Tekniikantie 14, Espoo, 02150, Finland
+358 50 544 7272 • roman.fomin@omegawave.com • www.omegawave.com

LITERATURE REVIEW OF OMEGAWAVE METHODS

PART 1

Direct Current Potential of the Brain
Amplitude-Frequency Analysis of Electrocardiogram
Heart Rate Variability

Roman Fomin, PhD

This review presents an analysis of scientific literature on the three physiological functional state and readiness assessment methods used by Omegawave technology: direct current potential of the brain, heart rate variability analysis, and amplitude-frequency analysis of electrocardiogram.

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INTRODUCTION

This review describes the scientific basis for the methods of evaluating an athlete's functional state and readiness integrated in the Omegawave technology. A comprehensive and integrated approach to the evaluation of an athlete's functional state was the primary basis on which the founding methods were selected. The principal criteria for selecting a specific scientific method consisted of validity and reliability, reproducibility, sensitivity and specificity, accuracy and stability, non-invasiveness and portability, quickness and ease of use.

The main purpose of the methods used by Omegawave is to provide monitoring of the athlete's current functional state (Readiness) in his or her natural training environment. Such monitoring allows coaches to: make the balancing of training loads and recovery individual for each athlete; avoid overtraining; ensure that the athlete is able to realize their full capacity.

The integrated approach uses a number of informative scientific methods for a cohesive evaluation of the athlete's functional state, as opposed to the assessment of individual organs or systems. The Central Nervous System (CNS) and cardiac system are the main systems that determine the organism's functioning. Optimal functioning of these systems allows for efficient adaptation to training loads, thereby improving the athlete's performance. Continuous dynamic monitoring of the Readiness of these systems is necessary for achieving high performance while also maintaining the health of the athlete.

Most of the existing methods for measuring the functional state cannot be implemented in the natural environment of the training process. Such methods require a laboratory, cannot be used daily, and require a significant investment of time and effort. The methods can further be invasive, difficult to use and situation-specific. These factors, as well as others, can significantly impair the efficiency of these methods in the preparation of athletes.

Therefore, it is clear that there is a need in the marketplace for immediate, portable and non-invasive technologies for the monitoring of an athlete's functional state and tracking adaptational changes in the entire body. The Omegawave technology uses state-of-the-art developments in the fields of physiology, cognitive neurobiology, and computer modeling to provide a solution to this significant problem.

DIRECT CURRENT POTENTIAL OF THE BRAIN

HISTORY

At present, the *direct current (DC) potential of the brain* method is widely used in physiology [1-4], medical science [5-8], neurosciences [9], and sports [10]. The DC potential method has been proved to be highly informative for evaluating the functional state of the adaptation and de-adaptation systems in healthy and unhealthy persons.

However, there are differences in how the DC potential of the brain is defined in the literature. In Western publications, the term "direct current potential" is used to denote the DC potential [11-13]. In Russian literature, the DC potential has been termed as: superslow electrical activity, a quasi-steady difference of potentials, the omega potential, ultraslow bioelectrical potential oscillations, superslow electrical processes, superslow bioelectrical potentials, superslow physiological processes, superslow potential fluctuations, etc. [3]. Regardless of these differences, researchers generally agree on defining the **DC potential as brain biopotentials within a frequency range that is lower than the EEG range (0 through 0.5 Hz).** To avoid confusion with terms, we will use the term "direct current potential" (DC potential).

The first attempts to record the DC potential were made in **1939** [14]. In **1949**, Kohler and colleagues reported a positive variation in the DC potential in response to light and sound stimuli [15]. At that time, the origin of DC potential was unclear. Scientists termed the DC potential as "quasi-steady changes" and regarded it from the viewpoint of the electrotonic conduction of the neural process corresponding to perception [15].

