



Approaches to the Autonomic Nervous System in Female Athletes

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The effect of female hormones needs to be considered in the conditioning and training of female athletes. However, quantitative evaluation of autonomic function is an important indicator for determining the conditioning of athletes, in place of female hormone testing, in the sport setting. Improving intestinal environment, as well as an adequate breathing method, is recommended as an easy approach aimed at increasing the autonomic function and performance. Use of *in-vivo* approaches to the autonomic nervous system in female athletes is anticipated to expand in the future.

Key words: autonomic nervous system (ANS), total power, heart rate variability (HRV), intestinal environment, breathing method

Approaches to the autonomic nervous system

In recent years, there has been an increasing interest in the autonomic function and activation in the field of sports.

In the area of sports medicine, many possibilities of training and conditioning have been scientifically validated, information has been accumulated and analyzed, and the evidence has been constructed. Given these circumstances, it has come to be recognized that a physical approach alone has limited benefits to athletes.

Mental training is also receiving attention. However, unfortunately, there is no evidence supporting this training. Mental training has not been standardized, but performed only based on the empirical experience of some trainers in Japan.

For female athletes who are physically and mentally affected by female-specific physiological phenomena such as menstruation and hormonal changes, the evidence-supported conditioning and

training methods focusing on the autonomic nervous system (ANS) are recommended.

We have achieved good conditioning and training results by monitoring athletes' specific physical conditions based on the findings of autonomic function testing and quantitative evaluation.

The autonomic function can be measured and quantitatively evaluated by means of heart rate variability (HRV).

It is believed that HRV variability will become as common as pulse, blood pressure or temperature in biological information in the near future. HRV has been used as a screening tool in many disease processes. Various medical disciplines are looking at HRV. In diabetes and heart disease it has been proven to be predictive of the likelihood of future events. In 1996, a special task force was formed between the US and European Physiological associations to outline current findings on HRV and set specific standards on using HRV in medical science and future practice. Since then a steady

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stream of new information and value continues to come out of HRV research.

The theory and technique for measuring and evaluating autonomic function are standardized in the United States and Europe. Research on ANS started in the former Soviet Union. Autonomic function testing has been developed and advanced as a tool to manage the biological information of individuals, such as astronauts in the space, nuclear submarine crew in the submarine, and combatants in the war, working under extreme stress.

After the collapse of the Soviet Union, the biological information management system, which was offered as a commercially available system by a corporation established by an exiled Russian scientist, has been introduced in the post-traumatic stress syndrome care program for returned servicemen, promoted by the US Department of Defense, as well as in the biological information monitoring program for MARS-500 (a simulated manned flight to Mars). Good results have been accumulated for many years.

In Japan, this system has also been introduced in many medical schools, research institutes, and a number of corporate laboratories specialized in stress research.

To prepare for the MARS-500 project, the Russian Academy of Sciences conducted a joint pilot study called MARS-500-P with Autosun Health Technology in Canada and Biocom Technologies in the USA for long-term monitoring of human adaptability and disease risk management in healthy individuals.

The ANS is a part of the nervous system that non-voluntarily controls all organs and systems of the body. As the other part of nervous system ANS has its central (nuclei located in brain stem) and peripheral components (afferent and efferent fibers and peripheral ganglia) accessing all internal organs. There are two branches of the ANS - sympathetic and parasympathetic (vagal) nervous systems that always work as antagonists in their effect on target organs.

For most organs including heart the sympathetic nervous system stimulates organ's functioning. An increase in sympathetic stimulation causes increase in HR, stroke volume, systemic vasoconstriction, etc.

In contrast, the parasympathetic nervous system inhibits functioning of those organs. An increase in

parasympathetic stimulation causes decrease in HR, stroke volume, systemic vasodilatation, etc.

At rest both sympathetic and parasympathetic systems are active with parasympathetic dominance. The actual balance between them is constantly changing in attempt to achieve optimum considering all internal and external stimuli.

