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Sensorization of Things Intelligent Technology for Sport Science to Develop an Athlete's Physical Potential

Chanita Sattaburuth[1] & Panita Wannapiroon[2]

[1] Faculty of Sport Science and health, Thailand National Sports University, Udon Thani campus, Thailand

[2] Division of Information and Communication Technology for Education, The Faculty of Technical Education, King Mongkut's University of Technology North Bangkok (KMUTNB), Bangkok, Thailand

Correspondence: Chanita Sattaburuth, Faculty of Sport Science and health, Thailand National Sports University, Udon Thani campus, Thailand. E-mail: sattaburuth.c@gmail.com

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Abstract

Sports can build both strength and be fun at the same time. When it comes to a professional athlete's victory, the winner will enhance his reputation and can earn a great deal of money. The problem that athletes frequently encounter is traumas, which can happen in games or during training. Today, the technology is very advanced and modernized. Innovations and perceptual devices can be created to monitor, measure, analyze and evaluate data from the information received from the introduction of an intelligent system of evaluation and prediction in terms of safety and risk prevention with regard to athletes, by collecting heart rate data, blood oxygen measurement, air density around the athletes' body, body temperature and a temperature in the sports training room. This is the point of view and vision of a sports industry leaders, who perceive the opportunity and advantage associated with the competition and training of both amateur and professional athletes, to develop the athlete's physical potential to achieve international excellence. The study of intelligent sensor technology that is used to support devices that work on the guidelines of Internet of Things (IoT) leading to the development of real time data collecting applications. These are used to process or interpret physiological knowledge for an analysis of results and for the prediction of incoming results. It was found that using intelligent sensing technology which are two main groups of detection and measurement: First, human body function sensing and second, measurement to environment around the body or object, and explained to detail in this article.

Keywords: Sensorization of Things (SoT), sensor, Internet of Things, sport science, physiology

1. Introduction

Playing sports is a recreation that can build physical strength and be fun simultaneously. Sport also enhances the reputation and increases the income of athletes, as well as making enormous earnings for related businesses and industries as seen at the global level in countries such as the United States, Australia, Russia, Japan, Canada, Germany, and the United Kingdom (Maas et al., 2021). In Thailand, there are also entrepreneurs in the sports industry, producing sports products such as equipment, clothes, medical supplies, services, and managing competition locations, sports tourism, sports' associations, and organizations related to sports, etc. In sports, there are many movements and uses of muscle power that result in the risk of physical injury occurring during training or competitions. Injury severity does not only affect individual athletes, but also their teams and the results of games. Pain and wounds including acute, repeated minor or chronic injuries, directly affect athletes, causing some athletes to stop their sporting activity. These injuries may be found in a variety of sports, and may be due to physical movements using different muscles and organs. Using technology to prevent such injuries and analyze risks in sports, is a means of keeping athletes safe, and reducing the risk of injury from sports (Yuxia Wang, 2021). The use of IoT systems in the rehabilitation of sports injuries, suggests that incorporating physiological science knowledge with regard to sports, in conjunction with modern technology, could be innovative in terms of allowing us to build intelligent sensor devices to monitor, measure, analyze, evaluate and predict results from information such as heartrate, the amount of blood oxygen, air density around an athlete's body, body temperature, and temperature in a training room, etc. By using biochip technology involving a body chemical and molecular detecting sensor to detect abnormality that causes necrosis or simulates the muscles and skin of living bodies, and placing it in a robot we could create a sensor system that could create a human-like

sense. The development of intelligent sensor technology is an interesting development in terms of differentiating by using a sensor to detect physiological values in the context of the Internet of Things (IoT). This allow the development of an intelligent sensor system, which could be applied to humans and their environments. The development of human capital is important. Consequently, success in the treatment of sports injuries would allow the creation of a competitive advantage in the sports industry. Therefore, intelligent sensor technology is a technology that could make a difference, and be highly beneficial to the sports industry. A supporting tool for sensors and for measurement that is connected to aborderless network could make communication possible with data at anytime, and from anywhere. This could predict outcomes by measuring data, so it could prevent and reduce the risk of injury when playing sports.

2. Objectives of the Research

The study's purpose is:

1) to synthesize the Sensorization of Things intelligent technology for sports science. This can be used in physiology education to develop an athlete's physical potential to achieve international excellence.

2) to design the Sensorization of Things intelligent technology for sport science. This can be used in physiology education to develop an athlete's physical potential to achieve international excellence.

3) to evaluate acceptance the of the Sensorization of Things intelligent technology for sport science. This can be used in physiology education to develop an athlete's physical potential to achieve international excellence.

3. Literature Review

3.1 Sensorization of Things (SoT)

Intelligent sensor technology as defined by the researchers, Wu Lv and Jiujun Guo (2021) stated that this application involves a collaboration between Internet of the Things technology and an intellectual location sensor device, to allow remote monitoring and taking care of patient. The sensor device acts as a center on internet to collect health information for processing. The sensor node has two functions. One function was a real-time physiological signal from a body such as ECG, respiration, blood pressure and body temperature. The second function was to transmit signal data wirelessly to a nearby or remote terminal (Lv & Guo, 2021). Mariana Jacob Rodrigues et al. (2020) stated that the intelligent sensor technology refers to a smart sensor system that combined with an Internet of Things technology to help improve the quality of life. It does this by receiving environmental data and physiological information which is then submitted to a cloud for algorithm computing and data analysis. The smart sensor used could display data providing health status information by the use of a detecting unit embedded in a regular wearing gadget (Rodrigues et al., 2020)**.** According to Hernández et al. (2020) a modern sensor system as part of an e-Health program could be used for checking interpersonal skin touching, based on internal communication standards in the body. These sensors would detect and sent a message for analysis and tracking, based on the communication within the body through the skin. There are two parts to the detecting system. The first part involves skin touching detection, while the second part was an implementation of communicating environment based on the IEEE 802.15.6 standard, involving working with a program, system, and device (Hernández et al., 2020). Wannapiroon (2019) mentioned the use of a sensor as a detector for a personal behavioral context during learning and learning activities (Wannapiroon, 2019). In this context, the Sensorization of Things (SoT) technology refers to a paradigm technology linked to the concept of using an intelligent sensor device working together with systematic software, a network infrastructure, and a dynamic global internet network communicating protocols that could be customized according to international standards. This involves connecting objects to intelligent sensor devices, allowing the object's status to be detected and measured. The data are collected and stored for transmission to a central processing unit which automatically analyses and interprets the data, and which can command and control the devices from anywhere and at any time.

