WW II, athletes in the Soviet Union were trained in this type of environment and enjoyed notable success at the Olympic level. Many of the training methods we employ today are based upon those foundational theories; today's training environment, however, is far from identical. The following figures represent what supercompensation theory is *intended* to reflect based upon Soviet methods, as well as supercompensation theory *corrected* for environmental stressors.

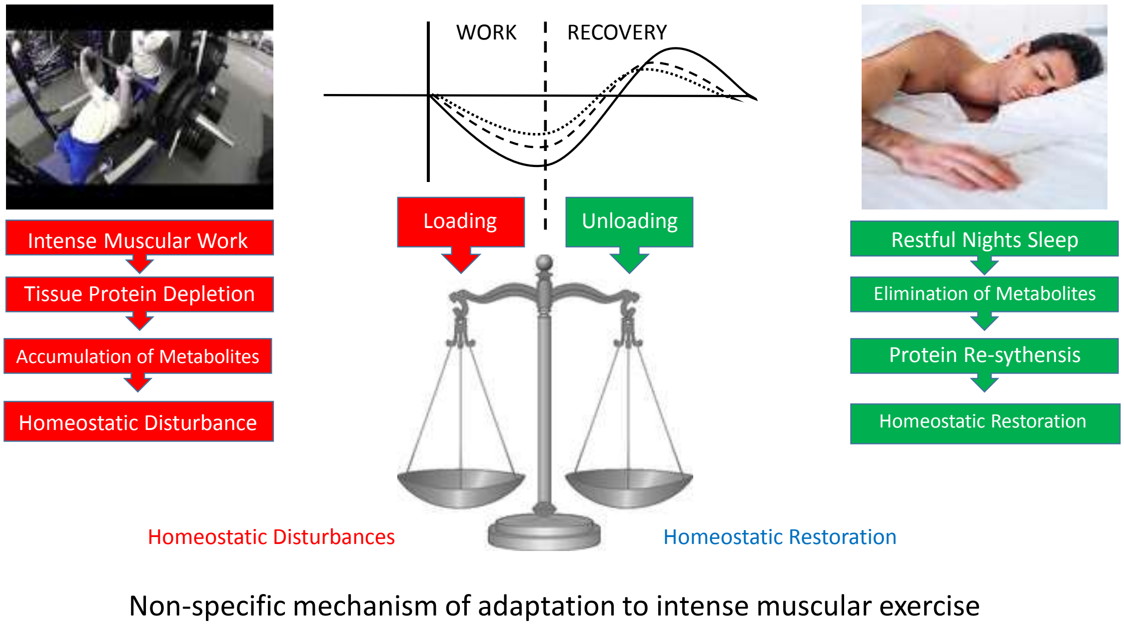


Figure 9. Ideal Mechanism of Adaptation Following Intense Muscular Exercise

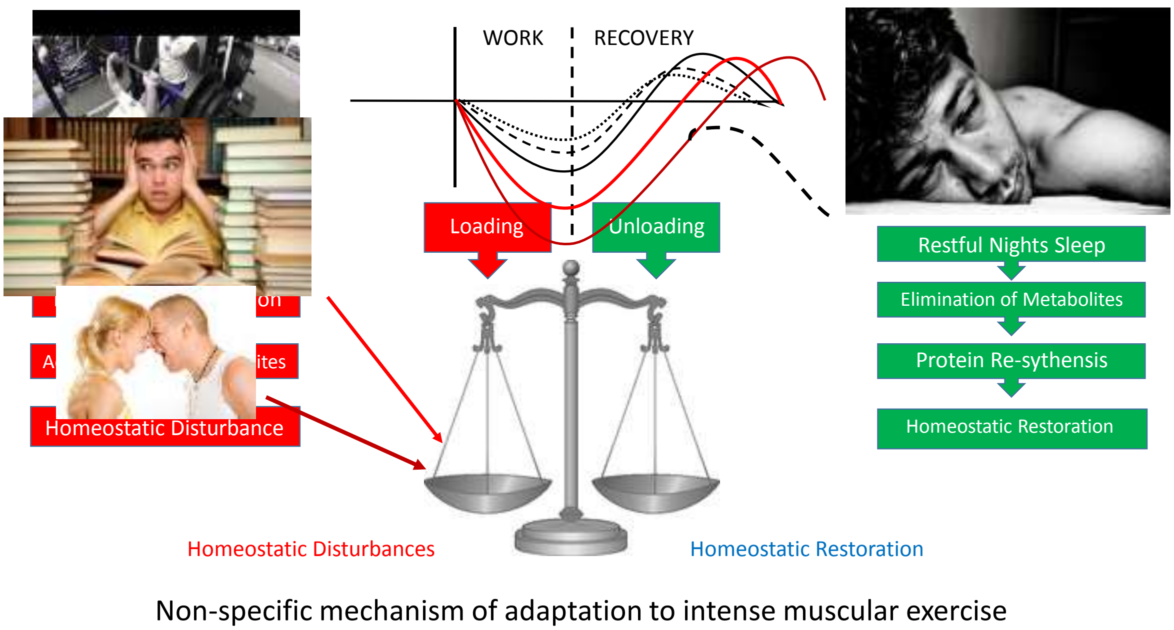


Figure 10. The Effect of Environmental Stressors on Recovery Following Intense Muscular Exercise

There will be times in which athletes will indeed recover as indicated in Figure 9; subsequently, they will be able to complete the next training session as planned. There will also be days (or even weeks), during which life presents extra challenges in the form of exams, financial struggles, relationship disputes, or social media pressure, all of which will affect the athlete's recovery mechanisms and compromise their ability to positively adapt to certain training loads.

Using the Omegawave Team system and its HRV indexes, strength coaches have the ability to track the evolving functional states of their athletes. HRV assesses the current internal load and should be viewed as a barometer or fuel gauge for adaptation. The following figure represents the spectrum within which HRV and autonomic tone should be interpreted.

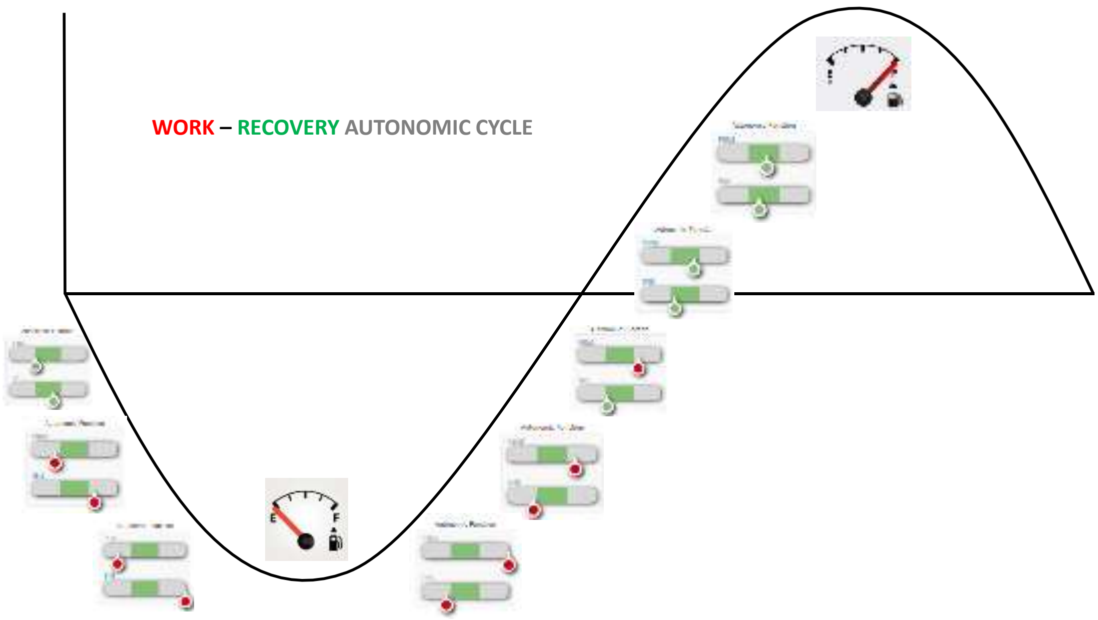


Figure 11. Work-Recovery Autonomic Cycle Following Intense Training Session

It cannot be assumed that this cycle progresses in a time-independent manner as presented in training periodization and supercompensation theory. Using HRV as a guide will allow you to choose a load which the athlete can handle on a given day, loads which can be targeted for specific Windows of Trainability (or "openings" in which an athlete can positively adapt to training loads directed toward a range of physical qualities). These Windows will open and close in varying degrees throughout the Work-Recovery Cycle, reiterating the idea that the *timing* of the training stimulus should take precedent over training load or volume.

These concepts (and the actual statistical and spectral analysis) reflect the principles of HRV most widely accepted by the European Society of Cardiology and the North American Society of Electrophysiology. Though a good representation of Hans Selye's "General Adaptation Syndrome" and the autonomic systems neurohumoral regulation of homeostasis, these concepts reflect a Western-based view of HRV analysis and negate an extensive body of Soviet space medicine research. It is important to understand the role of functional systems theory and biological cybernetics as it will become useful when discussing index interpretation.