There are various factors affecting autonomic regulation of the heart, including but not limited to respiration, thermoregulation, humoral regulation (rennin-angiotensin system), blood pressure, cardiac output. One of the most important factors is blood pressure. There are special baroreceptive cells in the heart and large blood vessels that sense blood pressure level and send afferent stimulation to central structures of the ANS that control HR and blood vessel tonus primarily through sympathetic and somewhat parasympathetic systems forming continuous feedback dedicated to maintain systemic blood pressure. This mechanism is also called baroreflex, which increases HR when blood pressure decreases and vice versa. This mechanism is also targeted to maintain optimal cardiac output.

Heart rate variability analysis

The HRV analysis is a powerful tool in assessment of the autonomic function. It is accurate, reliable, reproducible, yet simple to measure and process. The source information for HRV is a continuous beat-by-beat measurement of interbeat intervals (Figure-1).

The electrocardiograph (ECG or EKG) is considered as the best way to measure interbeat intervals. ECG is an electrical signal measured with special conductive electrodes placed on chest around heart area or limbs. It reflects minute changes in electrical field generated by heart muscle cells originating from its Sinoatrial node. ECG signal has a very specific and robust waveform simple to detect and analyze.

According to the standards set forth by the Task Force of the European Society of Cardiology and North American Society of Pacing and Electrophysiology in 1996, there are two methods of analysis of HRV data: time and frequency-domain analysis. In either method, the interbeat intervals should be properly calculated and any abnormal heartbeats found.

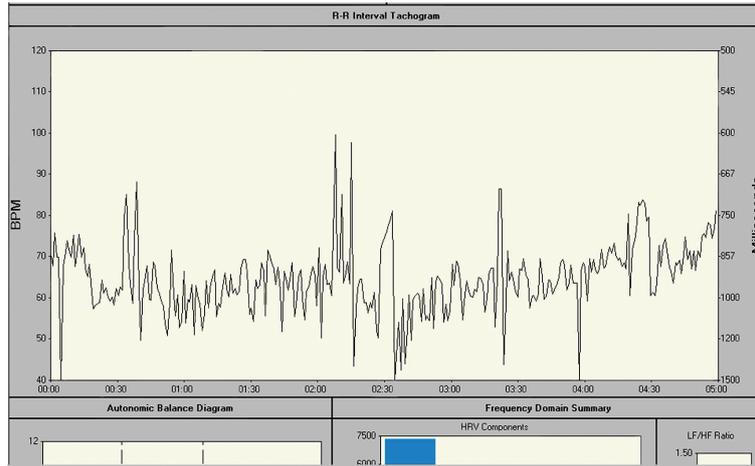


Figure-1 Heart rate variability (HRV) Tachogram
The source information for HRV is a continuous beat-by-beat measurement of interbeat intervals.