3.2 Sports Science in Physiology

According to López-Sánchez et al. (2020), physiology in the realm of sports science refers to differences in body composition, physical fitness, physical activities, and living and sports behaviors. Body composition measurements include body weight, mass fat index, body fluids, metabolic rate, body mass index, and free fat mass index. The independent variables for the measurement of physical fitness are jumping, height, electrical power, speed, running, distance, and the analysis of body composition (López-Sánchez et al., 2020). Petersen et al. (2020) described exercise as being beneficial for health, reducing risk of death from cardiovascular diseases, stroke, hypertension, cancer, diabetes, osteoporosis, and mental illness. Therefore, exercise can be promoted with

the use of activities provided by media applications that are convenient to access. Based on the theory of behavioral change that could predict exercise that could predict exercise use and motivate people to exercise over a long period of time (Petersen et al., 2020), the researchers, Hansen and Kennelly (2017) stated that the dangers of premature complicating exercises overly complicated exercises were the basic technical skills of physiology. An exercise focusing on physical movements that involved risk of injury, followed by treatment, was the shortest path to achieving excellence. A basic understanding of physiology with regard to physical properties including agility, stability, strength, power, speed, and endurance, is essential for injury prevention **(**Hansen & Kennelly, 2017). Button, C. and Croft, J. L. (2017) stated that a sudden cold water soaking after exercise led to a similar physiological response in swimmers with little skill novice swimmers. It was realized that swimming skills did not consider to the degree of risk in cold water. It is necessary to improve the ability to recognize important limitations on human behaviors. Consequently, in the future, the necessary constraint model will require a multidisciplinary research approach, and researchers from many disciplines such as muscle learning, muscle controlling and data analyses on biomechanics, physiology, psychology, and statistics must be involved. The ongoing results of such a program would be interdisciplinary in nature in the context of solving the problem of drownin (Button & Croft, 2017). Miller (2016) stated that an analysis of sports performance involved an understanding of the factors leading to success in playing. This will involve on measuring the physical factors leading to success in sports, such as height, biophysics, health, exercise, optimization, speed, power, strength, flexibility, agility. In addition, there is a need to consider factors with regard to psychological and intellectual aspects, such as intellect, personality, and attitude, all of which ensure that skilled athletes have knowledge, skills and performance when it comes to engaging in sports and in competitive games (Miller, 2016). The medical research of John M. Cissik and Michael Barnes (2011) found that physical examination was necessary to identify medical problems as a means of maintaining the health and safety of athletes. This can be used to assess a level of exercise needed, the provision of training advice, and the means of developing physical qualities such as stamina, power, agility, etc. In addition, athletes must have a level of flexibility, strength, maturity, skill and practice. For athletes who lack these requirements, they will not get full benefit from training. Physical properties such as strength and agility are essential for helping athletes excel in training. In the fields of Sports Science, such as physiology and biomechanics, proponents have to learn about muscles, which can be trained for developing an athlete's strength (Cissik & Barnes, 2011). Clive Brewer (2017) discussed Sports Science in terms of such aspects as exercise science, human movement, physicals, physical education, sports psychology services, by focusing on efficiency. Medicine and science cover biomechanics and physiology, including the topics related to physiology. Sports and activity specifications, together with sports nutrition, are required to prevent injury, and to provide treatment and rehabilitation. In the field of applied sports, Sports Science has become widely accepted. Sports performance does not relate only to physical attributes, but also to psychological factors (Brewer, 2017). In conclusion, the physiological aspects of Sports Science refer to disciplines that study the chemistry and physics of body structures and the positions of organs through a variety of complex and functional methods. There are patterns related to functions in living organisms. These involve the analysis of physical properties, nerve functions and the muscle regulations of movement, awareness of important limitations with regard to human behaviors to support human life in stable conditions, the reduction of the risks of illness, and the prevention of injury.

4. Method

4.1 A synthesis to the Sensorization of Things Intelligent Technology for Sport Science with Regard to Physiology Education As a Means of Developing an Athlete's Physical Potential to Achieve International Excellence

The study of documents and research related to technological support of the Sensorization of Things, the Sensorization of Things ecosystem, body composition and physiological functioning, physiological and environmental measurements with regard to the human body, analysis of the relationship between the Sensorization of Things intelligent technology and physiology, as published in the international research database system between 2022 and 2008, a total of 35 papers.

The study of documents and research related to the technological support of the Sensorization of Things, the Sensorization of Things ecosystem, body composition and physiological functioning, physiological and environmental measurements with regard to the human body, analysis of the relationship between the Sensorization of Things intelligent technology and physiology, which use instruments of research in the form of content analysis and data analysis using content analysis techniques.

4.2 A design of Sensorization of Things Intelligent Technology for Sport Science with Regard to Physiology Education As a Means of Developing an Athlete's Physical Potential to Achieve International Excellence

The result of synthesis process brings to design the Sensorization of Things intelligent technology for sport science in education of physiology to develop athlete's physical potential to international excellence consist of Technology support to Sensorization of Things, Sensorization of Things Ecosystem, Body composition and Physiological function, Physiological and Environmental measurements around human body, Analysis to relation Sensorization of Things intelligent technology.

4.3 The evaluation of Sensorization of Things Intelligent Technology for Sport Science with Regard to Physiology Education as a Means of Developing an Athlete's Physical Potential to Achieve International Excellence

The Sensorization of Things intelligent technology for sport science in physiology education to develop an athlete's physical potential to achieve international excellence, is evaluated by a group of 10 experts. These individuals each have more that 5 years' experience in related fields in the areas of Sensorization of Things (SoT), Sensors, Internet of Things, Sport Science, Physiology.

Rectification of the Sensorization of Things intelligent technology for sport science with regard to physiology education as a means of developing an athlete's physical potential to achieve international excellence, is based on the suggestion of experts. The research instrument consists of an evaluation form to assess the value of the Sensorization of Things intelligent technology for sport science with regard to physiology education as a means of developing an athlete's physical potential to achieve international excellence. The mathematical statistics used in the analysis consist of arithmetic mean and standard deviation.

5. Results and Discussion

The results of research are presented in 3 parts according to the objectives of the research. These are as follows:

5.1 The Results of Synthesis to Sensorization of Things Intelligent Technology for Sport Science in Education of Physiology to Develop Athlete's Physical Potential to International Excellence

5.1.1 The Results of the Synthesis of Technological Support for the Sensorization of Things

According to the research paper of Wu Lv and Jiujun Guo (2021), the synthesis of the technological support with regard to the Sensorization of Things involves intelligent sensor technology such as working on the body i.e., touch, movement; signals i.e., heat, electricity; measurement i.e., motion, temperature, heat, vibration, noise, moisture, density, volume, weight, pressure, acceleration, direction, speed, distance; and function i.e., wearables, smart home, smart city (Lv & Guo, 2021). Mariana Jacob Rodrigues et al. (2020) stated that intelligent sensor technology includes the following: working on the body i.e., eye, sound, movement, brain, signals i.e., thermal, electricity; and measurement i.e., motion, light, vibration, noise, air, moisture, density, pressure, acceleration, speed, distance (Rodrigues et al., 2020). Saif Allah H. AlMetwally et al. (2020) states that intelligent sensor technology involves the following: working on the body i.e., eye, sound, touch; signals i.e., chemical, electricity; measurement i.e., light, temperature, heat, air, volume, weight; and function i.e., smart home, smart city, smart factory (Almetwally et al., 2020). Zhong and Li (2020) state that intelligent sensor technology is as follows: Working on the body i.e., movement, brain; signals i.e., mechanical, thermal, electricity; measurement i.e., motion, temperature, heat, electrocardiogram, frequency, volume, weight, pressure, acceleration, speed, direction, GPS, distance, ratio; and function i.e., wearables, smart home, smart city (Zhong & Li, 2020). Xhafa et al. (2017) identify intelligent sensor technology as follows: working on the body i.e., touch, movement, brain; signals i.e., mechanical, magnetic, thermal, electricity; measurement i.e., motion, light, touch sensor, temperature, heat, vibration, noise, air, moisture, electrocardiogram, frequency, density, volume, weight, pressure, acceleration, speed, direction, GPS, height, distance, radiation, wind; and function i.e., wearables, smart home, smart city, smart factory (Xhafa et al., 2017). Meijer identifies intelligent sensor technology as follows: working on the body i.e., eye, sound, touch, movement, brain; signals i.e., radiant, mechanical, magnetic, chemical, thermal, electricity; measurement i.e., motion, light, touch sensor, temperature, heat, vibration, noise, air, moisture, electrocardiogram, frequency, density, volume, weight, pressure, acceleration, speed, direction, GPS, height, distance, radiation, ratio; and function i.e., smart home, smart city, smart factory (Meijer, 2008).

