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Wearable Technology and Psychometric Tests to Improve Athletic Performance

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ABSTRACT

Wearable technology plays an important role in enhancing athletes' performance. These technologies collect various biometric data through devices that are worn or attached to athletes' bodies. This data can be used in many areas such as optimizing training, cognitive skills, preventing injuries and monitoring overall health. These devices are now applying to athletes in the training field or during the competitions as mobile versions and athletes are guided with concrete data. These systems, which provide data to experts in different brands and models, especially neurofeedback and biofeedback systems, have become very useful in understanding and guiding the needs of the athlete. Today, the methods and technologies used to improve athletic performance show great diversity. While in traditional methods there were physical training and competition preparations with experts, nowadays, with technological developments, both physical and mental preparations of athletes are provided with both measurements made with the help of devices and techniques used in training. Devices and psychometric tests are used to better understand, monitor and improve the physical and mental state of athletes.

1. INTRODUCTION

Today, the methods and technologies used to improve athletic performance show great diversity. While in traditional methods there were physical training and competition preparations with experts, nowadays, with technological developments, both physical and mental preparations of athletes are provided with both measurements made with the help of devices and techniques used in training. Devices and psychometric tests are used to better understand, monitor and improve the physical and mental state of athletes. As in every field, the effects of technological developments in sports have started to be recognized today. Especially thanks to technology, reaching the details of the factors affecting sports performance provides experts with a lot of data and changes are made that will affect the result.

It is useful to know psychology to understand and explain human behavior, the brain to understand psychology, and psychology to understand the brain. In this context, concepts such as "physiological psychology" and "behavioral neuroscience" come to the fore. Physiological psychology is the branch of science that examines the effects of many physiological conditions such as eating, drinking, sleeping and moving on psychology. Behavioral neuroscience, on the other hand, is the branch of science that examines the structures and processes of the nervous system such as neurons, neuronal circuits, systems and centers related to behavior by using the knowledge and methods of psychology and biology [1]. These disciplines have feedback methods that use several technologies to reach more valid and reliable data.

1.1. Wearable Technology

Wearable technology plays an important role in enhancing athletes' performance. These technologies collect various biometric data through devices that are worn or attached to athletes' bodies. This data can be used in many areas such as optimizing training, preventing injuries and

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monitoring overall health. These devices are now applied to athletes in the training field as mobile versions and athletes are guided with concrete data. These systems, which provide data to experts in different brands and models, especially neurofeedback and biofeedback systems, have become very useful in understanding and guiding the needs of the athlete.

Today, many technological devices are of the service of humanity. Smart watches, biosensors, EEG (eloktroencephalography) devices, smart phone applications and many other systems, which are called wearable, make our daily lives easier and offer us opportunities for a healthy life. Wearable technology is the general name of technological devices worn on the body. For a product to be called "wearable technology", it must transfer the data it receives from sensors to software programs in various ways. These devices can take many different forms, such as watches, glasses, wristbands or pieces of jewelry. Wearable devices are defined by six key characteristics: monopolization, non-restrictive, observable, controllable, attentive and communicative [2]. Wearable technology devices use a combination of position sensors (global positioning system (GPS), global navigation satellite system (GNSS), ultrawideband (UWB), and so on) and inertial sensors to track an athlete's movement pattern and speed. Many commercial products provide athlete speed and position parameters using the satellite-based positioning system. However, GPS has a low update rate (up to 10 Hz), and factors such as satellite signal attenuation, the number of satellites available, and their position also affect the accuracy of the positioning system. An inertial measurement unit (IMU) that comprises inertial sensors (accelerometer, gyroscope, and magnetometer) has a higher update rate (100 Hz), but the data from these sensors are noisy and often drift away [3].

Biofeedback is an operant conditioning procedure in which an individual learns to gain control over physiological functions such as muscle movements, breathing, heartbeat, skin tension and brain waves that they normally cannot control or are not conscious of. This method is the state of being able to make some changes in one's body by taking it under control. It increases the individual's bodily awareness and helps him/her to get rid of mental tension and relaxation. The person becomes aware of many bodily reactions that they could not notice before. Body parameters can be measured as well as changed. Neurofeedback utilizes the plasticity theory of the brain. It aims to make the brain change the electrical current of the brain by using classical conditioning and operant conditioning methods [4].

Picture 1. Inner balance, heart math device

Heart Rate Variability (HRV) biofeedback therapy, in the simplest terms, measures and regulates heart rhythm variability and rhythm. To explain in more detail; Heart Rhythm Rate: The normal resting heart rhythm rate is 60-100 beats/min. Most people are in the range of 40-60 beats/min in direct proportion to how fit they are. When there is moderate mental stress, there is an increase of 8-11 beats/min and then it is expected to return to baseline. The sympathetic nervous system (SNS) regulates the homeostatic mechanism. It is directly involved in the neuronal and hormonal stress responses that we know as the Fight and Flight mechanism, which requires an immediate response. The parasympathetic nervous system (PNS) is a system that does not require an immediate response, but a slower response.