In the second half of the 20th century, neurophysiologists conducted many fundamental studies in animals by taking measurements to determine the nature and physiological mechanisms of the DC potential [1,7,11,16,17]. The results of these studies revealed that there are three principal factors contributing to DC potential generation: *metabolic, humoral and neuronal.*

At present, the genesis of the DC potential is being widely discussed in literature [6,7,17,18]. Despite certain contradictions, most researchers argue that the following are sources of the DC potential:

- Neuron and glia membrane potentials [19]
- Hematoroencephalic barrier potentials [19,20]
- Vascular potentials [21]
- Skin potentials [22]

Based on these studies, scientists proposed the concept that a **Slow Regulatory System of the Brain** is responsible for the homeostasis and functional state of the human organism. According to researchers [1,23-26], the Slow Regulatory System of the Brain responds only to environmental factors that are either extremely strong or frequent. This system differs to the Fast Regulatory System of the Brain, which responds to environmental factors that are weaker and irregular, as measured by an EEG. Combining the Slow Regulatory System of the Brain theory with the DC potential method became widely used in studying the physiological mechanisms of adaptation, stress resistance, functional reserves, and compensation capacity of animals and humans under the influence of physical, thermal, chemical, toxic, mechanical, psychogenic, and other environmental factors.

During the 70 years of intense research of DC potential by physiologists and clinicians, a number of scientific schools and areas emerged.

The **Burr school's** (1923-1958) conceptions about DC potential were based on the existence of electrical fields in the organism, not only reflecting the activity of various organs and formations but also supporting their normal living and functioning [27]. In their works, Burr and his students investigated changes in the DC potential under various functional states of humans and animals (e.g. hypnosis, various stages of the ovulatory cycle, hunger, satiation, etc.).

The **Rusinov school** (1965-1979) approached studying the DC potential from a perspective based on Ukhtomsky's dominant concept from [28]. Rusinov and his students used the hypothesis of a continuous excitation focus described by altered excitation thresholds of neuron cells. The representatives of the Rusinov school paid special attention to changes in slow electrical potential at various conditioning stages, as well as to nerve center activity modification by polarizing the brain using the direct current.

The **school of Bekhtereva and Aladzhalova** and their students (1965-2008) approached studying the DC potential from the perspective of electroencephalography, i.e. they regarded DC potential as superslow EEG waves. Bekhtereva and colleagues were the first to record the DC potential in deep human brain structures using long-term golden electrodes in **1966**. In 1980, Sychev proposed and approbated a new vertex/thenar technique for DC potential recording [29]. In 1982, Ilyukhina et al. developed a method for continuous discrete recording of DC potential using surface leads placed on the head and the body [30].

According to Ilyukhina [31-33] and Sychev [29], there is a close correlation between the difference of potentials recorded using the vertex/thenar lead and the functional energy states of an organism. Ilyukhina and Zabolotskikh [34,35] suggested a relation between DC potential and energy-deficient states of the body. These authors termed slow waves as "omega potentials" in their work. In 1988-2010, a new method for recording DC potential - **omegametry** - was created and adapted for medicine [36], physiology of extreme environments [37], and sports [38,39].

The scientific school of Bekhtereva and Aladzhalova regard DC potential as an **integrated indicator of the functional state of a human**, reflecting the degree of coordination of neurohumoral relationships between individual organs and the relationships between organs and separate systems, as mainly regulated by the CNS and autonomic nervous system (ANS). According to active followers of this school, DC potential is a universal, integrated indicator allowing the functional state and stress resistance of the body to be evaluated, and the compensation and adaptation abilities of the main regulatory systems and their compensation reserves to be determined [30,40,41].

These views are closely associated with the **"functional state"** concept interpreted in physiology as "...such relationships between the components of systems of any degree of complexity and extent of dynamic interaction between these systems and the environment, that are organized in a certain way and are relatively stable at a given time interval" [42,43]. A number of authors [43-45] regard such concepts as the "wakefulness level" and "activation level" as synonyms of the body's functional state.