5.1.2 The Results of the Synthesis of the Sensorization of Things Ecosystem

According to Wu Lv and Jiujun Guo (2021) the Sensorization of Things ecosystem is an intelligent sensor technology ecosystem made up of the following: sensor devices i.e., fixed, mobile, wearable, sensor node, smart intelligent; objects i.e., human, material; technology i.e., internet, IoT, sensor, real time, software; networks and connections i.e., wireless, communication, analog/digital; data and attributes i.e., medical health information,

physiology, ECG, respiration, blood pressure, temperature, movement, light; and functions i.e., collect data, inspection, location, receive and send data, processing, compile and analyze data (Lv & Guo, 2021). Mariana Jacob Rodrigues et al. (2020) describes an intelligent sensor technology ecosystem as follows: sensor device i.e., fixed, wearable, mobile, sensor node, smart intelligent; object i.e., organizer, institute, material; technology i.e., internet, IoT, sensor, real time, software; networks and connections i.e., wireless, RFID, communication, analog/digital; data and attributes i.e., medical health information, ECG, respiration, blood pressure, temperature, movement, light; and functions i.e.,remote tracking, collect data, inspection, location, control, decisions, receive and send data, processing, compile and analyze data (Rodrigues et al., 2020). Caitlin D. Cottrill et al. (2020) state that intelligent sensor technology involves the following: sensor device i.e., fixed, wearable, mobile, sensor node, smart intelligent; object i.e., personal, organizer, material; technology i.e., internet, sensor, IoT, real-time, software; network and connections i.e., wireless, wire, analog/digital, data and attributes i.e., medical health information, physiology, ligh; and functions i.e., remote tracking, collecting data (Cottrill et al., 2020). Saif Allah H. AlMetwally et al. (2020) indicate that an intelligent sensor technology ecosystem is as follows: sensor devices i.e., fixed, wearable, mobile, sensor node, smart intelligent; objects i.e., human; technology i.e., internet, sensor, IoT, software; networks and connections i.e., wireless, communication; Data and attributes i.e., medical health information, physiology, temperature, light, and functions i.e., collect data, control, decisions, receive and send data, processing, compile and analyze data (Almetwally et al., 2020). Jiang (2020) believes that an intelligent sensor technology ecosystem is as follows: sensor device i.e., fixed, wearable, mobile, sensor node, smart intelligent; object i.e., human; technology i.e., internet, sensor, IoT, real-time, software; networks and connections i.e., wireless, wire, communication; data and attributes i.e., medical health information; and functions i.e., collect data, receive and send data, processing, compile and analyze data (Jiang, 2020). Zhong and Li (2020) describe an intelligent sensor technology ecosystem as follows: sensor device i.e., fixed, wearable, mobile, sensor node, smart intelligent; object i.e., material; technology i.e., internet, sensor, IoT; networks and connections i.e., wireless, wire, communication; data and attributes i.e., medical health information, physiology, ECG, respiration, blood pressure, temperature, movement; and functions i.e., collect data, inspection, location, receive and send data, processing, compile and analyze data (Zhong & Li, 2020). Qiet et al. (2018) describe an intelligent sensor technology ecosystem as follows: sensor device i.e., wearable; object i.e., material; technology i.e., IoT; networks and connections i.e., RFID, communication (Qi et al., 2018). Xhafa et al. (2017) state that an intelligent sensor technology ecosystem is as follows: sensor device i.e., fixed, wearable, mobile, sensor node, smart intelligent; object i.e., human, organizer, institute; technology i.e., internet, sensor, IoT, real-time, software; networks and connections i.e., wireless, RFID, analog/digital; data and attributes i.e., medical health information, physiology, ECG, respiration, blood pressure, temperature, movement, posture, light, humidity; and functions i.e., remote tracking, collect data, inspection, location, administrative, control, decisions, receive and send data, processing, compile and analyze data (Xhafa et al., 2017).

5.1.3 The Results of the Synthesis with Regard to Body Composition and Physiological Function

In terms of the synthesis of body composition and physiological function, Ji and Piovesan (2020) stated that the field of biomedicine deals with body composition and physiological function as follows: organs i.e., external organs (arm, leg, elbow, knee, hand, foot, head, face, neck, body, skin), internal organs (ligaments, joints, bones, backbone, muscle, tissue); and organ and body functions i.e., behavior (sitting, standing) (Ji & Piovesan, 2020). Zhao and Li (2020) describe body composition and physiological functions as follows: organs i.e., external organs (arm, leg, elbow, knee, hand, foot, body), internal organs (heart, ligaments, joints, bones, backbone); organ and body functions i.e., circulatory system (i.e., heartbeat, heart rate, pulse measurement), and behavior (walking) (Zhao & Li, 2020). Yifei Wang et al. (2020) describes body composition and physiological functions as follows: organs i.e., external organs (arm, leg, elbow, knee, hand, foot, eye, nose, mouth, ear, body, skin), internal organs (heart, brain, stomach, bones, backbone, muscle, tissue); organ and body functions i.e., respiratory system (breathing), circulatory system (heartbeat, heart rate, pulse), behavior (walking, sleeping) (Wang et al., 2020). Ren et al. (2020) state that body composition and physiological function is as follows: organs i.e., external organs (arm, leg, elbow, knee, head, face, neck, body), internal organs (heart, brain, stomach, bones, backbone, muscle, tissue); organ and body functions i.e., respiratory system (breathing), circulatory system (heartbeat, heart rate, pulse), behavior (walking, running) (Ren et al., 2020). Uddin et al. (2020) state that body composition and physiological function are as follows: organs i.e., external organs (i.e., arm, leg, elbow, knee, body), internal organs (i.e., heart); organ and body functions i.e., respiratory system (breathing), nerves, behavior (i.e., walking, sitting, standing, running, sleeping, jumping, dance, climbing and cycling) (Uddin et al., 2020). Heydari et al. (2020) suggest that body composition and physiological function are as follows: organs i.e., external organs (i.e., arm, leg, elbow, knee, head, face, nose, mouth, ear, body), internal organs (i.e., heart); organ and body functions i.e., respiratory system (breathing), circulatory system (heartbeat, heart rate, pulse), behavior

(sitting, standing, climbing, cycling) (Heydari et al., 2020). Lin et al. (2020) state that body composition and physiological function are as follows: organs i.e., external organs (i.e., arm, leg, elbow, knee, hand, foot, head, face, neck, eye, nose, mouth, ear, body, skin), internal organs (i.e., heart, brain, muscle, tissue); organ and body functions i.e., respiratory system (i.e., breathing), circulatory system (i.e., heartbeat, heart rate, pulse measurement), nerve, behavior (i.e., walking, sitting, standing, sleeping) (Lin et al., 2020).