Biological Cybernetics – the study of the controlling or governing mechanisms of homeostasis

The functional system responsible for the regulation of blood flow is a multi-circuit, hierarchical, self-organizing system in which the dominant role of the individual components is determined by the current need in the body (Baevskii, 2002). The biological cybernetic approach presents a two-circuit model for heart rhythm regulation including central and autonomic components. The scheme of the two-circuit model is shown in figure 12.

The functional system of blood flow regulation and biological cybernetic representation of the two-circuit model of heart rhythm is a more comprehensive method of understanding the complexity of HRV analysis. The neurohumoral regulation of functions, as presented earlier, only takes into consideration the ANS effects on blood flow, which was referred to as the gas (sympathetic) and brake (parasympathetic) model. The cybernetic approach is more holistic and recognizes the importance of the central circuit in blood flow regulation.

The cybernetic model can be thought of as a hybrid vehicle, a two-circuit model in supplying energy/fuel to the working parts of the car via electric and traditional gas circuits. When energy demand is low (i.e. cruising speeds), the electric supply system is able to accommodate the need; when the need to accelerate quickly arises, however, it prompts a shift in circuits. The shift towards the gas circuit is the first step in supplying the demand, the autonomic shift towards central circuits. If the supply does not meet the demand (i.e. you are drag racing in a Prius), then different gears must be activated to achieve the end goal. This is both an example of functional systems theory (the car reorganizing its fuel system to meet a demand) and biological cybernetics (the two circuit model of the hybrid vehicle).

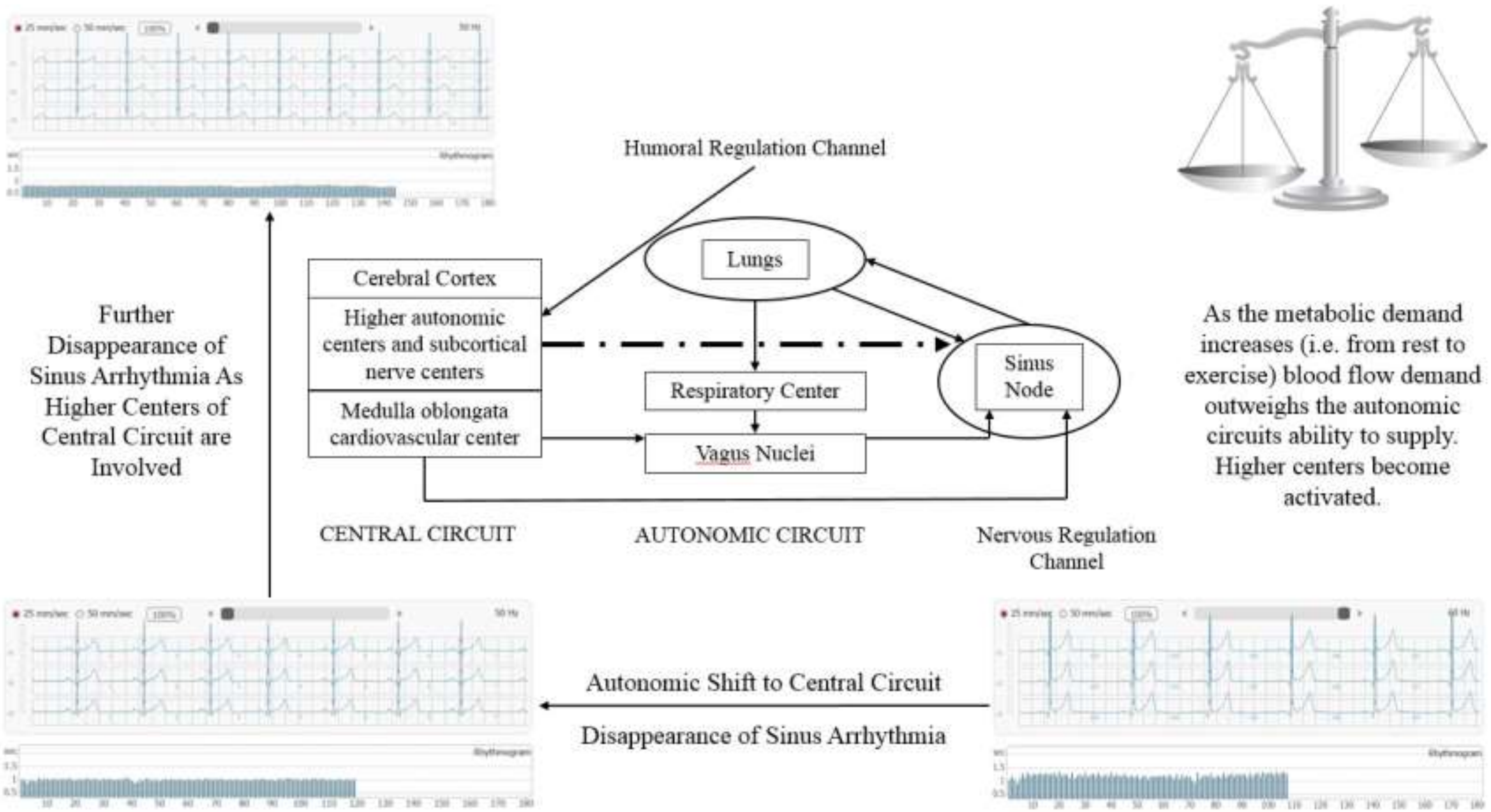


Figure 12. The scheme of a two-circuit model of heart rhythm regulation (Adapted from Baevskii, 2002)

ENERGY SUPPLY STATE: THE BASICS

Throughout the 1960's and into the late 1980's, Professor S.A. Dushanin made monumental discoveries by examining the bioelectrical activity of the heart as it correlates to the body's energy supply state. His methods were utilized during the early development of Omegawave when the energy supply state was examined using a multi-lead ECG; this method, however, proved to be impractical for analysis in the field as laboratory conditions were required. Over the past decade, Omegawave has expanded upon Dushanin's methods based upon our extensive and diverse athletic database. The use of the Omegawave method provides a practical assessment of the energy supply state with the use of a single lead ECG.

Although our methods have deviated from Dushanin's, the strong correlation between cardiac and skeletal muscle energy supply is still fundamental. Since skeletal and cardiac muscle share similar structures and common biochemical reactions, longitudinal training adaptations to specific training modalities elicit correlative changes in both (as was observed throughout the studies performed on members of the Swedish cyclic sport teams) (14). This relationship allows for the analysis of specific characteristics of the QRS complex, which provide an assessment of the energy supply state at the cardiovascular and skeletal muscle level.

In simple terms: This assessment does not refer to the ability to generate power or force, but instead reflects the body's ability to efficiently supply the range of energy demands during exercise. Imagine, for example, a vehicle that has a clogged fuel injector. The ability to supply fuel to the engine is limited, which causes a decrease in performance and an increase in fuel consumption. The vehicle will run and likely make it from point A to B; the cost of the trip, however, will be much more significant than it would with a vehicle running with an efficient fuel supply. The following figure represents two athletes with contrasting energy supply systems:

Correlative Parameters	Value	Norm	
Metabolic reaction index *	465	100 - 500	Very high
Aerobic status index	131	110 - 160	High
Anaerobic status index	143	-	-

Efficient Energy Supply System

Correlative Parameters	Value	Norm	
Metabolic reaction index *	187	100 - 500	Lower than average
Aerobic status index	**104**	110 - 160	Low
Anaerobic status index	**131**	-	-

Inefficient Energy Supply System

Figure 13. Energy Supply System Comparison

The energy supply system analysis is a snapshot of the previous 14+ years of the athlete's development and cannot be interpreted as an acute condition—thus, a longitudinal approach must be considered. Strength and conditioning professionals will inherit athletes with vastly different energy supply systems: these systems are developed over the course of many years and are influenced by a host of factors ranging from genetics to sport specificity to personal lifestyle. Even though an athlete might present an inefficient energy supply system, that doesn't mean they will not perform at a high level—it simply reflects the potential costs of the specific training.

