

Enhanced the anxiety monitoring system among athletes with IoT for sports performance: a review

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Abstract:

Modern sports have made considerable utilization of advancements in robust modern technology for anxiety monitoring systems (AMSs). This study introduces the AMS for sports athletes based on the Internet of Things (IoT) which accurately identifies athlete performance. In sports applications, the technological devices integrated with IoT systems have been extensively used for the real-time utilization of the athlete's health conditions for anxiety factors, instead of tracking real-time location between the athlete and the coach. Several anxiety parameters were discussed in this study, due to athletes' inconsistency in performance issues. This review model incorporates athlete psychological and physiological anxiety parameters and multiple sensors of an AMS-IoT to enhance overall sports performance. An IoT health monitoring system was explicitly designed based on a sports application, and encompasses four primary aspects: sensing, networking, data processing and an application layer. The IoT technology can connect functions between sensors, microcontrollers, cloud systems, technological devices, and digital equipment for the targeted users. The communication between IoT devices mainly involves wireless communication, and accessibility is open with any Internet-enabled device. Based on the review, using an AMS during games results in improved readiness for athletes during the actual competitions. The coaches can provide appropriate training to the athletes according to their current health conditions. Therefore, the can AMS greatly assists the coaches in designing training activities for their athletes. It is highlighted that an efficient monitoring system can produce consistent and excellent sports performance according to the athlete's individual fitness level. The further study emphasizes that AMS powered by IoT technology merits further investigation based on athletes and their sport's needs.

Key Words: -Athlete performance, internet of things, anxiety monitoring system, and sport application

Introduction

The intelligence of anxiety monitoring systems (AMSs) to communicate autonomously between persons, devices, and sensors in real-time is called the Internet of Things (IoT). The involvement of IoT technology in sport applications improves athlete performance under various circumstances, whether during training, or in actual competitions. A significant problem in the current sports world these days is the rising number of players who exhibit inconsistent performance between their training sessions and actual competitions (Karahana, 2020). The focus on physical training and game strategy cannot encourage athletes to perform optimistically. Inconsistent performance among athletes requires the coaches to be ready with appropriate multiple training sessions. Coaches must be aware that the elements of psychology and physiology are vital in enhancing an athlete's overall performance. When the athletes face high pressure during games, sudden changes in their psychological and physiological conditions are referred to as competitive anxiety.

Competitive anxiety comprises four general elements: cognitive, somatic, affective and motoric components (Hasanah & Refanthira, 2020). However, in this review, the researcher will limited the study to cognitive and somatic components, since they contribute most to competitive anxiety in sports (Wan Ahmad et al., 2022). Cognitive anxiety arises due to psychological changes as anxiety arises due to fear of surroundings, failure, and lack of confidence. In contrast, somatic anxiety is a physiological response that includes changes in heart rate level, difficulty in breathing, and changes in muscle tension. However, the physical symptoms occur due to psychological influence criteria. Notably, the level of competitive anxiety significantly differs between individual sports and team sports. Individual sports such as archery, darts, rifle shooting, running, gymnastics, judo and golf require high individual skills in self-concentration and confidence level, and strong skills in the kind of sport itself (Loh & Chong, 2018). Individual athletes tend to exhibit more serious psychological

problems such as emotion, anxiety, and depression than in team sports when they do not have enough experience to handle their emotions during big competitions. Pluhar et al. (2019) reported that individual sports require greater concentration and sensitivity to physical and psychological change during games, due to anxiety.

Inappropriate training for athlete health conditions leads to inconsistent performance for every game. In order to help the athlete with consistent performance during real games, the coaches need to make immediate analyses of the changes in the athlete's conditions. Therefore, health monitoring systems have received great attention from the coaches to monitor all the possible criteria of athletes, including real-time monitoring of the athlete's health conditions (Naranjo-Hernández et al., 2017). The combination of multiple sensors from the monitoring system can detect the psychological parameters and assist the coaches to monitor and record the athlete's overall health level. Besides that, the monitoring system can compare the previous data of athlete performance before, during and after the gaming sessions. A study in China discussed the significance of wearable health monitoring systems facilitating the coaches in analysing the athletes' conditions and performances (Zhao & You, 2021). This study aims to summarize the types and characteristics of AMS used in sports among sports trainers, coaches, and athletes. Moreover, this study presents the recent innovations and discusses issues related to athlete performance in AMS-IoT models.