5.1.4 The Results of the Synthesis of Physiological and Environmental Measurements with Regard to the Human Body

In terms of the synthesis of physiological and environmental measurements with regard to the human body, according to Mancuso et al., the composition of measurements in the physiological and environment with regard to the human body is as follows: physiology or biosensors i.e., body temperature, pressure of blood, hart rate, breathing, body fluid, sweating, oxygens, gas, weight, movement angle, fat index, skin conductance, accelerometers, physical activity, brain activity; and environment i.e., temperature environment, air flow, density, lighting (Mancuso et al., 2022). Wei Wang et al. (2021) say that measurement in the physiological and environment with regard to the human body is as follows: physiology or biosensors i.e., body and skin temperature, heart frequency, body fluid, sweating, oxygens, glucose, gas, weight, BMI, skin conductance, accelerometers, physical activity, brain activity; and environment i.e., temperature environment, air flow, density, lighting, humidity (Wang et al., 2021). Qian Shao (2021) says that measurement in the physiological and environment with regard to the human body is as follows: physiology or biosensors i.e., body and skin temperature, blood flow, pulse rate, breath, oxygens, hydrogen, height, weight, movement angle, fat index, accelerometers, physical activity and environment i.e., temperature environment, density, lighting (Shao, 2021). Mariana Jacob Rodrigues et al. (2020) say that measurement in the physiological and environment with regard to the human body is as follows: physiology or biosensors i.e., skin temperature, pressure of blood, pulse rate, breathing, body fluid, sweating, hydrogen, gas, height, weight, movement angle, fat index, skin conductance, accelerometers, physical activity, bone mass; and environment i.e., temperature environment, air flow, density, lighting, humidity (Rodrigues et al., 2020). Toan Dinh et al. (2020) say that measurement in the physiological and environment with regard to the human body is as follows: physiology or biosensors i.e., body temperature, pressure of blood, heartbeat, breath, body fluid, sweating, oxygens, glucose, weight, movement angle, skin conductance, accelerometers, physical activity; and environment i.e., temperature environment, air flow, density, lighting, humidity (Dinh et al.,2020*)*. X. Anitha Mary et al. (2020) say that measurement in the physiological and environment with regard to the human body is as follows: physiology or biosensors i.e., body temperature, pressure and blood flow, heart rate, breathing, hydrogen, glucose, movement angle, accelerometers, physical activity; and environment i.e., temperature environment (Mary et al., 2020). Yaoet et al. (2020) say that measurement in the physiological and environment with regard to the human body is as follows: physiology or biosensors i.e., body temperature, pressure of blood, heart rate, heartbeat, breathing, glucose, gas, weight, movement angle, skin conductance, accelerometers, physical activity, brain activity, bone mass; and environment i.e., air density, lighting, humidity (Yao et al., 2020).

5.1.5 The Results of Analysis to Relation Sensorization of Things Intelligent Technology with Physiology Form 5.1.1., 5.1.2, 5.1.3 and 5.1.4 as Shown in Table 1

Table 1. An analysis of the relationship between the Sensorization of Things intelligent technology and physiology

Sensorization of Things Technology																																	
SoT Support		SoT Ecosystem																															
Group	Subject	Device				Object			Technology						Network				Data								Functional						
		Mobile, Fixed	Wearables	Node	Smart Intelligent	Human, Personal	Organize, Company	Material, Building Fabric	Internet	IoT	Sensor	Sensor + IoT	Real time	Application, Software	Wireless	RFID	Communication,	Analog Digital	Physiology sport health	Electrocardiogram	Breathing	Blood pressure	Temperature	Movement, Motion	Light	Moisture	Remote, Tracking	Collected	Checking verification	Localization, GPS	Body control	Send Receive Store	Processing Translate
Physiological	Eye				✓	✓				✓	✓	✓	✓	✓			✓		✓					✓	✓		✓	✓	✓		✓	✓	✓
	Sound	✓	✓		✓	✓				✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓			✓		✓	✓	✓		✓	✓	✓
	Touch	✓	✓		✓	✓				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
	Movement	✓	✓		✓	✓				✓	✓	✓	✓	✓	✓		✓	✓	✓					✓	✓		✓	✓	✓	✓	✓	✓	✓
	Brain				✓	✓				✓			✓	✓			✓	✓	✓				✓					✓	✓		✓	✓	✓
Signal	Thermal, Heat	✓	✓		✓	✓		✓		✓	✓	✓	✓						✓				✓			✓	✓	✓	✓		✓	✓	✓
	Electrical	✓	✓	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓		✓		✓	✓	✓	✓	✓	✓	✓
Measurement	Movement	✓	✓		✓	✓				✓	✓	✓	✓	✓	✓				✓		✓			✓			✓	✓	✓	✓	✓	✓	✓
	Light	✓	✓		✓			✓		✓	✓	✓	✓	✓	✓			✓						✓	✓					✓	✓	✓	✓
	Temperature	✓	✓		✓	✓		✓		✓	✓	✓	✓	✓	✓				✓				✓				✓	✓	✓		✓	✓	✓
	Vibration	✓	✓		✓	✓		✓		✓	✓	✓	✓	✓	✓				✓					✓							✓	✓	
	Air		✓		✓			✓		✓	✓	✓	✓	✓	✓						✓		✓					✓	✓			✓	
	Moisture		✓		✓			✓		✓	✓	✓	✓	✓	✓												✓					✓	
	Electrocardiogram	✓	✓		✓	✓				✓	✓	✓	✓	✓	✓			✓		✓							✓					✓	✓
	Density		✓		✓			✓		✓	✓	✓	✓	✓	✓						✓		✓		✓			✓	✓	✓		✓	✓
	Volume/Weight				✓	✓				✓	✓	✓	✓	✓	✓				✓									✓	✓			✓	
	Pressure		✓		✓	✓		✓		✓	✓	✓	✓	✓	✓				✓	✓												✓	✓
	Accelerometers,Speed		✓		✓	✓				✓	✓	✓	✓	✓	✓				✓	✓	✓			✓				✓	✓	✓	✓	✓	✓
	Distance	✓	✓		✓			✓		✓	✓	✓	✓	✓	✓				✓								✓	✓	✓	✓		✓	✓
Function	Wearables		✓		✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
	Smart Home	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓					✓	✓	✓		✓	✓	✓	✓		✓	✓
	Smart City	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓					✓	✓	✓		✓	✓	✓	✓		✓	✓

Sport Science & Physiology																																										
		Sport Science Mesurement																	Physiology																							
		Physiological													Environment				Organ															Organ Functional								
												Activity							External						Internal												a series of actions					
Group	Subject	Body & Skin Temperature	Pressure	Heart rate, Pulse	Breathing	Sweating Body fluid	Oxygen, Glucose	Weight	Movement, Motion	Fat Index	Skin conductance	Muscle,Tissue,Physical	Brain	Bone mineral	Temperature	Air flow Density	Ambient, Lighting	Humidity	arm leg elbow knee	hand foot	head face neck	eye nose mouth ear	body	skin, surface	Heart	Lung	Brain	Liver pancreas kidney	Stomach	Ligament Joints	Bones backbone	Muscle, Body tissue	Nerve	Respiratory, Breathing	Circulatory system	Digestive, eating	Walking	Sitting	Running Jogging	Sleep, Lying	jump dance	Climbing Cycling
Physiological	Eye								✓			✓					✓					✓										✓										
	Sound			✓	✓																	✓			✓									✓	✓							
	Touch	✓				✓			✓		✓	✓						✓		✓				✓									✓					✓		✓		
	Movement	✓		✓					✓					✓					✓	✓			✓							✓	✓	✓		✓			✓		✓		✓	✓
	Brain												✓																				✓									
Signal	Thermal, Heat					✓					✓	✓			✓			✓					✓	✓								✓										
	Electrical	✓	✓	✓	✓	✓			✓				✓												✓							✓	✓					✓	✓	✓		
Measurement	Movement	✓		✓					✓			✓		✓					✓		✓	✓	✓									✓					✓		✓		✓	
	Light																✓																									
	Temperature	✓									✓		✓		✓			✓					✓	✓				✓	✓	✓		✓								✓		
	Vibration	✓		✓	✓						✓																														✓	
	Air				✓			✓								✓																		✓								
	Moisture					✓										✓		✓																								
	Electrocardiogram			✓	✓							✓	✓												✓								✓		✓							
	Density					✓	✓					✓				✓																			✓							
	Volume/Weight	✓	✓			✓	✓	✓		✓		✓				✓		✓					✓																			
	Pressure		✓	✓		✓										✓									✓										✓							
	Accelerometers,Speed	✓	✓	✓	✓	✓			✓																✓										✓							
	Distance																																				✓		✓			✓
Function	Wearables	✓	✓	✓		✓	✓		✓		✓								✓	✓	✓		✓	✓											✓		✓	✓	✓	✓	✓	✓
	Smart Home														✓	✓	✓	✓																								
	Smart City														✓	✓	✓	✓																								