According to Sokolov [44], the functional state of the CNS is a basis on which behavior is realized. Regarding this, the author divided **structure**, **process** and **state** of the CNS:

- **Structure** – reflects macro connections between neurons
- **Process** – reflects micro organization of inter cell mechanisms of life-sustaining activity of the assemblies of neurons
- **State** – reflects organizational relationships of multiple structures

The **Fokin school** (1989-2003) views DC potential as an electrical manifestation of slow brain processes directly related to the brains metabolism. According to the representatives of this school, DC potential can be regarded as an electrophysiological indicator of the CNSs energy metabolism [7,46]. The studies of Fokin and his students gained widespread acceptance in neurology, psychiatry, sports, and other applied disciplines [47-49].

In the last decade, the DC potential method became widely used not only in physiology and medical science, but also in sports. Omegawave, based on extensive literature research and many years of its own experience of using the DC potential method in sports practice, regards this parameter as an integrated marker of the athlete's functional state, which consists of adaptational changes that take place in the body as a whole and in the CNS in particular.

At present, there are a number of methods for accurate recording of DC potential. Omegawave uses the method proposed by Sychev [29], Ilyukhina [32], and Zabolotskikh [41]. The Omegawave method can utilize discrete or continuous recording of DC potential in a frequency band of 0.05-0.5 Hz for 2, 5, or 7 minutes at rest, and for 7-10 minutes after exercise. The active electrode is placed in the vertex area (V) or on the forehead (L), at the midline 2 cm above the eyebrows. The reference electrode is placed in the right-hand thenar area (T) (left-hand thenar area for left-handed persons). The following equipment is used for recording DC potential: a large-impedance DC amplifier, non-polarizing Ag/AgCl electrodes, a computer, and software. This equipment corresponds to the technical requirements and standards of DC potential recording as described in literature [43,46,50,51].

DIRECT CURRENT POTENTIAL IN PHYSIOLOGY AND MEDICINE

The DC potential method became widely used in many areas of **medical science**:

- Anaesthesiology and critical care medicine [41,52-54]. The DC potential method was used in determining the level of anxiety, for optimization and individualization of medication and treatment, and selecting methods for predicting the appropriate dose of anesthesia.
- Cardiology [55]. A correlation between DC potential and the systolic function and central hemodynamics in patients with acute coronary syndromes was established.
- Cerebral circulation disorders [56]. The DC potential method was used to locate cerebral circulation disorders.
- Endocrinology [57,58]. The DC potential method was used for optimizing nutritional support for patients with destructive pancreatitis.
- Epilepsy [1,7,59].
- Gastroenterology [60-62]. DC potential was used as a quick and non-invasive method for assessing the state of peritonitis patients.
- Gerontology [7].
- Narcology [63,64].
- Neurosurgery and organic lesions of the brain [65,66]. DC potential was used for identifying tumor locations. It was demonstrated that the negative potential difference may be a valuable means for the assessment of recovery of brain functions in neurosurgical patients.
- Obstetrics and gynaecology [41,61,67-69]. The DC potential method was used for studying the functional state of the CNS in pregnant women; assessing preeclampsia severity and the effectiveness of treatment.
- Orthopaedics [70].
- Paediatrics [71].
- Psychopathology: neuroses, psychopathies [8,31,72-74].
- Sports medicine [75]. DC potential was used for functional diagnostics.
- Toxicology. The effect of toxic substances on animals and humans [41,49,76-79]. DC potential was used to predict and assess the effectiveness of the body's detoxification system in sepsis patients.
- Traumatology [80-82]. The assessment of encephalopathy severity in patients with head injuries, cerebral concussions and contusions.
- Urology [83]. Superslow physiological processes in functional state evaluation in patients with acute uraemic intoxication.