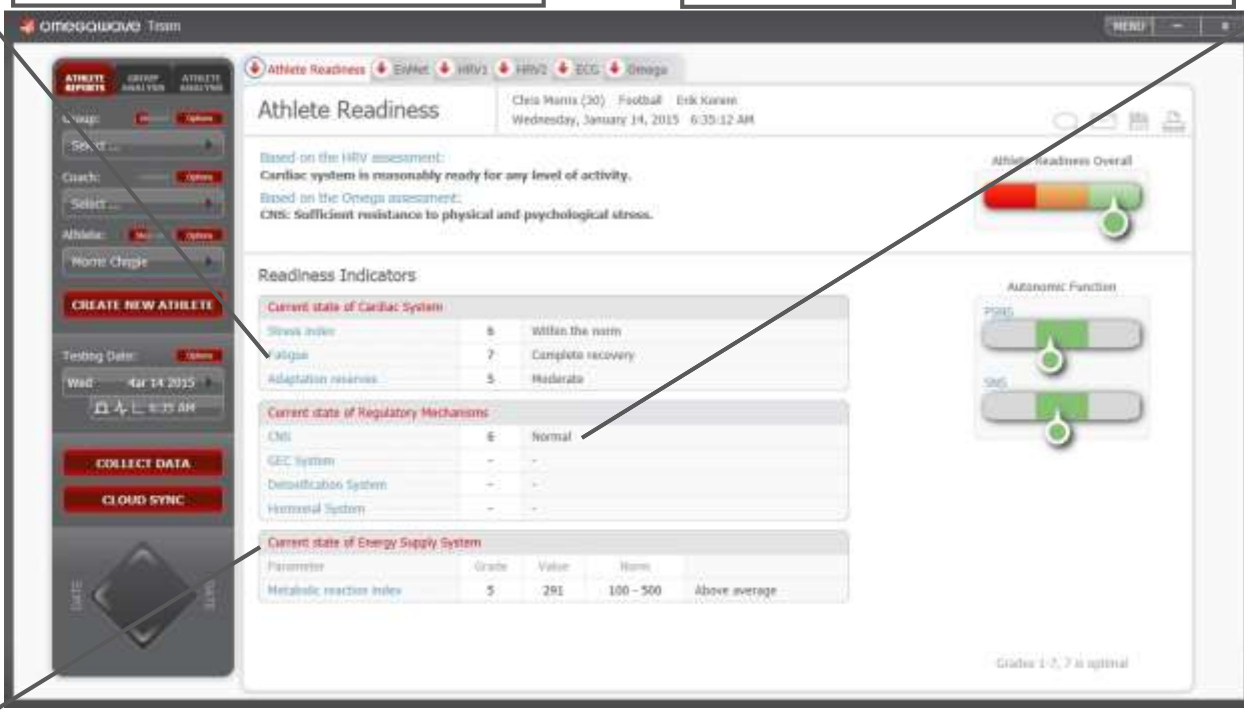
INDEX INTERPRETATION

ATHLETE READINESS: PHYSIOLOGICAL DASHBOARD

The Athlete Readiness tab of the Omegawave Team system can be thought of as the athlete’s physiological dashboard. Much like the dashboard in your vehicle, it displays the status of the critical components that drive the physiological processes behind training and adaptation.

Current State of the Cardiac System: The Stress Index, Fatigue, and Adaptation Reserves are based upon the HRV assessment. Additionally, the assessment reflects the current state of the Autonomic Nervous System function. This is the fuel gauge for adaptation and displays the potential resources needed to complete the adaptation process.

Current State of the Regulatory Mechanism: The CNS, Gas Exchange System, Detoxification System, and Hormonal System parameters are based upon the first and second Omega (DC Potential) assessment. These systems are the engine that drive adaptation and this parameter reflects the “horsepower” of the engine.

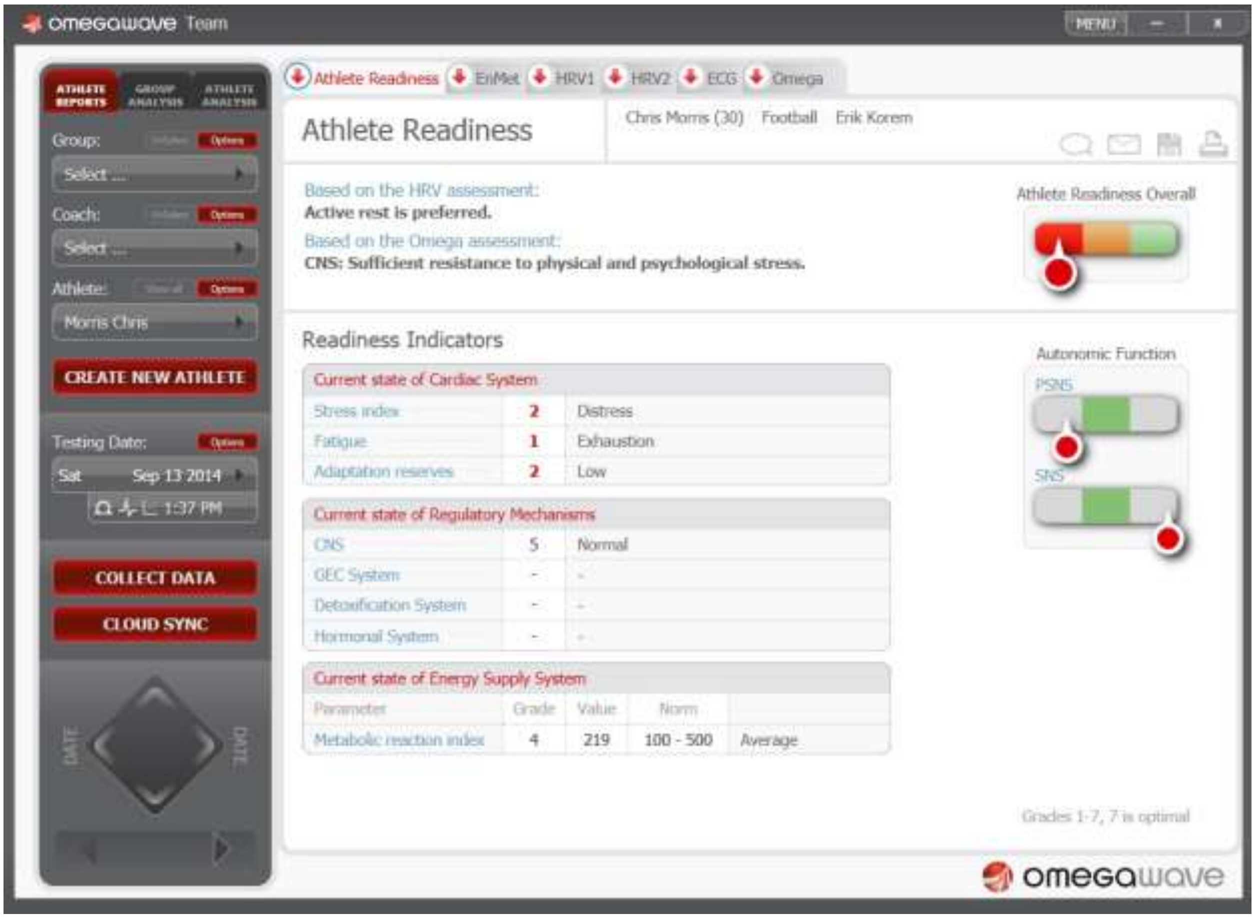


Current State of Energy Supply Systems: The Metabolic Reaction Index reflects the overall effectiveness and coordination of the metabolic system to support training loads. This parameter reflects the “octane,” indicating the speed in which metabolic reactions occur to supply the energy needed during training sessions.

All of the information displayed on the Athlete Readiness page is a summary of the HRV assessment, Omega Assessment, and the QRS complex amplitude-frequency assessment. The majority of training adjustments can be based upon the information displayed here; in addition, however, a comprehensive analysis is provided in the respective tabs located above the Athlete Readiness data.

STATE OF AUTONOMIC TONE: FUEL FOR ADAPTATION

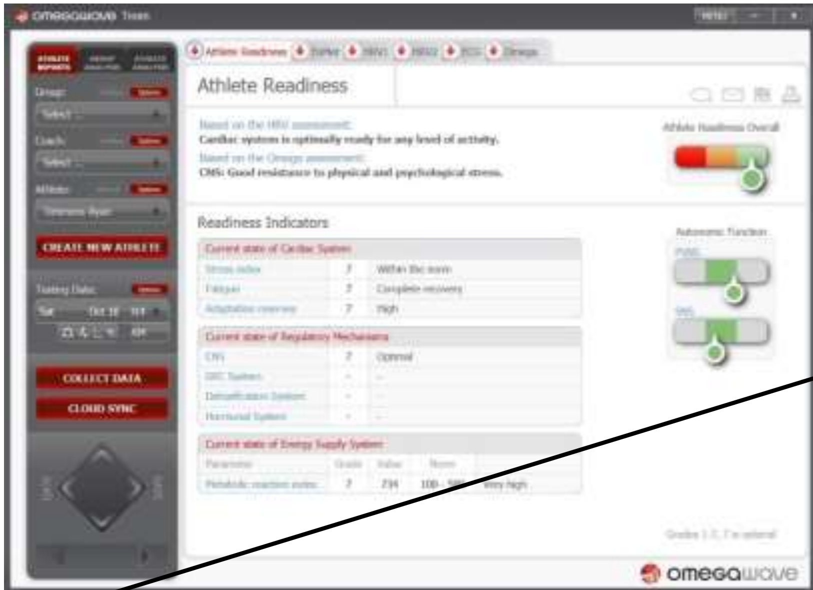
In the interests of science and to better explain the sensitivity of HRV parameters, the following data is offered to show a picture of the cardiac system following a night spent celebrating the completion of a doctoral program. These results (hopefully) represent a worst-case scenario, but serve to illustrate how the Stress Index, Fatigue, and Adaptation Reserves are impacted by real-life events. Based on the Athlete Readiness screen alone, it is obvious that the state of the cardiac system and autonomic function are limiting factors and training modification must be considered.