From Table 1, it can be seen that the Sensorization of Things intelligent technology and physiology are related when used to measure various values in Sports Science when it comes to measuring both internal and external aspects of bodies. Including the environment around the body most of the body. Heart rate, breathing rate and posture (walking, running, jumping), device muscles, work with the use of heat and electricity signals. Most of the measurement characteristics are movement, light, air temperature, humidity, electric wave, volume, weight, pressure, speed, distance, most of which are measurable with the use of wearable devices. Smart homes and smart cities are used to measure the environment around the body.

5.2 The Results of the Design to Sensorization of Things Intelligent Technology for Sport Science in Physiology Education to Develop an Athlete's Physical Potential to Achieve International Excellence

5.2.1 The Result of Design Technology Support with Regard to the Sensorization of Things

We Can See The Technologies That Are Used To Support The Sensorization Of Things As Shown In Figure 1.

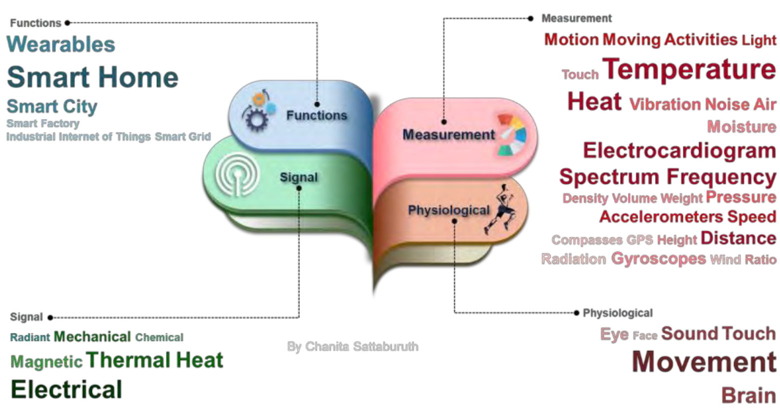

Figure 1. Technology support to Sensorization of Things

It is found that the technology support with regard to the Sensorization of Things is comprised of 4 groups:

1. Measurement to detect physiological functions in the case of theeye, the face, sound, touch, movement, the brain.
2. Signal to detection technology with regard to radiant, mechanical, magnetic, chemical, thermal, electricity.
3. Measurement and detection devices with regard to motion, light, temperature, vibration, noise, air, pollution, moisture, electrocardiograms, frequency, density, volume, weight, pressure, accelerometers, speed, distance.
4. Devices that are wearable, and found in smart homes and smart cities.

5.2.2 The Result of the Design of a Sensorization of Things Ecosystem

We can see the Sensorization of Things ecosystem as shown in Figure 2.

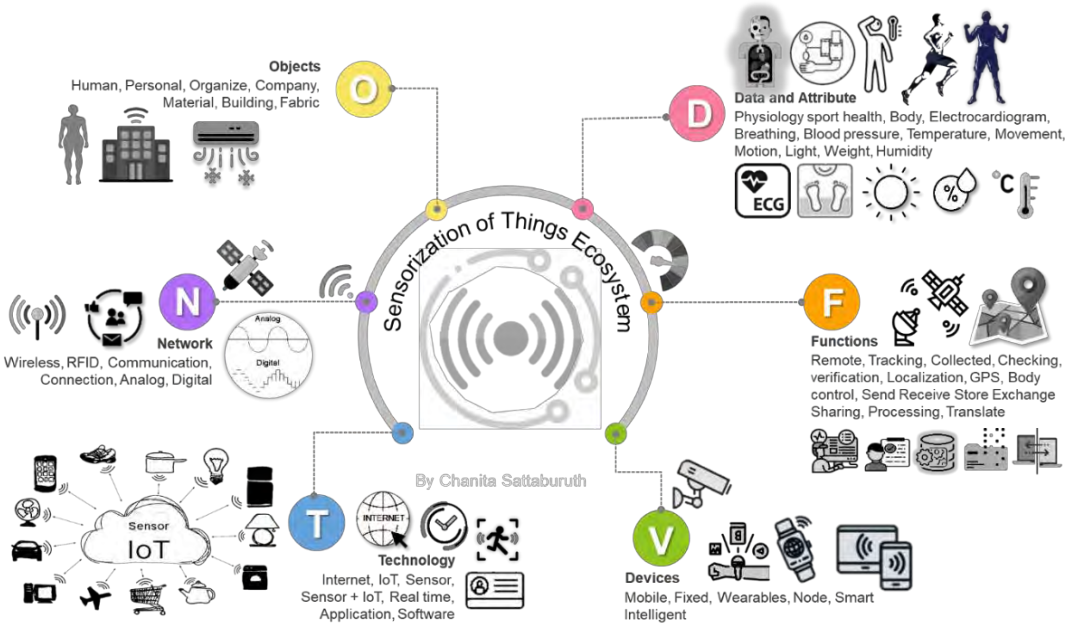

Figure 2. Sensorization of Things ecosystem.

It is found that the Sensorization of Things ecosystem is comprised of 6 groups:

1. Devices that are fixed, wearable, mobile, sensor node, smart intelligent.
2. The object is human, personal, organizer, institute, material.
3. Technology involves the use of the internet, sensors, IoT, real-time applications, applications/software.
4. Network involves the use of communication, wireless (e.g., wifi, bluetooth), signals (i.e., analog, digital)
5. Data consists of medical health information, physiological information, ECG, respiration, blood pressure, temperature, movement, posture, light, humidity.
6. Functional involves the collection of data, inspection, location, administration, control, decisions, receiving and sending data, processing, compiling and analyzing data.

5.2.3 The Results of the Design Body Composition and the Physiological Function

We can see the body composition and physiological function as shown in Figure 3.