The DC potential recording method is widely used in modern human **physiology**:

- Physiology of wakefulness and sleep [30,84-86]. The DC potential method was used to differentiate between wakefulness levels, from coma to superexcitation. Circadian changes of superslow physiological processes in humans were revealed.
- Neurophysiology [87-91].
- Autonomic nervous system [92]. DC potential was used for this study but is also widely used today for evaluating ANS functions.
- Homeostasis: immune, acid-base, and gas [46,93].
- Cognitive neurobiology and neuropsychology [3,79,85,94-96].
- Developmental physiology and pedagogics [8,97-102]
- Stress [103,104].
- Hemispheric asymmetries of the brain [7].
- Brain energy metabolism [7,9,105-107].
- Physiology of labour [108-110].

In conclusion, the DC potential method has been widely used for studies in various fields of physiology and medical science. Based on these studies, further research of DC potential and the implementation of the DC potential method in other areas of science and practice may be promising.

DIRECT CURRENT POTENTIAL IN SPORTS

At present, DC potential is widely used in studying athletes' **functional states, stress resistance, and adaptation capacity** in physical education and sports. Many researchers emphasize that the DC potential method is highly informative and highly sensitive to immediate and delayed adaptational changes taking place in the athlete's body under a training load. The DC potential method has been proven to be a reliable marker in describing the individual responses of the body's systems to loads. The main benefit of this method is to **achieve a high level of preparedness at the minimum physiological cost possible.**

The physiological mechanisms of adaptation to various extreme conditions and environmental factors are largely the same. Physical loads, hypoxia, cold tolerance exercises, and other factors all induce similar responses in the body by increasing the nonspecific resistance of the body [111-113]. Thus, we regard sports as an extreme activity with similar adaptational changes.

The DC potential method was first used for evaluating the athletes' functional state in **1989** by a group of sports scientists lead by Baba-Zade [114]. In 1996, Zabolotskikh and colleagues developed and proposed for the implementation in sports practice a new "method for athletes' functional state monitoring" involving DC potential measurement [115].

In the second half of 1990's, the method was rarely used. It was only in the 2000's that the DC potential method became widespread in sports science again. In **1999 through 2006**, Sivokhov and colleagues examined over six thousand athletes of various qualification levels, and various sports [75]. This seven-year experience of using the DC potential method in sports medicine allowed researchers to prove that this method can be used for the functional diagnostics of athletes and for optimization of the training process.

In **2002**, Kozhevnikov used the DC potential method to study the specifics of spatial, temporal, and quantitative characteristics of the athlete's functional state [73]. The author describes the mechanisms involved in the formation of immunodeficiency states in elite athletes during their training for important competitions. The author also successfully analyzed the dynamic curves of DC potential.

In **2004-06**, a number of studies investigating the use of the DC potential method for studying adaptational changes in sailors during voyages of different lengths were published [116]. These studies describe the causes and conditions for the onset of fatigue in sailors, as well as phases of the adaptation process. The studies also describe examples of various trends in adaptation responses in long-term voyage conditions. The authors utilized DC potential to describe the mechanisms supporting the interaction between the sailor's body and environment in voyage, as well as changes in these mechanisms depending on the amount of time spent at sea.

In **2005**, Shayakhmetova studied psychophysiological functions in 18- to 45-year-old persons working in extreme conditions [110]. The author used a DC potential method based on discrete measurements for quick evaluation of and predicting psychomotor functions in firefighters.

In **2006**, Akhmadeyev and colleagues obtained information indicating that short-term hypoxia has a bidirectional effect on athletes, with prevailing involvement of the anterior and parietal areas of the brain [117]. The study was conducted using the DC potential method and revealed that the DC potential level increases in the middle and at the end of hypoxic stress. In addition, significant variations in DC potential dynamics (depending on the hypoxia duration) were observed.

In **2007**, two studies investigating the utilization of the DC potential method in sports were published. Struganov directly used the DC potential method for planning the training process of elite marathon runners during the sport-specific stage [118]. The measurements allowed the author to appropriately plan training loads and predict the trend of the athlete's performance.

Bazhin established that DC potentials of various cerebral areas demonstrate that the brains energy metabolism remains stable under the simultaneous influence of information and hypoxic loads in highly actively persons [119].