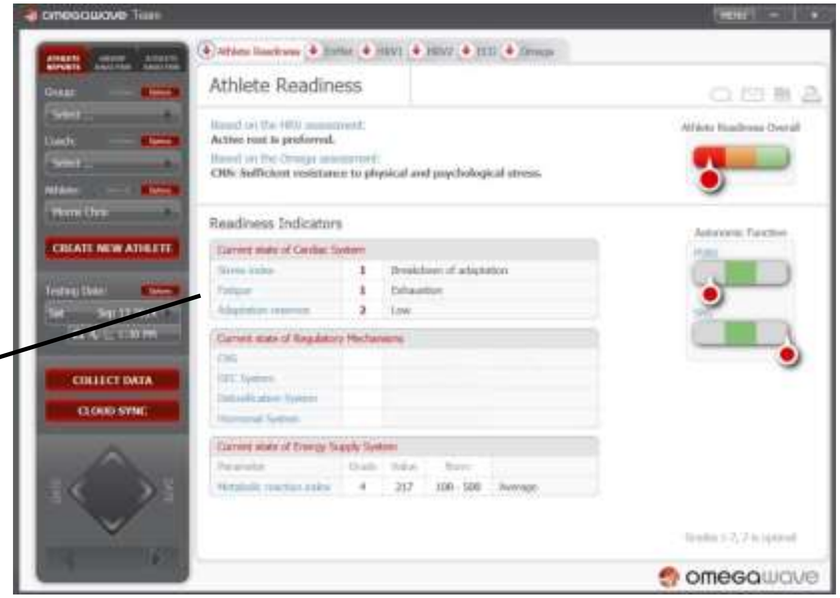
Looking deeper at the comprehensive analysis in the HRV1 & HRV2 tabs, the screens indicate how the parameters for the Stress Index, Fatigue, and Adaptation Reserves parameters are calculated (with the final numbers based upon the theories outlined previously, with the five Russian-influenced parameters, and the ten time/frequency domain parameters set forth by the European Society of Cardiology and the North American Society of Electrophysiology) (1). The following section represents an analysis of athletes who are in optimal states of readiness as compared to those who are in states of sympathetic or parasympathetic dominance.

STRESS INDEX, FATIGUE, & ADAPTATION RESERVES

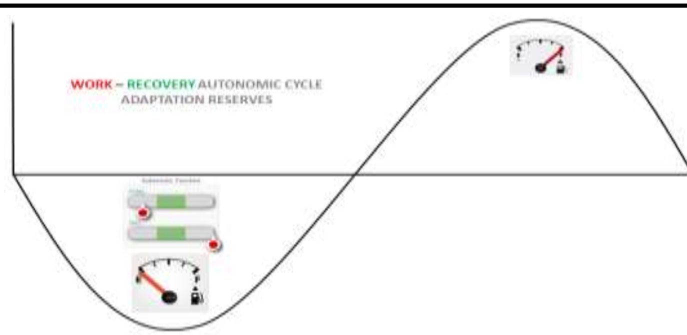
Optimal State of Readiness



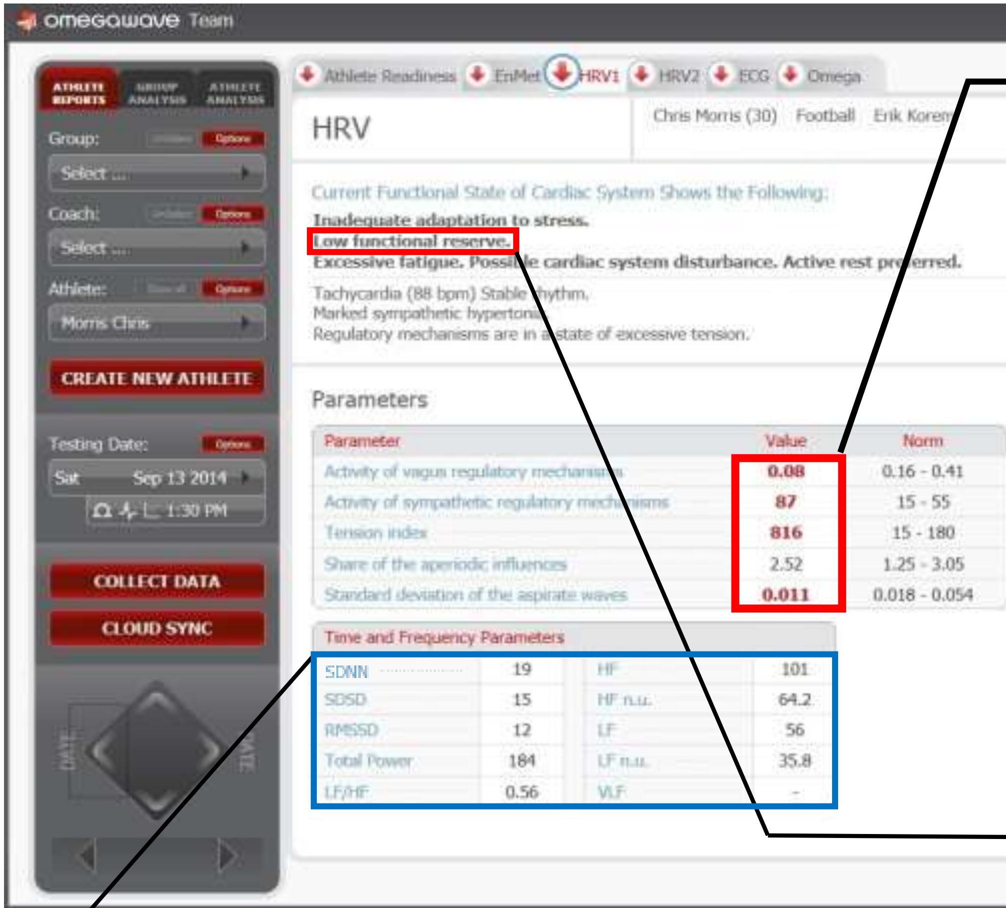
Non-Optimal Sympathetic Dominant



Stress – the level of tension on the cardiac system in response to physical and mental loads. How stressed is the body today?
Fatigue – the state of excessive or prolonged stress in response to physical and mental loads. How tired are the regulatory systems?
Adaptation Reserves – a reflection of the adaptation "fuel" to physical and mental loads. How much can I handle today?



Non-Optimal HRV 1 Sympathetic Dominant



Russian Parameters: These parameters reflect the theories of functional systems, biological cybernetics, and neurohumoral regulation of functions.

Activity of Vagus and Symp. Reg. Mechanisms:

The gas pedal is fully engaged while the brake has limited functionality. The body is in a high state of homeostatic disturbance as reflected by the extreme activation of sympathetic nervous system

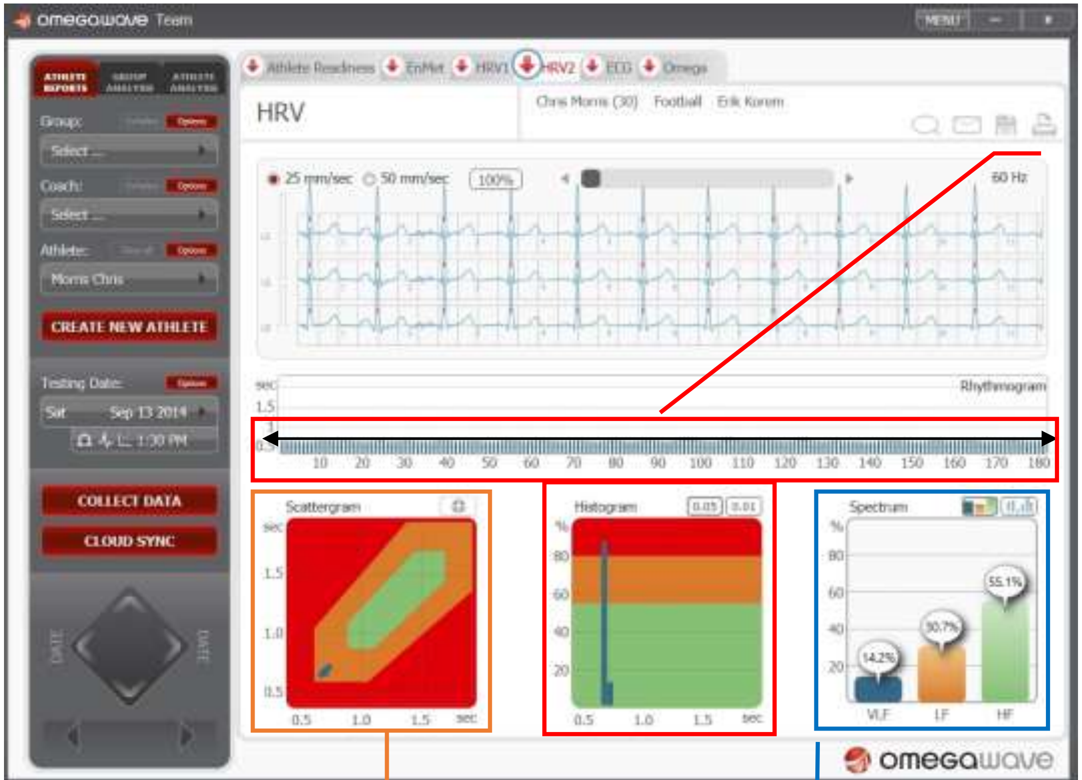
Tension Index & SD of Aspirate Waves:

The tension index represents the centralization of heart rate rhythm. Your hybrid electric vehicle has switched to the gas circuit and has downshifted to the lowest gear. You are revving the engine at a high rate in a low gear and burning through precious fuel. Physiological cost is high. The minimization of aspirate waves (respiratory waves) indicates that the autonomic circuit has little involvement and central mechanisms have taken over to supply metabolic needs.