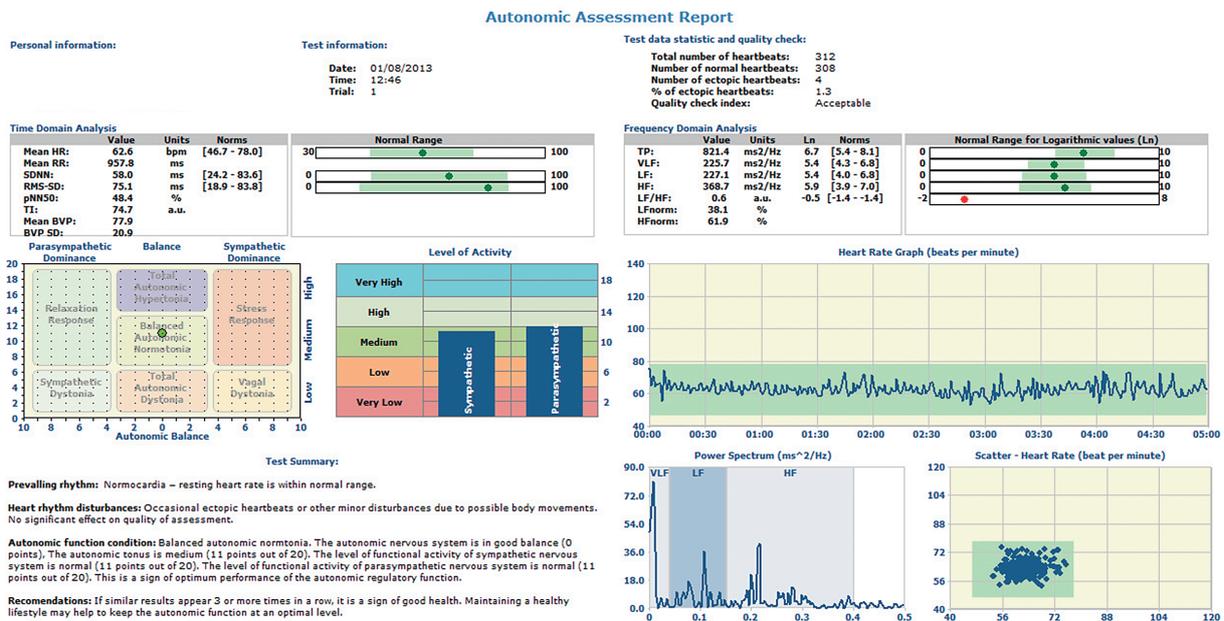


Figure-2 Autonomic assessment report of female athlete (Heart rhythm scanner)
This female athlete have high TP and predominant parasympathetic involvement of the autonomic nervous system.

A standard spectral analysis routine is applied to modified recording and the following parameters evaluated on 5-min time interval: Total Power (TP), High Frequency (HF), Low Frequency (LF) and Very Low Frequency (VLF). When long-term data is evaluated an additional frequency band is derived - Ultra Low Frequency.

The HF power spectrum is evaluated in the range from 0.15 to 0.4 Hz. This band reflects parasympathetic (vagal) tone and fluctuations caused by spontaneous respiration known as respiratory

sinus arrhythmia.

The LF power spectrum is evaluated in the range from 0.04 to 0.15 Hz. This band can reflect both sympathetic and parasympathetic tone.

The TP is a net effect of all possible physiological mechanisms contributing in HR variability that can be detected in 5-min recordings, however sympathetic tone is considered as a primary contributor.

The LF/HF Ratio is used to indicate balance between sympathetic and parasympathetic tone. A decrease in this score might indicate either increase

in parasympathetic or decrease in sympathetic tone. It must be considered together with absolute values of both LF and HF to determine what factor contributes in autonomic disbalance (Figure-2).

Conditioning of female athletes

We carry out an analysis of the results of autonomic function testing obtained from top athletes with the aim of applying the obtained data to their conditioning and training.

In female athletes who need to consider the effect of female hormones on their performance, autonomic function testing is useful in many sports events because of its simpler method than blood testing.

Both the female hormones and autonomic nerves are controlled by the hypothalamus and thus are affected with each other.

While the performance of male athletes is minimally affected by male hormones, female athletes are physically affected by female hormones in a significant way. Thus, autonomic function testing allows female athletes to be not only indirectly but also quantitatively evaluated.

Since the autonomic function testing also allows real-time and long-term analysis, it is beneficial for planning the training, as well as for preparing for matches or games.

Menstrual cycles are likely irregular in female athletes who are often put on a restricted diet or weight restrictions for a game or a match.

Quantitative evaluation of autonomic function is also important to indirectly assess and control the female hormone balance. Autonomic function testing is anticipated to become a popular tool for evaluating the conditioning of female athletes in the future.

The autonomic nerves can be classified as sympathetic or parasympathetic nerves. It is necessary for athletes to maintain a well-balanced sympathetic and parasympathetic nervous system and high total power (TP) that reflects the whole autonomic function.

Many top athletes had high TP and predominant parasympathetic involvement of the autonomic nervous system. Their conditioning program should be aimed at maintaining the good autonomic function condition.