In **2008**, Rumyantseva used the DC potential method to assess energy metabolism intensity in order to understand the capacity of reserves in elite fencers [120]. The author successfully used the resulting information for managing the athletes' preparation.

In **2009**, six studies on the utilization of the DC potential method in combat sports (boxing and fencing) were published:

Kalmetyev and colleagues [121] studied DC potential in boxers of various age groups. It was established that a boxer's body's response to muscle work of the same volume and direction is individual understandable but can be rephrased for better flow. The authors believe that analysis of DC potential changes in boxers before and after a training session provides objective information about the nature of adaptation processes taking place in the body during recovery, as well as information about mental capacity reserves.

Khabibullina and colleagues used the DC potential method to study the physiological basis of long-term adaptations of fencers to intense physical loads [38]. The author found that the fencer's DC potential can be used as a marker for describing the athlete's capacity of reserves.

Shayakhmetova and colleagues used DC potential for evaluating bodily adaptations to training and competition loads in combat athletes [122]. It was found that training loads change DC potential, but values remained within the optimal range. The maximum frequency of the optimal range of DC potential before ("junior" age group) and after a training session ("adult male" age group) was also found. The authors believe that competitive activity imposes a strain on adaptation mechanisms, thereby resulting in a decreased DC potential in combat athletes of various age groups.

In 2009, Muftakhina and colleagues used the DC potential method to study the psychophysiological state of boxers of various ages and qualification levels [123]. The authors found that a speed/strength-type training load induces changes in the amplitude and temporal performance of DC potential in boxers. A correlation between DC potential and the mental and physical state of the boxer's body was also discovered. The authors argue that the shifting of DC potential into the non-optimal range after a training session serves as an indicator that the athlete's body is in an abnormal psychophysiological state. A correlation between DC potential and psychomotor performance in boxers was established. It was also found that the rate of a simple visual-motor response and a complex visual-motor response, and rate of motion is increased at optimal DC potential levels.

In **2010**, Rozhnova used the DC potential method to reveal specifics of the brain's energy metabolism in teenagers with various physical activity levels at rest and during functional testing [105]. The resting hemispheric asymmetry and DC potential were the closest to the norm in the group of teenagers with a high physical activity level. However, these teenagers were less accustomed to physical training than teenagers with a moderate physical activity level. A more optimal functional state was observed in teenagers with a moderate level of physical activity.

In 2011, several studies were undertaken:

In **2011**, Bindusov studied the effect of various gymnastics exercises on DC potential in female students [39]. The authors revealed several types of DC potential responses to training and used this information for adjusting training loads.

Mosckovchenko investigated the adaptation capacities of over 500 elite athletes (runners, skiers, and combat athletes) using the DC potential method [10]. Based on this research, the author proposed new criteria for evaluating adrenal regulation mechanisms in sports practice. Moskovchenko believes that the DC potential method can be used to determine individual costs of adaptation and manage the state of adaptations based on the on the organism's reserves.

Budagayev provides the results of managing the training process of 10 elite skiers using the Omegawave system [124]. The functional state of the skiers was evaluated throughout the training year, which made it possible to optimize athlete preparation.

In 2012, Struganov and Galimov used the DC potential method for monitoring adaptational changes in the body, evaluating the body's reserves, tracking adaptation processes to physical loads, and managing the training process while avoiding overreaching and adaptation failures [125].

The literature review offers evidence that the DC potential method is highly promising for the evaluation of a body's adaptation to physical and mental loads of various intensities and durations. The review also demonstrates the extent to which the method has been adopted in sport science.

HEART RATE VARIABILITY

The assessment of the athlete's functional state is a difficult task that requires a comprehensive assessment of all organs and systems of the body. However, this is not always possible in the natural training environment. As a result, scientists, doctors, and coaches investigate the activity of the **athlete's cardiovascular system**, which is an indicator of the functional state of the entire body. Since comprehensive examination of the state of the heart can take considerable time, the investigation is often restricted to the most significant functional parameters indicative of heart activity. **Heart Rate Variability** (HRV) can be used as such a parameter because it has proved to be a highly informative, simple, and accessible indicator of the athlete's heart activity and body on a general level.