Fuel for Adaptation =

European Society of Cardiology and the North American Society of Electrophysiology:
These parameters reflect the time and frequency domain parameters most commonly reported in Western literature. It describes the statistical "Variability" of the beat to beat intervals. The time domain parameters (SDNN, SDSD, & RMSSD) reflect the status of the autonomic nervous system. In this example, these parameters are quite low, indicating less variability. This is also reflected in the Tension Index and infers that higher levels of regulation are involved. The frequency parameters (Total Power, LF/HF, HF, HF n.u., LF, and LF n.u.) reflect the status of the autonomic nervous system as well. In this example Total power is diminished indicating less variance in the beat to beat and the significant input of the Low Frequency domain indicated sympathetic involvement and centralization.

Non-Optimal HRV 2 Sympathetic Dominant



Rhythmogram & Histogram:

These two figures complement each other and clearly indicate the significance of functional systems theory and biological cybernetics. A straight arrow was placed to illustrate the ridged heart rate rhythm and lack of respiratory waves. As mentioned previously, the lack of sinus arrhythmia indicates that higher levels of regulation have been activated due to a prolonged homeostatic disturbance.

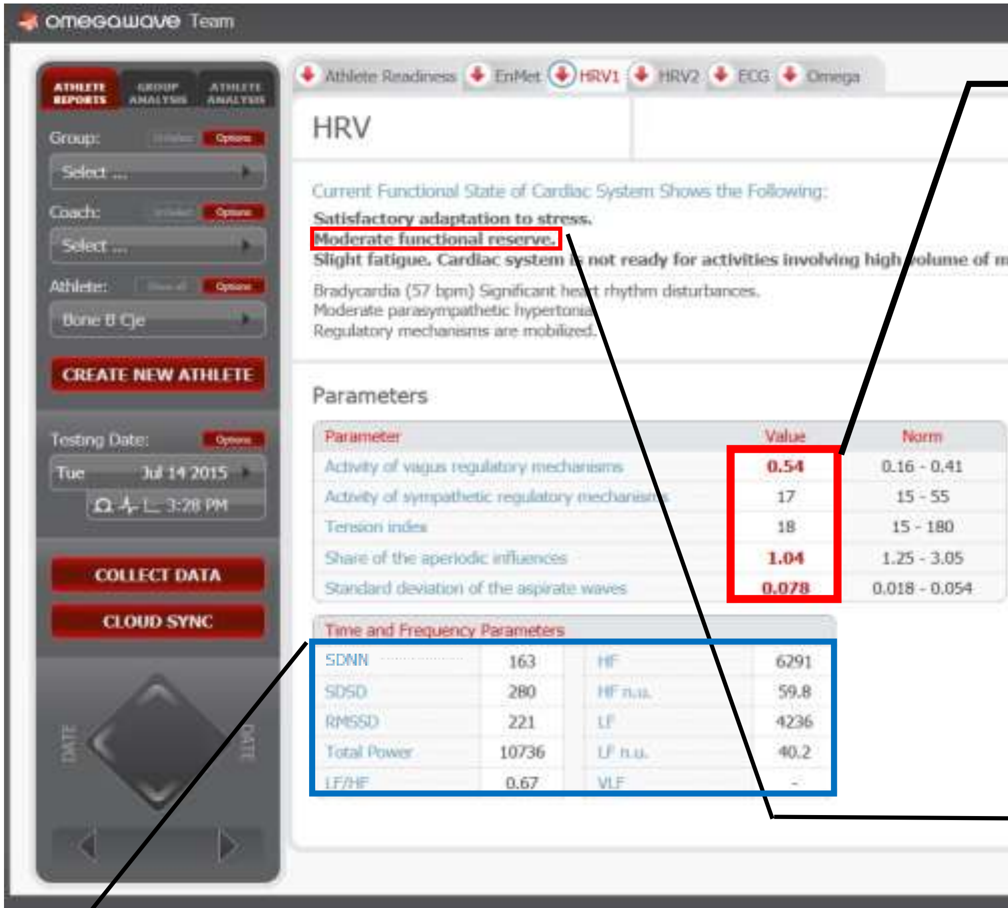
The Histogram illustrates the % of HR counts occurring at certain time intervals (ms). In this example roughly 90% of the beat to beat intervals are identical in time. Further supporting the ridged appearance of the rhythmogram and the activation of higher regulation levels.

Scattergram:

The X-axis of the scattergram plots the duration of one beat to beat interval, while the Y-axis represents the time from the preceding beat to beat interval. The tightness of the plot indicates the time between successive beats are very similar as supported by the histogram and rhythmogram. Higher levels of regulation have been recruited and the sympathetic nervous system activated due to prolonged homeostatic disturbance.

Spectral Analysis:

The HF spectrum represents activity of the parasympathetic nervous system while VLF (Hormonal) and LF (Vasomotor) spectrum have origins in the sympathetic nervous system. In this example there is significant influence from the sympathetic nervous system indicating high homeostatic disturbance.



Russian Parameters: These parameters reflect the theories of functional systems, biological cybernetics, and neurohumoral regulation of functions.

Activity of Vagus and Symp. Reg. Mechanisms:

The physiological brake is pressed as the body is still compensating for prior homeostatic loads. The cardiovascular system will struggle to meet high demands due to the limited functionality of the gas pedal.

Tension Index & SD of Aspirate Waves:

The lack of tension in the cardiovascular system indicates that higher levels of regulation are not involved and the significant input of aspirate waves reflect complete automatization of blood flow via the autonomic circuit. Too much parasympathetic input is noted, which is non-optimal when working at high cardiovascular loads.

Fuel for Adaptation = 

European Society of Cardiology and the North American Society of Electrophysiology:
As mentioned previously, these parameters reflect the "Variability' in the heart rate rhythm and provide information regarding the status of the ANS. In this example, the time domain parameters are significantly elevated when compared to those in sympathetic dominant states, indicating significantly more variability in the beat to beat time intervals. The frequency analysis indicates significant involvement of the low frequency spectrum, however the low frequency spectrum is believed to have both sympathetic and parasympathetic input. Parasympathetic input originates in the vasomotor center which is the lowest level of central regulation. To determine which branch of the ANS is active, refer to the rhythmogram in the HRV2 tab. The presence of aspirate waves indicates the LF spectrum is modulated by parasympathetic input.

Non-Optimal HRV 2 Parasympathetic Dominant

Rhythmogram & Histogram:

In parasympathetic dominant states there will be a significant amount of variability in the beat to beat intervals. It is best illustrated by the variance around the mean beat to beat time interval represented by the black arrow. The taller lines are reflective of the dominant parasympathetic input and take on a wave-like appearance.

The histogram further supports the increased variability by the distribution of times between beat to beat intervals. Due to the increased parasympathetic input, the cardiovascular system will struggle to adapt to loads of high intensity or volume. Just like a vehicle, adapting to external loads is limited when you try to press the gas with the brake still engaged.

Scattergram:

The pattern displayed in the scattergram is typical in parasympathetic dominant states. Referred to as the “four corner” pattern, it is indicative of the strong presence of aspirate waves and is reflected in the HRV1 tab. This is just one of several parasympathetic patterns. Training implications will be consistent regardless of the parasympathetic pattern.

Spectral Analysis:

This message is common when significant parasympathetic dominant states are observed. As indicated by the significant amount of variability present in the rhythmogram and histogram.

STATE OF CENTRAL NERVOUS SYSTEM: ADAPTATION HORSEPOWER

Optimal Direct Current Potential Curve

Omega Resting Potential:

The Omega resting potential represents the activation level of the cumulative activity of all functional systems.

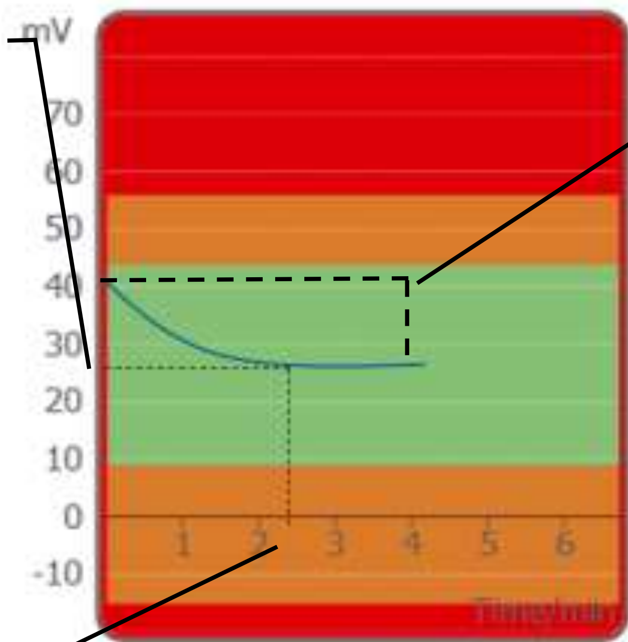
The following are the current ranges of functionality for the central regulatory system:

Fatigued: < 9.0 mV

Ideal: >9.0 mV<45.0 mV

Tension: >45.0 mV

Training within the ideal range ensures the body's ability to achieve useful adaptive results.