2. Psychometric tests and technology

There are too many empirical tests to measure cognitive and psychological state. However, these tests are based on the participant's interpretation and the net result is always

determined by generalization. When we use these tests in combination with technology, their accuracy is even more satisfactory. For example, when we measure an athlete's stress state through both the stress inventory and HRV with the inner balance device, we get more valid data about the athlete's condition through concrete data.

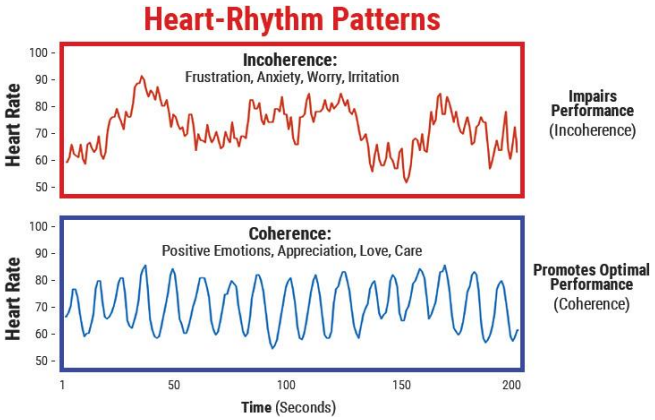

Figure 1. Inner balance, coherence and incoherence image by heart math device

In addition, this technology not only helps to measure, but also has a psychophysiological effect through breathing, attention, concentration or meditation exercises included in the application. Biofeedback systems in particular show us the quality of the exercises performed.

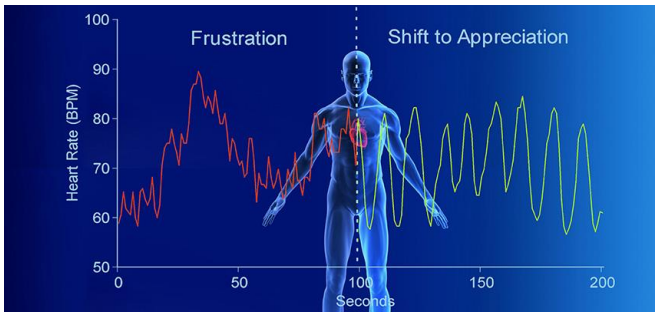

Figure 2. Coherence and incoherence image to explain stress and appreciation

For example, figures 1 and 2 show the effect of breathing exercise on the autonomic nervous system and its coherence state.

Picture 2. Imotive Epoc+ EEG Device

2.1. Hardware and Software of Wearable Technology in Sport

The second level headings should be written with wearable technology, at its core, is Internet of Things devices and consist of three layers as illustrated in figure 3: sensor, processing, and network. The first two layers, sensor, and processor, encompass all the operations that take place solely on the electronic hardware of the WT. Additionally, various external devices, computing methods, and communication protocols are incorporated into the network layer as part of wearable technology [5].

Recently wearable technology and software are much more usable, especially in the form of smart phone applications, and provide convenience in terms of application. Especially with the development of artificial intelligence, the use of devices is becoming more powerful and access to data is becoming easier.

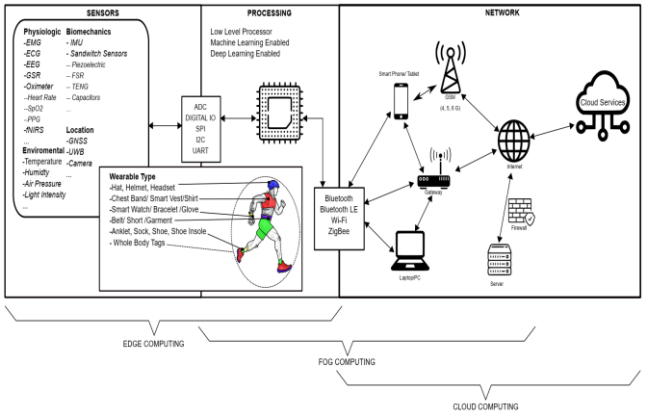

Figure 3. Layered Structure of Wearable Computing

Physiological data encompasses information derived from the biological processes occurring within the human body, serving as a valuable source of insights into an individual's health, performance, or overall condition. Prominent

among the sensors used for capturing physiological data are well-recognized devices such as Electromyography (EMG), Electrocardiography (ECG), and Electroencephalography (EEG). Furthermore, physiological data acquisition extends to include an array of sensors such as functional Near-Infrared Spectroscopy (fNIRS), Oximeter, Blood Pressure Sensors (BPS), Galvanic Skin Response (GSR), and respiratory monitoring sensors. In the context of sports and related fields, the term "biometric data" is at times used to describe the physiological data obtained from athletes [5].