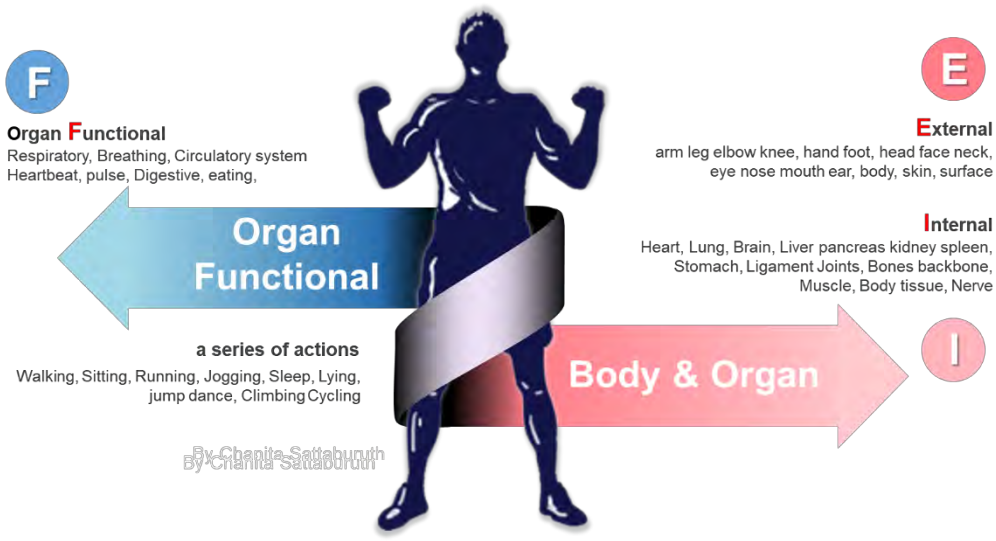

Figure 3. Body and function of physiological organs

It is found that physiological has the body and function of the major organs with regard to the human body is comprised of 2 parts:

Part 1 Organ i.e., External organ (i.e., arm, leg, elbow, knee, hand, foot, head, face, neck, body, skin), Internal organ (i.e., heart, muscle, tissue).

Part 2 Organ and body functions i.e., Respiratory system (i.e., Breathing), Circulatory system (i.e., Heartbeat, heart rate, pulse measurement), behavior (i.e., walking, sitting, standing, running).

5.2.4 The Result of Design Physiological and Environmental Measurements around Human Body

We can see physiological and environmental measurements as shown in Figure 4.

It is found that physiological and environmental measurements with regard to the human body is comprised of 2 parts:

Part 1 Physiology or biosensors i.e., body and skin temperature, pressure of blood or blood flow, heart rate, breathing/breath, body fluid or sweating, blood chemistry (i.e., oxygen, hydrogen, glucose, gas), weight, movement angle, fat index, skin conductance, accelerometers, physical activity, brain activity.

Part 2 Environment i.e., temperature of the environment, air flow, density, lighting, humidity.

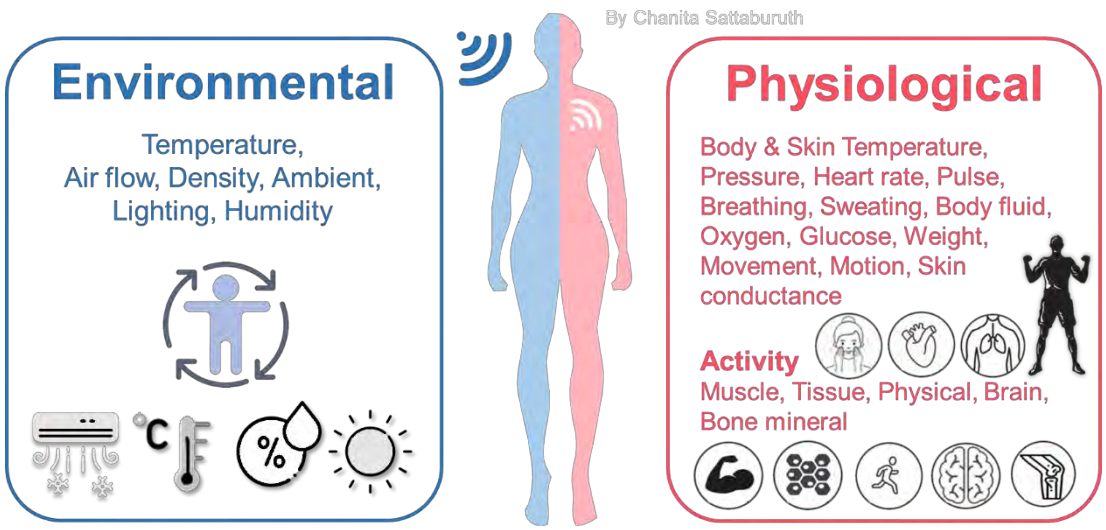

Figure 4. Physiological and environmental measurements

The results of the information synthesis relating to an analytical design in the intelligent sensor technology for Sports Science, indicated that in sports activities, both during competition, in practicing, or in playing for recreation purposes, there were four main groups of supporting technologies i.e. 1) technology for detecting human body functions, 2) signal wave technology using a sensor device, 3) measuring technology acting as a detecting device, and 4) functions and characteristics of the detectors. There is an ecological intelligent sensor technological system that consisted of devices, objects, technology, networking, information, and functions or modules. The physiological aspect of the human body in terms of intelligent sensor technology, could be categorized into two main groups: organs both outside and inside the body, and the functions of these organs. Using intelligent sensor technology, the sensors were able to detect perceptions and measure values as a means of providing physiological data and environmental values surrounding the body. These were the input factors that could be interpreted, processed, analyzed, and used for predicting results in advance, and for use for further controlling and directing as shown in Figure 5.

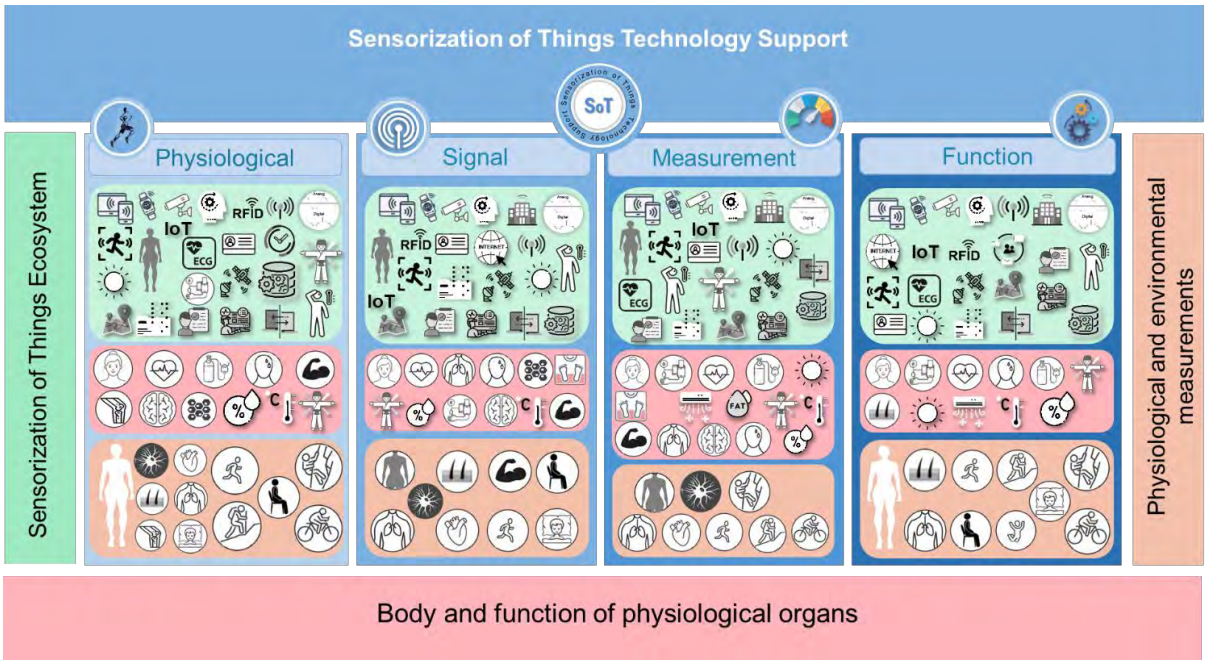

Figure 5. An analytical Sensorization of Things intelligent technology for Sports Science

In terms of intelligent sensor technology for Sports Science, in the study of physiology for developing an athletes' physical potential to achieve international excellence, it was important to collect data related to sensing perceptions, and various value measurements as shown in Figure 6. This indicates that certain technological components can be used to support the ecological intelligent sensor technology system. The data obtained from detection and measurement is displayed in a highlighted circular border image. This shows data measured in the environment including room temperature, air, humidity, etc., and displays information obtained from detecting features of the body, such as body temperature, water content, movement, blood pressure, heart rate, respiratory system, etc. that were important factors when it comes to detecting and measuring aspects which can be used to improve an athlete's performance.