Shape of DC Potential Curve:

The shape of the curve reflects the *stability* of the CNS and its ability to regulate adaptive results. Optimal curves should begin at a level of active wakefulness (LAW) and descend in a smooth curve linear path to a level of operative rest (LOR).

Deviations in this pattern indicate instability of the CNS and could reflect tension, anxiety, or stress in your athletes.

Time to Stabilization:

The time to stabilization reflects the *efficiency* in which the central regulatory system achieves adaptive results. Optimal time to stabilization should occur within 1-3 minutes. Delayed states of stabilization or the lack of stabilization indicates states of fatigue in the CNS.

STATE OF ENERGY SUPPLY SYSTEM: ADAPTATION OCTANE

Correlative Parameters	Value	Norm	
Metabolic reaction index *	465	100 - 500	Very high
Aerobic status index	131	110 - 160	High
Anaerobic status index	143	-	-

Efficient Energy Supply System

Correlative Parameters	Value	Norm	
Metabolic reaction index *	187	100 - 500	Lower than average
Aerobic status index	104	110 - 160	Low
Anaerobic status index	131	-	-

Inefficient Energy Supply System

An examination of the two contrasting energy systems will demonstrate how the QRS complex is indicative of the energy supply system. The Omegawave Team system incorporates the basic principles established by Dushanin and his colleagues, modifying the parameters based upon the company's years of research and extensive database in elite athletic populations. Consider the following parameters based upon the examples above:

Metabolic Reaction Index: Reflects the overall effectiveness and coordination of the metabolic system to support planned training loads, measured over extended periods of time. As athletes train, they develop specific adaptations within the cardiovascular and muscular system in response to imposed training demands. Specific functional systems are cultivated to increase the efficiency with which the athlete generates the energy required for their given sport. The rate and amplitude of the individual waves of the QRS represent the cumulative metabolic reaction. As athletes train, these rates and amplitudes should increase—provided the training process is being properly managed.

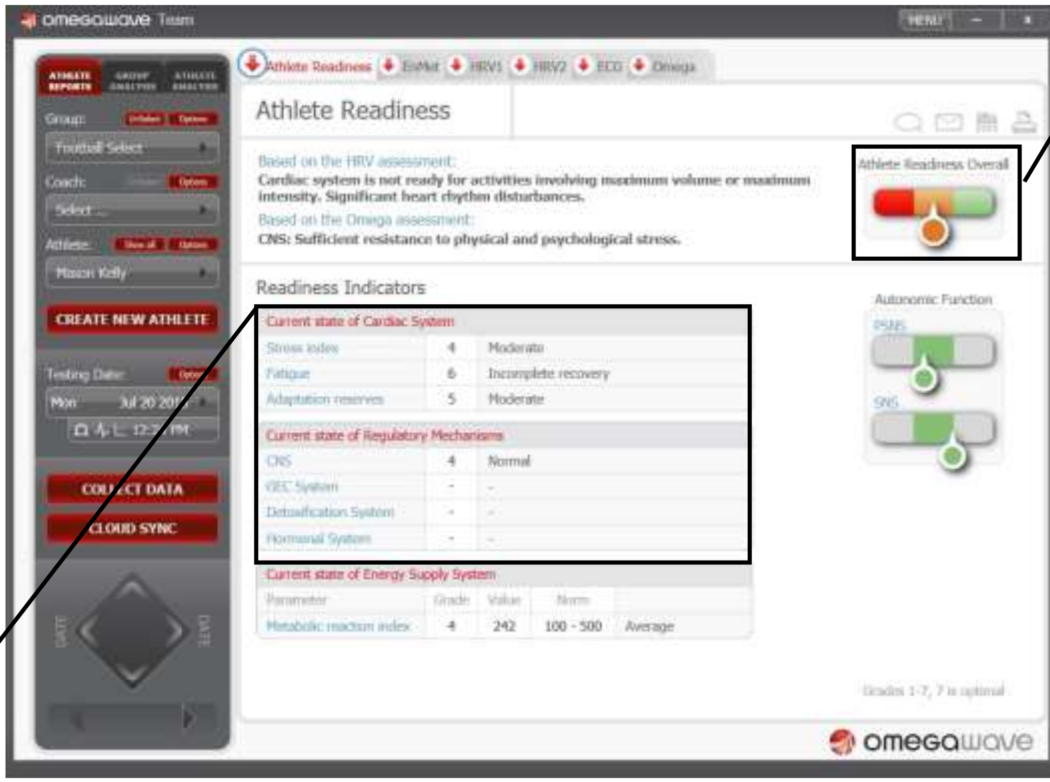
Aerobic Status Index: Reflects the current state of the aerobic metabolic pathway and the ability to perform aerobic work in training. This parameter relies heavily on the rate and amplitude of the R & S waves. The R-wave represents ventricular depolarization, while the S-wave represents depolarization of the Purkinje fibers. Athletes with robust aerobic systems will have large R-wave rates and amplitudes due to the increased ventricular filling and eccentric hypertrophy. The amplitude and rate are a direct response to the strength of the stretch during ventricular filling. Likewise, the depolarization intensity of Purkinje fibers is decreased due to the accommodating stretch-reflex generated during ventricular depolarization. Large S-waves are indicative of ventricular hypertrophy due to increased peripheral resistance, a situation often seen in strength athletes.

Anaerobic Status Index: Reflects the current ability to perform muscle work using the glycolytic energy system while withstanding a high level of lactate in the blood. Extensive anaerobic training leads to increased lactate and decreased pH in the blood for extended periods of time, which is evidenced by alteration in the T-wave. Using the T-wave as an indicator of blood acidity allows for an assessment of the individual's tolerance for anaerobic exercises during which lactate levels will be elevated.

PRESCRIPTION: WHAT ARE THE LIMITING FACTORS?

The Athlete Readiness screen provides a snapshot of the individual's physiological state: think of it as the engine status as you start your car. Your vehicle will notify you if a major system is not functioning properly, indicating this by displaying a warning message. A mechanic can then investigate further, assessing the severity of the limiting factor and prescribing a solution to fix the problem. As a strength and conditioning professional, you are the "mechanic" who must diagnose limiting factors and prescribe exercise, recovery, nutrition, and other modalities to keep your athletes in a state of optimal function.

The Athlete Readiness Overall indicator is the "Check Engine" light. The color scale will indicate if one or more regulatory systems are insufficient.



Further analysis will reveal which system is the limiting factor. It is important to remember that the HRV analysis reveals limitations in the adaptation "fuel tank," while the CNS represents the status of the "engine" driving all functional systems (including adaptation).

As a strength and conditioning professional, there are a limited number of factors under your direct control, with these conforming to the classic FITT acronym:

F: ***Frequency*** – the frequency of the programmed training sessions is a balance between work and rest. Mismanagement of the work-rest ratio can lead to states of non-functional overreaching or overtraining. Using Omegawave allows the coach to determine if the athlete has recovered from prior training loads.

I: ***Intensity*** – refers to either the % of heart rate maximum or % of one-repetition maximum of weight lifted. Training in higher heart rate zones will produce greater levels of fatigue, depleting a significant amount of fuel for adaptation. Weight training at high intensities will elicit neural adaptations, but can lead to CNS fatigue if mismanaged. Using Omegawave allows the coach to determine appropriate training intensities based upon the fuel tank (HRV) and engine (CNS) status.

T: ***Type*** – the type of training determines which physiological adaptation one is seeking with the prescribed training session. Using Omegawave and its Windows of Trainability, the coach will be able to choose which training modality is appropriate for any given day.

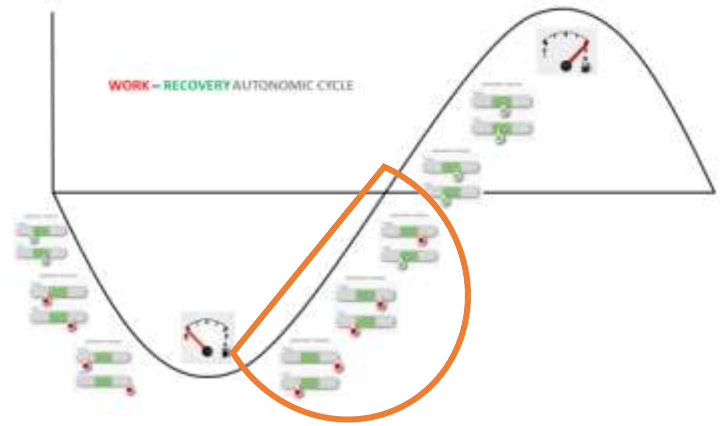
T: ***Time*** – refers to the duration of the training session, but can be likened to the volume of a given exercise. Using Omegawave will allow the coach to determine how much of a given training load the athlete will be able to sufficiently handle.

Beyond these training factors, specific modalities can be prescribed to expedite the recovery process. The following are suggestions for exercise prescription and recovery modalities when faced with physiological limiting factors. The most common limitations are found via the HRV and CNS assessment, with athletes presenting sympathetic or parasympathetic nervous system dominant states or reduced capabilities of the CNS and its ability to coordinate functional system activity.