Picture 3. Neurosky EEG Device

2.1.1. Why We Use Wearable Technology

We use wearable technology because the instantaneous data of athletes during training and competition provide us with the necessary data to bring performance to the desired point. Thanks to the psychophysiological and biological data obtained now of performance, we can make the adjustments the athlete needs more clearly and concretely.

Picture 4. Wearable Devices on Human Body

There are many areas where wearable technology is used. Migliaccio and his colleagues categorized the fields in the study they published in 2024 and listed them as follows.

1. Hearables: earphones, earbuds, headsets.
2. Smart clothing: smart shoes, bras, suits (jacket, trousers), shirts, pants, socks.
3. Smart jewelry: bracelets, necklaces, brooches, rings, analog watches, fitness jewelry.
4. Head-mounted displays: AR HDMs, VR HDMs, mixed HDMs.
5. Glasses: smart, AR.
6. Wearable cameras.
7. Body sensors.
8. Implantable.
9. Ingestible.
10. Tattooable.
11. Exoskeletons: active, passive.
12. Location trackers.
13. Gesture control.

2.2. Biofeedback and Neurofeedback

Neurofeedback is a kind of biofeedback, which teaches self-control of brain functions to subjects by measuring brain waves and providing a feedback signal. Neurofeedback usually provides audio and video feedback. Positive or negative feedback is produced for desirable or undesirable brain activities, respectively [6].

Biofeedback is a type of mind-body technique you use to control some of your body's functions, such as your heart rate, breathing patterns and muscle responses. During biofeedback, you're connected to electrical pads that help you get information about your body [7]. The following classified biofeedback applications can be performed by using wearable technology. Thus, it can be seen concretely how useful and effective biofeedback applications are.

Type of Biofeedback

Breathing. While breathing biofeedback, bands are placed around your stomach and chest. Sensors on the bands check your breathing rate and patterns. You can control your breathing and feel better.

Brain waves. During this type of biofeedback, an electroencephalograph (EEG) uses scalp pads to monitor your brain waves. There are certain brain waves that show different mental states, such as relaxation, wakefulness and sleep. With

biofeedback training, you can see a change in the brain waves that improve your health.

Heart rate. In this type of biofeedback, pads are placed on your chest, lower trunk or wrists. These pads are connected to an electrocardiogram (ECG) that measures your heart rate and how your heart rate changes. A sensor also can be placed on your finger to measure your heart rate. When you are relaxed, your heart rate may decrease.

Muscle activity. A machine called an electromyograph (EMG) uses sensors to measure muscle tightening. This helps make you aware of muscle tension so you can take steps to control it.

Sweat gland activity. Pads attached to the fingers, palm or wrist measure the activity of the sweat glands. The amount of perspiration on your skin warns you of nervousness.

Temperature. Pads attached to your fingers or feet measure blood flow to your skin. Because your temperature often drops when you're under stress, a low reading can prompt you to begin relaxation methods. As you become more relaxed, your fingers and toes may become warmer.

Wearable biometric sensors are pivotal in modern healthcare, offering continuous monitoring of physiological parameters and providing valuable insights into an individual's health status. These sensors are integrated into various wearable platforms, such as wristbands, patches, and textiles, and utilize different sensing mechanisms to capture biometric data. Tracking vital signs like heart rate, blood pressure, body temperature, and oxygen saturation levels, biometric sensors provide insights into cardiovascular health and overall physical condition [8]. The types of wearable biometric sensors can be categorized based on their sensing mechanisms and the biofluids they analyze [9].

Wearable devices provide real-time tracking of physiological signals, such as heart rate, ECG, and respiratory data, which are essential for analyzing athletic performance and optimizing training routines. Additionally, these devices measure sports indicators like speed, navigation, and workload, facilitating a scientific approach to training enhancement [9].

Picture 5. Neeuro 6 Channel EEG Device

5. CONCLUSION

International sports governing bodies, such as the International Federation of Association Football (FIFA) and the International Tennis Federation (ITF), have already allowed the use of these devices in international matches in 2018 [1] and 2019 [2], respectively. Besides providing an accurate measure of an athlete's movements, wearable technology can be useful in preventing athlete injury or reducing athlete fatigue through workload management [3]. Next up, many more organizations and sports institutions will be approved to use the technology.

Wearable technology has undeniably revolutionized sports science and athletic performance. Categorizing these devices into location-based, biometric, and performance wearables offers a clear framework for understanding their diverse applications and limitations [10].

Although wearable technology provides us with information and applications but again, those of us who will use these applications on a regular basis. That's the only way we can measure its impact and get the result we want. Wearable Through technology, our mental and physical awareness is increasing, but when and how the practices It is still in human hands to do it. This is why the discipline of the practitioner is important as well as its use [11]. With the speed of technological development, the development of applications that will affect sportive performance will change at the same speed. At this point, especially sports scientists need to keep up with this pace and follow developments closely.

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