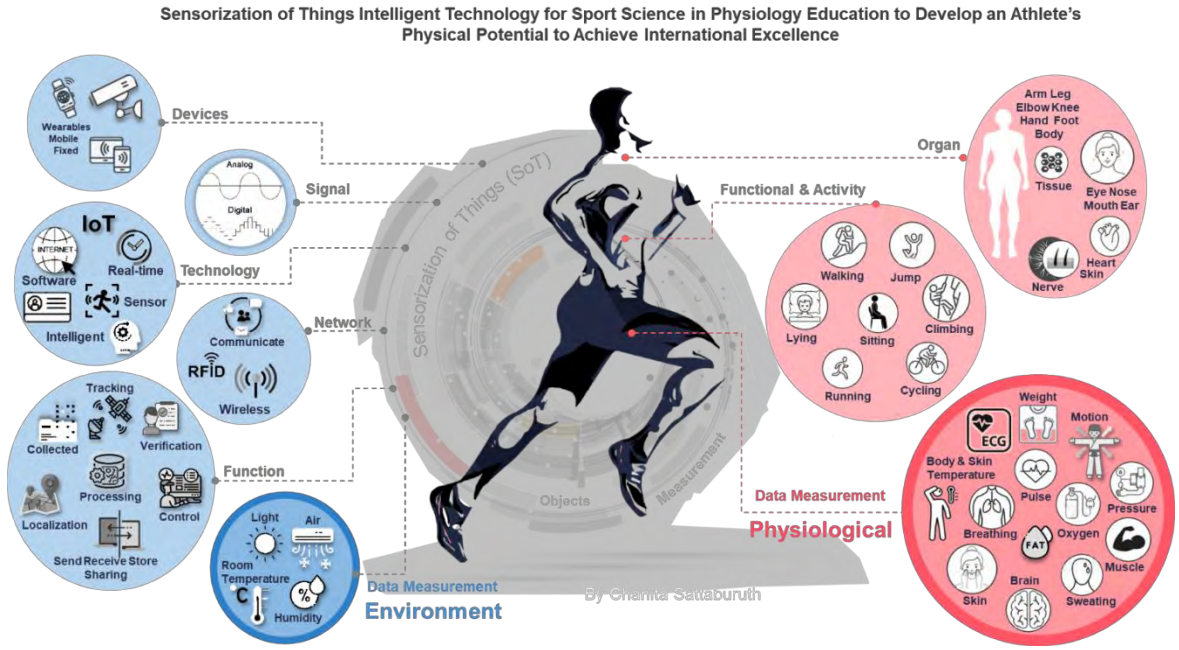

Figure 6. The Sensorization of Things intelligent technology for sport science in physiology education to develop an athlete's physical potential to achieve international excellence

5.3 The Result of Evaluating the Sensorization of Things Intelligent Technology for Sport Science in Physiology Education to Develop an Athlete's Physical Potential to Achieve International Excellence

A qualified person assessed the suitability, and certified the intelligent sensor technology for use in Sports Science, specifically in the study of physiology, to develop the physical potential of athletes to achieve international excellence. From Table2, the results of the evaluation are displayed as an arithmetic mean of 4.78and a standard deviation of 0.44. These indicated that the intelligent sensor technology for Sports Science, in the physiological aspect of the study aimed at developing an athlete's physical potential to achieve international excellence, had a highestlevel of suitability, and could be used for information collection in the form of detecting, sensoring and measuring values that could be used to develop the physical potential of athletes to achieve international excellence.

Table 2. The result of evaluating the Sensorization of Things intelligent technology for sport science in physiology education to develop an athlete's physical potential to achieve international excellence

	Rate of appropriateness	
Content	Arithmatic Mean	Standard Deviation
1. Technology support to Sensorization of Things		
1.1 Measurement	4.50	1.27
1.2 Signal	4.70	0.48
1.3 Measurement and detection	4.70	0.48
1.4 Devices	4.80	0.42
2. Sensorization of Things ecosystem		
2.1 Devices	4.90	0.32
2.2 Object	5.00	0.00
2.3 Technology	4.90	0.32
2,4 Network	4.80	0.42
2.5 Data	4.50	0.53
2.6 Functional	4.80	0.42
3. Body and function of physiological organs		
Part 1 Organi.e., External organ, Internal organ	4.80	0.42
Part 2 Organ and body functions	4.90	0.32
4. Physiological and environmental measurements		
Part 1 Physiology or biosensors	4.90	0.32
Part 2 Environment	4.80	0.42
5. Form Figure 6:		
5.1 The suitability of the elements in Figure 6.	4.80	0.42
5.2Asuitable sensing and measurement for sports science.	4.80	0.42
Total	4.78	0.44

Note. Arithmatic Mean>= 4.51 is equal to highest level.

6. Conclusion

The application of intelligent sensor technology to improve athletic performance and increases the potential of athletes, from a physiological perspective in the field of Sports Science, required the main system of devices for detection, sensoring, and measuring, the creation of software and an intelligent program, wireless networking, the development of a real-time database management system. Such detection, sensoring, and measuring was done by using wearable, portable, or fixed measuring devices, the latter to be placed in the competition field or training rooms.

Intelligent sensor technology involved the linking of devices to athletes while practicing or competing, using a wireless network connection. The device would send real-time information from personal measurements and the surrounding areas to the database for processing and interpreting, the concise evaluated results can then be immediately used for prediction or anticipation of events or incidents happening to the athlete, and can be used to anticipate precisely what would happen in the future using the latest up-to-date and current information.

Therefore, the use of an intelligent sensor technology system could lead to innovation in the sports industry. The system could be used to measure body and organ performance, including movement, and posture. In addition, it could measure the environmental status of the body in terms of temperature, heat, humidity and air density. This could be analyzed and processed, and used for predicting outcomes. It might also make it possible to prevent and reduce risks of injury on the art of the athletes, and could be used for the rehabilitation of athletes injured during training or competition. In addition, the results could also contribute to the development of athletic performance and an increase in potential.

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References

Almetwally, S. A. H., Hassan, M. K., & Mourad, M. H. (2020). Real Time Internet of Things (IoT) Based Water

Quality Management System. *Procedia CIRP, 91*, 478-485. https://doi.org/10.1016/j.procir.2020.03.107

Brewer, C. (2017). *Athletic Movement Skills : Training for Sports Performance*. United Kingdom: Coaching & Performance Development Ltd., Human Kinetics Publishing. https://doi.org/10.5040/9781492595250

Button, C., & Croft, J. L. (2017). Sports science needs more interdisciplinary, constraints-led research programmes: The case of water safety in New Zealand. *Human Movement Science Journal, 56*(3), 157-159. https://doi.org/10.1016/j.humov.2017.04.017

Cissik, J. M., & Barnes, M. (2011). *Sport Speed and Agility Training* (2nd ed.). CA, United States: Coaches Choice Publishing.