Recommendations will be made on the four basic training adaptations as represented by the Windows of Trainability: Endurance, Speed & Power, Strength, and Coordination & Skill.

AUTONOMIC TONE: PARASYMPATHETIC DOMINANCE

Training Recommendations & Recovery Modalities



When the functional state of the cardiac system is the limiting factor, the fuel tank for adaptation will be limited. The *volume* of training is the biggest consideration when dealing with reduced fuel or states of fatigue. Volume is equal to reps x sets x intensity (weight or HRmax%), so any one of those three variables can be manipulated to accommodate athletes with insufficient recovery.

Endurance: As indicated by the Windows of Trainability, endurance is the only "window" that is fully open to receive the maximum training effect. Training for aerobic development does not incur a significant physiological cost, provided total duration is kept within reason and the HR intensity is held below 85% of HRmax. Even in slightly fatigued states, athletes can still train for endurance without jeopardizing recovery.

Speed & Power: Volume considerations for speed and power development should focus on reducing reps or sets. Provided the CNS is not a cofounding limiting factor, intensity can still be maintained. Depending on where the athlete falls on the state of fatigue spectrum (Refer to HRV1 tab), reductions can range anywhere from 10-60% in total volume.

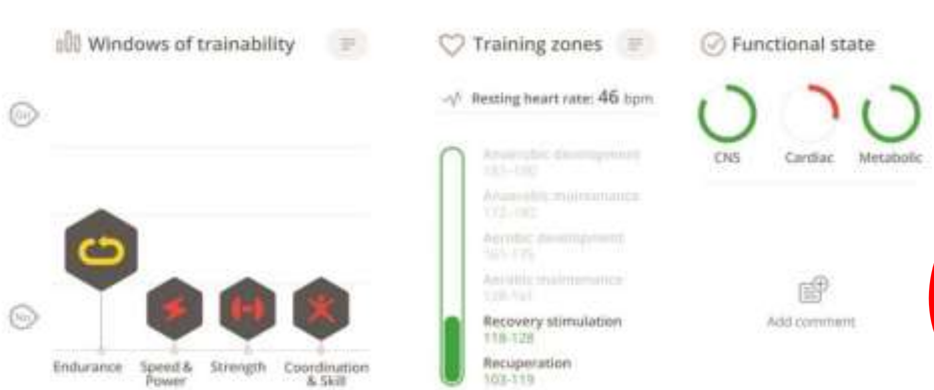
Strength: Similar to speed & power, strength is predominately neural. The volume of workloads, however, may produce fatigue beyond the athlete's Adaptation Reserves. Consider reducing volume in the accessory work, while maintaining your core working sets.

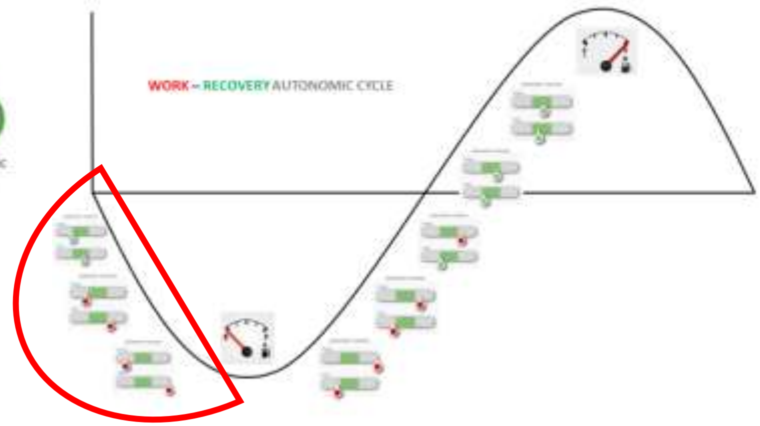
Coordination & Skill: Coordination & skill are adversely affected by states of fatigue and should be the focus of development in parasympathetic states. Training in fatigued states will likely produce altered mechanics and create poor functional systems.

Recovery: Anything the affects recovery can be a possible intervention. Increasing sleep and nutritional intake are the first steps. If these fail to produce a significant result, consider using contrast bath therapy, intensive massage, or active recovery modalities.

AUTONOMIC TONE: SYMPATHETIC DOMINANCE

Training Recommendations & Recovery Modalities





Sympathetic dominance indicates the body is in a state of moderate to severe fatigue and is currently in a state of homeostatic disturbance Adding additional stressors would only increase the time and resources needed to recover.

Endurance: In this state, this is the only training modality that may provide a moderate training effect. The intensity of the training session must be kept below 60% of maximum heart rate to provide recovery stimulation while keeping fatigue to a minimum.

Speed & Power: In controlled settings, such as the weight room, athletes may perform up to 1 working set of 85% 1RM to maintain neural drive. All other resistance training modalities should be eliminated as the fuel gauge for adaptation is nearing empty.

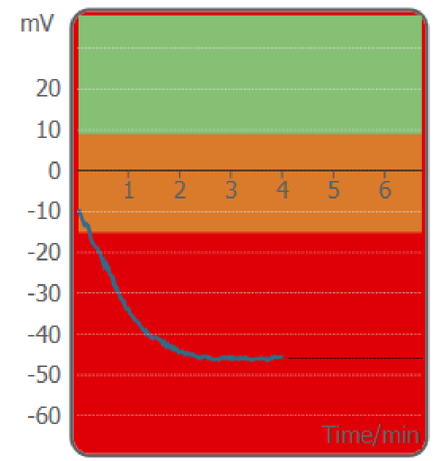
Strength: The same applies for strength: work up to 1 set of 85% 1RM to maintain neural drive, but limit all accessory work. Again, use the spectrum of sympathetic dominance to determine the reduction in volume. Typical volume reductions should be anywhere from 50-85%.

Coordination & Skill: Practicing coordination and skill in states of extreme fatigue is not advisable. Mechanics will be severely affected, which can lead to the development of poor functional systems. Also, the risk of injury is significantly higher when training in fatigued states.

Recovery: Depending on the athlete and the situation, the recovery modality can differ. Acute sympathetic states can be caused by mental stress or anxiety, and the recover modality will be specific to the individual and what that person views as relaxing. Meditation/mindfulness and slow rhythmic exercise have shown a lot of promise for those who are chronically sympathetic.

CENTRAL NERVOUS SYSTEM: FUNCTIONAL STATE

Training Recommendations & Recovery Modalities



The functional state of the CNS represents the status of the athlete’s engine: the CNS drives all functional systems, ranging from skill acquisition and execution, to adaptation. Is the athlete running on a 4-cylinder engine, like in the example above, or is the athlete cranking out 500 horsepower from a V-12 sports car? This metric represents the speed and efficiency of the CNS’s ability to communicate across neurons and coordinate functional system activity.

Endurance: Endurance training requires the coordination of many functional systems to supply the metabolic needs of the numerous organs and tissues activated during training. When the CNS is reduced, the ability to coordinate optimally is compromised; consequently, the cost of training is increased, regardless of the functional state of the cardiac system. Volume and intensity should be held to moderate levels.

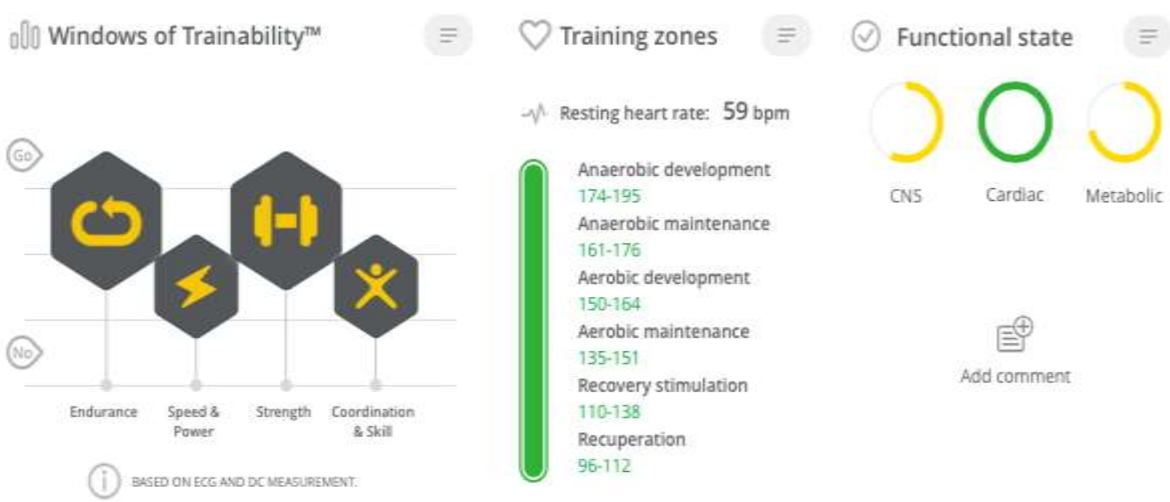
Speed & Power: Speed and Power development should be held to moderate levels, with the volume of work being the primary consideration. Activities should be limited to the weight room, where skill and coordination can be controlled. Accessory work can be incorporated with moderate volume considerations.