HISTORY

The first studies of HRV were conducted in the USSR in the early 1960's in space medicine [156]. They were followed by research in clinical medical science. In 1966, the first symposium on the mathematical modeling of heart rhythm was held, where over fifty scientific reports on the HRV method were presented [157-159]. The second symposium on this subject was held in 1977, where more than 300 reports were presented.

In the 1960's and 70's, a great number of articles [160,161] and two monographs [162,163] on the use of the HRV method in space medicine were published. In addition, large-scale research investigations in cardiology, surgery, physiology of labor and sports, and experimental physiology utilizing the HRV method were conducted. As a result of these numerous studies, the HRV method became a very significant tool for investigating the autonomic balance and evaluating the nonspecific adaptation responses of the human body [164]. The results of these studies were summarized in two monographs [162,164]. In 1986, Baevskii published a monograph on using the HRV method in athletes.

In Western Europe and the USA, intensive studies of the HRV method only began in the **1980's** [165-169] and continue today. Research on the HRV method is now published almost monthly, and it is also discussed at every congress of cardiology.

In 1996, a group of experts of the European Society of Cardiology and the North American Society of Electrophysiology developed standards for the recording, physiological interpretation, and clinical use of HRV [170].

In 2002, extended methodical guidance on the practical use of the HRV method and data comparison for experts was published [171]. The authors believe that the standards published in western countries in 1996 do not consider the 30-year Russian experience of using the HRV method in space medicine, sports, and other areas. Taking this experience into consideration may be beneficial for future studies.

At present, HRV is commonly adopted and widely used in applied physiology, clinical and aerospace medicine. Many studies include HRV investigation in healthy and unhealthy children and adults. In addition, the HRV method has recently become widely used in sports science [172].

Omegawave's HRV analysis for the evaluation of an athletes' functional state is based on the following scientific principles of human adaptation to stress, loads, and the environment:

- The adaptation syndrome theory [162,164,173,174]
- The functional system theory and biological cybernetics [159,175]
- The neurohumoral regulation of functions [176,177]

Omegawave considers HRV an indicator of the current integrated response of a multicircuit and multilevel regulatory system of the human cardiovascular system in the process of adaptation to loads.

METHODS OF HEART RATE VARIABILITY ANALYSIS

Different HRV analysis methods can be used to investigate the various physiological mechanisms that form the basis of the athlete's adaptation to training loads. At present, the following HRV analysis methods are commonly used in physiology, medicine, and sports:

- **Statistical:** statistical analysis; time analysis [170]; short rhythmogram section analysis [178].
- **Geometrical:**

    Variation pulsometry or histogram analysis [179]

    Correlation rhythmography: 2D scattergram analysis [180,181]; 3D scattergram and histogram analysis [182]; Histogram dome assessment [183]; Triangular interpolation methods [184].

- **Rhythm wave structure:** visual rhythmogram evaluation [185]; spectral analysis [170]; autocorrelation analysis.
- **Non-linear:** 1/f Fourier spectrum scaling; cluster spectral analysis; Kholmogorov entropy; index method.
- **Integrated:** adequacy assessment of regulatory processes [163,186]; integral estimation of regulatory systems [187].

The following movement tests are used for evaluating the functional state of the cardiovascular system using the HRV method: active orthostatic test; orthoclinostatic test; vegetative reactivity test; controlled deep breathing test; Valsalva test; exercise test; isometric contraction test; pharmacological tests; and other functional tests [188].

HEART RATE VARIABILITY IN PHYSIOLOGY AND MEDICINE

Due to the significant amount of articles associated with the physiological mechanisms of heart rate regulation, only those regarding the main practical implementations of HRV use in medicine for health and cardiovascular disease will be discussed.