Specifically, excessive stress should be eliminated to always keep the autonomic function in a good condition.

- 1) Listening to favorite music.
- 2) Taking lukewarm carbonate spring bath to avoid body heat loss after bathing.
- 3) Improving the intestinal environment.
- 4) Autonomic nervous exercise.
- 5) Adjusting the lifestyle.
- 6) Employing the breathing method.
- 7) Preventing sudden increase in core body temperature before and after training (use of core control).

These above methods are important for increasing parasympathetic function and adjusting the autonomic balance in athletes.

Above all, improving the intestinal environment and employing the breathing method are attracting attention in the field of sports.

Approaches to the intestinal environment

Bowel motility is controlled by the autonomic nerves. Female athletes often have constipation, and improvement of the intestinal environment is shown to relieve their constipation, thereby enhancing their performance.

Intestinal environment greatly varies among individuals; however, the well-balanced ratio of so-called good to bad bacteria is crucial for optimal intestinal environment. The autonomic balance can be corrected by adjusting the ratio of good to bad bacteria.

Taking activated lactobacillus or bifidobacterial preparation alone is often not enough to improve the intestinal environment. Simultaneous intake of soluble fiber is recommended.

Breathing method

Breathing is scientifically proven to cause HRV, thereby affecting the ANS and improving the parasympathetic function.

The biofeedback breathing exercise, which is a training procedure for athletes, has also been introduced in military training, space development, and treatment of various diseases.

We have achieved good results of the breathing training from many female athletes.

Biofeedback is a technique for controlling the internal condition by scientifically defining imperceptible physiological indicators and feeding them back to the subject in a perceptible manner.

It is also necessary for athletes who are constantly under physical and psychological stress to be trained, with the aim of increasing parasympathetic function and creating a relaxed state even during intense condition.

Many athletes are well-known to introduce yoga breathing exercises in their training or conditioning programs.

However, why breathing improves the physical performance of athletes has yet to be determined.

We have investigated the effect of breathing on the ANS and its technique through analyzing the results of quantitative evaluation of autonomic function and examining the application of the obtained data to breathing.

HR and blood pressure, as well as other physiological systems, show complicated fluctuation patterns characterized by multiple-frequency vibrations in healthy individuals. These vibrations reflect the homeostasis. Breathing-induced HRV is called respiratory sinus arrhythmia (RSA). HR increases with inhalation and decreases with exhalation. During the biofeedback training to increase the RSA amplitude, the HRV maximizes only around 0.1 Hz (taking one breath in 10 seconds). When breathing slowly to adjust the respiratory rate around 0.1 Hz, the breathing-induced RSA is attuned to the natural vibration generated by the respiratory rate partly due to the baroreceptor reflex. Specifically, taking one breath in 10 seconds (5-second inhalation followed by 5-second exhalation) maximizes the HRV and increases the autonomic function, especially at the parasympathetic level.

This is why slow, deep breathing calms us down when we are tense. Our study revealed that 1-to-2

breathing method (5-second inhalation followed by 10-second exhalation), focusing on the exhalation, increases the TP and the parasympathetic level in many athletes.

Breathing is part of the mechanism underlying heart rhythm variability. The breathing-induced heart rate variability in healthy individuals usually occurs in the frequency band of 0.15-0.4 Hz (9-24 breaths/min) and is called "high-frequency" heart rate variability. Simultaneously, a large amplitude variability also occurs in the frequency band of 0.05-0.15 Hz (3-9 breaths/min). It is called "low-frequency" heart rate variability and is affected by both the sympathetic and parasympathetic nervous systems.

RSA induces quite a strong reflection phenomenon in the body to promote the adjustment due to the whole autonomic nervous system. Breathing method increases heart rate variability. Such an increase in heart rate variability is efficiently achieved by training such important reflection exercise and controlling the body.

The conditioning and training methods aimed at improving the autonomic function are anticipated to improve the performance of female athletes.

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