Cottrill, C. D., Jacobs, N., Markovic, M., & Edwards, P. (2020). Sensing the City : Designing for Privacy and Trust in the Internet of Things. *Sustainable Cities and Society, 63*(2020), 102453. https://doi.org/10.1016/j.scs.2020.102453

Dinh, T., Nguyen, T., Phan, H., Nguyen, N., Viet, D., & Bell, J. (2020). Biosensors and Bioelectronics Stretchable respiration sensors : Advanced designs and multifunctional platforms for wearable physiological monitoring. *Biosensors and Bioelectronics Journal, 166*, 112460. https://doi.org/10.1016/j.bios.2020.112460

Hansen, D., & Kennelly, S. (2017). *Plyometric Anatomy*. United Kingdom: Coaching & Performance Development Ltd., Human Kinetics Publishing.

Hernández, D., Rafael Ors, J. V. C., Bonastre, A., & Campelo, J. C. (2020). New Contact Sensorization Smart System for IoT e-Health Applications Based on IBC. *Sensors (Switzerland), 20*(20), 1-18. https://doi.org/10.3390/s20247097

Heydari, F., Ebrahim, M. P., Redoute, J. M., Joe, K., Walker, K., & Rasit Yuce, M. (2020). A chest-based continuous cuffless blood pressure method: Estimation and evaluation using multiple body sensors. *Information Fusion, 54*(July 2019), 119-127. https://doi.org/10.1016/j.inffus.2019.07.001

Ji, X., & Piovesan, D. (2020). Validation of inertial-magnetic wearable sensors for full-body motion tracking of automotive manufacturing operations. *International Journal of Industrial Ergonomics*, *79*(July), 103005. https://doi.org/10.1016/j.ergon.2020.103005

Jiang, Y. (2020). Combination of wearable sensors and internet of things and its application in sports rehabilitation. *Computer Communications Journal, 150*, 167-176. https://doi.org/10.1016/j.comcom.2019.11.021

Lin, K., Li, Y., Sun, J., Zhou, D., & Zhang, Q. (2020). Multi-sensor fusion for body sensor network in medical human-robot interaction scenario. *Information Fusion Journal, 57*, 15-26. https://doi.org/10.1016/j.inffus.2019.11.001

López-Sánchez, G. F., Radzimiński, Skalska, M., Jastrzębska, J., Smith, L., Wakuluk, D., & Jastrzębski, Z. (2020). Body composition, physical fitness, physical activity and nutrition in Polish and Spanish female students of sports sciences. *Science and Sports, 35*(1), e21-e28. https://doi.org/10.1016/j.scispo.2019.04.002

Lv, W., & Guo, J. (2021). Real-time ECG signal acquisition and monitoring for sports competition process oriented to the Internet of Things. *Measurement: Journal of the International Measurement Confederation, 169*(July 2020). https://doi.org/10.1016/j.measurement.2020.108359

Maas, B., Pakeman, R. J., Godet, L., Smith, L., Devictor, V., & Primack, R. (2021). Women and Global South strikingly underrepresented among top-publishing ecologists. *Conservation Letters, December 2020*, 1-9. https://doi.org/10.1111/conl.12797

Mancuso, V., Stramba-Badiale, C., Cavedoni, S., & Cipresso, P. (2022). *Biosensors and Biofeedback in Clinical Psychology*. Reference Module in Neuroscience and Biobehavioral Psychology. pp. 1-23. https://doi.org/10.1016/b978-0-12-818697-8.00002-9

Mary, X. A., Mohan, S., Evangeline, S., & Rajasekaran, K. (2020). *Physiological parameter measurement using wearable sensors and cloud computing*. In Systems Simulation and Modeling for Cloud Computing and Big Data Applications. Elsevier Inc. https://doi.org/10.1016/B978-0-12-819779-0.00002-2

Meijer, G. C. M. (2008). *SMART SENSOR SYSTEMS* (G. C. M. Meijer (ed.)). A John Wiley and Sons, Ltd, Publication. https://doi.org/10.1002/9780470866931

Miller, T. W. (Ed.). (2016). *Sports Analytics and Data Science : Winning the Game with Methods and Models*.

Pearson Education, Inc.

Petersen, J. M., Kemps, E., Lewis, L. K., & Prichard, I. (2020). Psychological mechanisms underlying the relationship between commercial physical activity app use and physical activity engagement. *Psychology of Sport and Exercise, 51*(June). https://doi.org/10.1016/j.psychsport.2020.101719

Qi, J., Yang, P., Waraich, A., Deng, Z., Zhao, Y., & Yang, Y. (2018). Examining sensor-based physical activity recognition and monitoring for healthcare using Internet of Things: A systematic review. *Journal of Biomedical Informatics, 87*(August), 138-153. https://doi.org/10.1016/j.jbi.2018.09.002

Ren, J., Guan, F., Pang, M., & Li, S. (2020). Monitoring of human body running training with wireless sensor based wearable devices. *Computer Communications Journal, 157*, 343-350. https://doi.org/10.1016/j.comcom.2020.04.015

Rodrigues, M. J., Postolache, O., & Cercas, F. (2020). Physiological and behavior monitoring systems for smart healthcare environments: A review. *Sensors (Switzerland), 20*(8), 1-26. https://doi.org/10.3390/s20082186

Shao, Q. (2021). Comparative study of wireless sensors for measuring the energy consumption of human running. *Measurement Journal, 168*. https://doi.org/10.1016/j.measurement.2020.108382

Uddin, M. Z., Hassan, M. M., Alsanad, A., & Savaglio, C. (2020). A body sensor data fusion and deep recurrent neural network-based behavior recognition approach for robust healthcare. *Information Fusion, 55*(July 2019), 105-115. https://doi.org/10.1016/j.inffus.2019.08.004

Wang, W., Zhang, F., Feng, T., Zhou, X., & Li, J. (2021). Facilities based on passive RFID sensors on growth and physiological characteristics of Lycium barbarum seedlings. *Measurement Journal, 168*, 108385. https://doi.org/10.1016/j.measurement.2020.108385

Wang, Yifei, Wang, H., Xuan, J., & Leung, D. Y. C. (2020). Powering future body sensor network systems: A review of power sources. *Biosensors and Bioelectronics Journal, 166*, 112410. https://doi.org/10.1016/j.bios.2020.112410

Wang, Yuxia. (2021). Microprocessors and Microsystems Embedded IoT system and functional recovery of sports spinal cord injury. *Microprocessors and Microsystems Journal, 82*, 103906. https://doi.org/10.1016/j.micpro.2021.103906

Wannapiroon, P. (2019). *Development of Cloud Learning Management Systems for Higher Education Institutions*. https://doi.org/10.1109/RI2C48728.2019.8999877

Xhafa, F., Leu, F.-Y., & Hung, L.-L. (2017). *Smart Sensors Networks, Technologies, Communication Applications, Intelligent*. United Kingdom: Mara Conner Publisher.

Yao, G., Yin, C., Wang, Q., Zhang, T., Chen, S., Lu, C., Zhao, K., Xu, W., Pan, T., Gao, M., & Lin, Y. (2020). Flexible bioelectronics for physiological signals sensing and disease treatment. *Journal of Materiomics, 6*(2), 397-413. https://doi.org/10.1016/j.jmat.2019.12.005

Zhao, J., & Li, G. (2020). Study on real-time wearable sport health device based on body sensor networks. *Computer Communications, 154*(February), 40-47. https://doi.org/10.1016/j.comcom.2020.02.045

Zhong, C.-L., & Li, Y. (2020). *Internet of things sensors assisted physical activity recognition and health monitoring of college students*. Pp. 159. https://doi.org/10.1016/j.measurement.2020.107774