HRV is used in the following areas of medical science:

Pediatrics and developmental physiology

HRV was studied in healthy children [189,190] and in children with various disorders [191,192]: functional cardiac diseases; allergic dermatoses; bronchial asthma; acute nonspecific diseases of respiratory organs; non-communicable diseases of the gastrointestinal tract.

Adults

HRV has been studied in healthy trained individuals under information loads and other stress. In addition, trend-analysis of the functional state of different occupations, e.g. pilots, astronauts, submariners, has been performed [179,193,194].

HRV has been studied in people with various diseases: arterial hypertension; arterial hypotonia [178]; stenocardia [195]; myocardial infarction [196,197]; chronic cardiac insufficiency [198]; coronary artery bypass surgery [199]; cardiac transplantation [200]; diabetes mellitus [188]; nervous system diseases [201]; under the influence of medications [170].

HEART RATE VARIABILITY IN SPORTS

During the last decade, there has been an increasing number of studies using the HRV method in many sports. The research was conducted under the argument that the mathematical analysis of heart rhythm is one of the most efficient methods for the investigation of how athletes adapt to loads. The HRV method makes it possible to efficiently perform quantitative and qualitative assessment of the state of the body's regulatory systems. In addition, the HRV method is indispensable for studies in an extreme environment where one needs to assess the level of strain in regulatory mechanisms, measure the level of stress, and predict potential disorders of the body's functionality.

The HRV method is currently used in the following sports and research areas:

Cyclic sports

- Elite athletes [202-212].
- Triathlon [213]
- Track and field [214]
- Marathon [215-219]
- Running, endurance sports [220-224]
- Swimming [207,225-228]
- Diving [229-234]
- Cycling [235,236]

Team sports

- Soccer [237-245]
- Volleyball [246]

Coordination sports

- Judo [247,248]
- Gymnastics [249]
- Powerlifting [250]

Children [225,251], **teenagers and university students** [252-254], and **women** [255-257].

Overreaching and overtraining [258-263].

Studying the effect of specificity of the **training process** on HRV [209,264,265].

This list is incomplete as there are numerous sports scientists, doctors, and coaches continuously using the HRV method in research and sports practice.

In addition, **five articles** on HRV research using **Omegawave technology** to assess athletes [214,257,266,267] and clinical patients [268] have been published in international peer-review journals.

In conclusion, the doctor and coach can use the HRV method to identify de-adaptation states (overreaching and overtraining) at an early stage and assess the adaptability and preparedness of athletes. The HRV method has become a powerful tool for monitoring the functional state of athletes, allowing the coach to efficiently analyze its correlation to the training process, thereby allowing improvements to be implemented in order to achieve the best performance possible.

CONCLUSION

Based on an extensive literature review and thirteen years of experience, the following conclusion concerning the scientific validity of the three functional state and readiness assessment methods underlying the Omegawave technology can be made.

The **DC potential** method is a specific, reliable, sensitive, and reproducible scientific method for evaluating the functional state of the human body. This method has been validated in fundamental physiology and medical science for over seventy years and has been used in sports for over ten years. The DC potential method can be utilized in sports for assessing current and delayed functional states of athletes and evaluating adaptational changes taking place in the organism in response to loads.

The **Amplitude-Frequency Analysis of ECG** method of energy metabolism has been validated for over twenty years and is a scientific method for the quick assessment of the athletes' current functional state and preparedness. This method is supported by scientific literature including sports medicine. It can be utilized for managing athlete preparation using specificity of individual energy metabolism.

Heart Rate Variability analysis is a scientific method for assessing the functional state of the cardiovascular system. Throughout its fifty-year history, the HRV method has been approbated in physiology, clinical and space medicine, labour and sports physiology, and has demonstrated its effectiveness in the assessment of adaptational responses of the human cardiovascular system to loads. This method can be used for evaluating the athlete's functional state, predicting overreaching and overtraining, and managing the training process.

All three methods used by Omegawave technology are based on science and can be used for enhancing the training process in order to achieve superior sports performance.

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