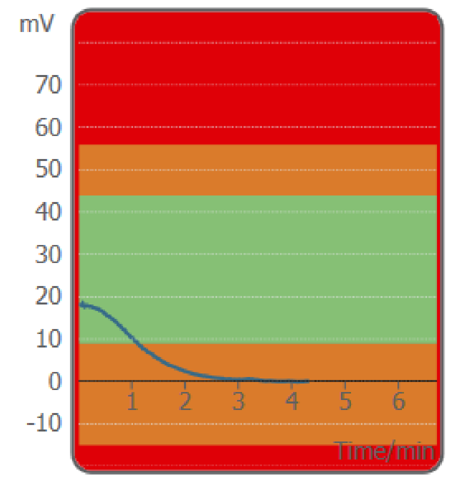
Strength: The same applies for strength: athletes may work up to a working set of 85% 1 RM, but multiple working sets are not advisable. Accessory work can be added in moderate amounts—stimulate, don’t annihilate.

Coordination & Skill: All skill and coordination activities should be kept to a minimum, due to the extensive involvement of the CNS in the execution of such activities. Skill acquisition will be hindered and the development of non-optimal functional systems may ensue. The risk of injury is significantly elevated when performing skills at high velocities and should not be performed while in reduced CNS states.

Recovery: Typically, the functional state of the CNS is affected by stimuli that is very strong and/or lasting in long duration. Long periods of regulation, mental strain, or traumatic events will have significant impacts on the DC potential. Promising literature suggest grounding technique such as barefoot walking can help re-establish CNS readiness. Other techniques include mindfulness, meditation, deprivation chambers, and yoga.

Remember to keep training modifications and reductions in training load on a spectrum of slightly reduced functional states to severe functional states. In the example below, the functional state of the CNS is reduced compared to the previous example, however it is mild rather than severe. The corresponding Windows of Trainability reflect this difference (still, limits remain based on this diminished functional state). The coach must always evaluate the Readiness of the athlete and ask "What can my athlete adapt to today?"

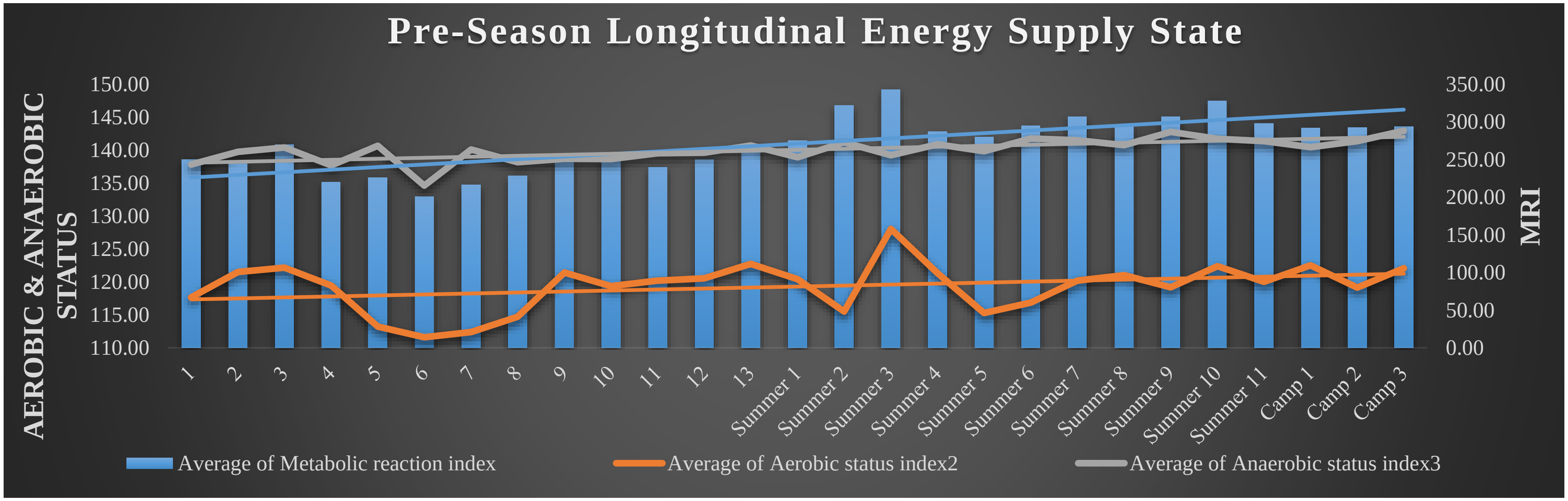




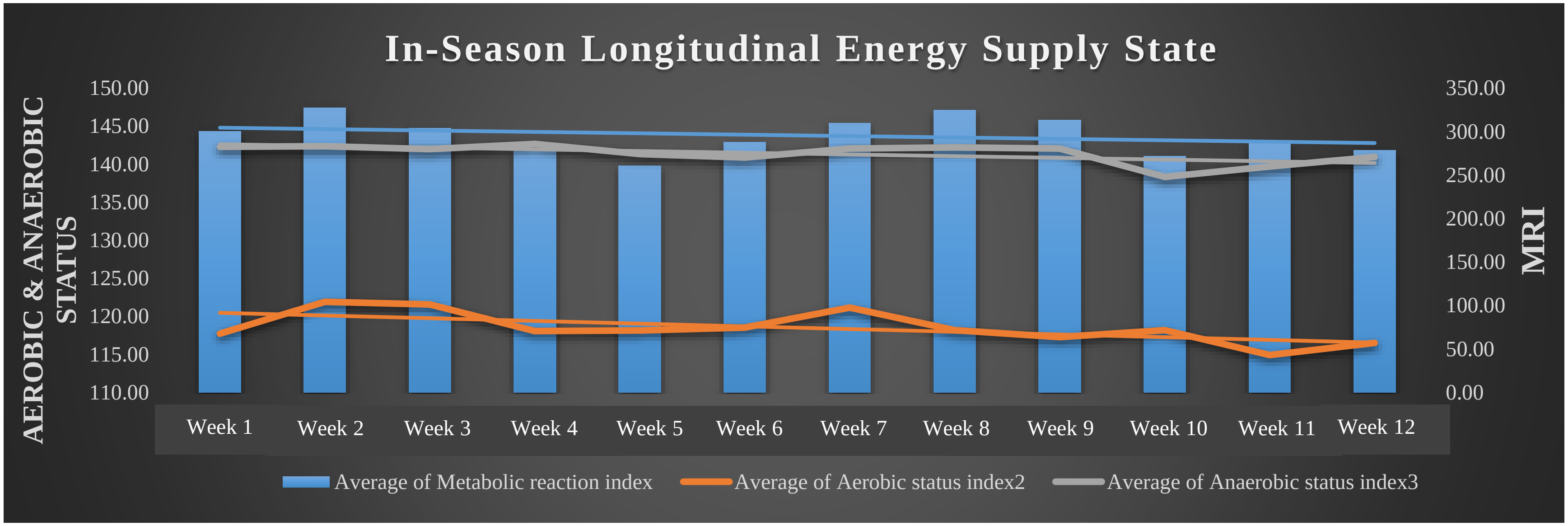
STATE OF ENERGY SUPPLY SYSTEMS

Training Recommendations

When examining the state of the energy supply system, it is best to view changes on a longitudinal basis. The chart below is an example taken from an American football team as the squad prepared for their upcoming season. The focus here is not to isolate the individual weeks, but to look at the linear trends of adaptation. A large variety of factors will affect the QRS complex on any given day or week, so it is important to look at the longitudinal result of the training adaptation. This data can be viewed within the Team software under “Athlete Analysis,” or the data can be exported to a CSV file in Excel, where appropriate charts can be constructed.



Based upon the chart above, one can assume that positive adaptations were made throughout the pre-season preparatory period. However, as we examine the in-season trends in the chart below, it is evident that the adaptations achieved in the off-season begin to taper off. Compared to aerobic status, decrements in the anaerobic system were less pronounced, most likely due to the dominant anaerobic stimulus during practice.



By evaluating the long-term trends, strength and conditioning professionals can intervene with specific training stimuli to maintain energy supply at a sufficient level. If the trends continue unchecked, the cost of the training sessions will increase while the athletes' capacities for supplying energy will decrease. Again, these parameters should not dictate daily training modalities in the same manner that HRV and DC potential analysis do; instead, they should be viewed on a longitudinal basis to assure that positive training adaptations are maintained.

CONCLUSION

Due to the vast genetic variability between athletes, it is essential to monitor the individual response to training using objective physiological feedback. Without this information, it is likely that training modalities employed today are effective for 68% of our athletic population, while 16% are overtrained and 16% undertrained as illustrated below.

Figure 14. Normal distribution of training effects

Using the Omegawave Team system allows strength professionals to identify athletes who fall outside the 68%, and will assist with the individualization of training. By selecting the appropriate Window of Trainability, as well as individualizing the appropriate volume and intensity of training, coaches can guide their athletes toward efficient training adaptations with minimal costs. This method has been proven to be successful as evidenced by recent publications, where daily training modifications were made based upon the functional state of the individual(11) (7). By keeping physiological costs low, athletes can allocate more resources towards skill mastery—the ultimate adaptation.

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