Anxiety in Athlete Performance

Every sport has specific requirements for winning. Athletes' success, whether in the beginning, intermediate, or elite categories, can be primarily determined by their performance during competitions. However, good performance does not rely solely on skills. Instead, how to overcome anxiety helps athletes produce more consistent performance. According to prior studies, athletes who compete in individualistic sports report feeling more anxious than those who compete in team sports (Soltani et al., 2016). Individual athletes are more engaged in their skills and abilities without depending on team athletes. Anxiety, motivation, stress, self-confidence, general activation, attention, and team cohesion are all psychological factors that influence athletes' performance and well-being.

For this reason, athletes must work on psychological skills to perform better. A psychological component is crucial for an individual sport requiring high accuracy or concentration levels, such as darts, rifle shooting, or archery. Rizal et al. (2019) discussed that, in archery, psychological attitude is highly demanded to ensure that the arrow's accuracy on the target butt is always on target. When the athlete perceives the anxiety as debilitating, they lose their concentration on target, resulting in inconsistent performance. A psychological reaction that engages with athletes' mental manifestations, such as anxiety, stress, and depression (Saçaklı, 2019). Handling emotion and mental manifestation are crucial aspects of psychology for individual sports.

Health Monitoring System in Sport

Nowadays, the utilization of health monitoring among athletes is increasing gaining attention in the development of sports technology and sporting ability. Conventional monitoring systems from the coach's practices commonly fail to identify athlete health conditions during the early stages of physical or emotional changes. The intense emotional and physical pressure the game can bring can hinder athletes' ability to focus on their opponents. In other words, if athletes lose concentration during games, their performance will decline. After all, poor or inconsistent sports performance will show that the athlete is not in good condition during the games. Due to this, a technological AMS is necessary for sports trainers to monitor and track athletes' health status during practice or competitions (Scataglini et al., 2020). According to Worsey et al. (2019), the dataset of health status was gathered by placing the sensors on the athlete's body, and collecting useful information throughout all the athlete's movements during gameplay. Many studies are concentrating on a wearable device-based health monitoring system to improve and enhance sports performance among all levels of athletes. One study by (Simón-Grima et al., 2021) developed a fitness monitoring system using smartphone devices via mobile apps to ensure the trainers and coaches quickly access their athlete's conditions in terms of place and time concurrently.

Fundamentally, the health monitoring system is classified into two types: responsive and preventive. However, from a sports perspective, health monitoring is classified as a prevention system that aims to detect the early changes in an athlete's conditions, both psychological and physiological, during games. The information derived offers real-time data about the athlete's condition. The most popular preventive health monitoring system types are fitness trackers to measure heart rate, blood pressure, and calories burned. A preventive monitoring system encourages a healthy lifestyles or habits by reducing the risk of significant illness by automatically identifying and notifying athletes about unhealthy practices. Utilizing monitoring system technologies in athletes as assistive devices has contributed to incorporating additional devices that improve physical resistance and players' health. A responsive system is capable of providing ongoing monitoring and early detection of users' health issues before they deteriorate significantly (Mosenia et al., 2017).

A responsive system can detect health conditions early and provide various health options based on the normal situation. A study in Spain revealed that the monitoring systems consists of multiple sensors that detect a possible mistakes during any movement of basketball players (Guembe et al., 2021). The device alerts the player when the reading parameter exceeds the optimum index. Thus, this monitoring system could detect possible faults while performing movements, and the device would alert the player throughout the game session. With

this, the improvement in the athlete's performance becomes better and more consistent. However, there are limitations in providing direct information about an athlete's condition and requiring accurate readings of athlete data for coach action and supervision from the appropriate sensor selection. Table 1 summarizes the health monitoring systems commonly used by the athletes, sports trainers and coaches during training and games. These monitoring systems are essential in obtaining real-time readings from the athlete's body.

Table 1. The summary of the anxiety sensors for a health monitoring system in sports applications

Research Study	Sensor	Description/Functional Mechanism	Sport Discipline
(Oktavius et al., 2021)	Sweating Skin	Monitor body fatigue for cyclist sport through cortisol level	Cycling
(Elshafei & Shihab, 2021)	Muscle	Monitor fatigue during repetitive muscle contraction	Gym -bodybuilder
(Huifeng et al., 2020)	Heart Rate	Monitor electrical activity from the heart	Open to all sport
(Zhao & Li, 2020)	Body Sensor Network	Monitoring body motion and physiological information	Open to all sport
(Taborri et al., 2020)	Electromyography (EMG)	Monitor muscle activity through the body movement	Open to all sport
(Scataglini et al., 2020)	Temperature Monitor	Monitor skin convective heat flux in temperature	Running
(Li et al., 2020)	Electrochemical Sweating Analysis Technology	Monitor both psychological and physical condition, metabolism and adaptability of a body during sports.	Open to all sport
(Zhong et al., 2020)	Electronic Cuff	Monitor the accuracy of blood pressure calibration was improved	Open to individual spot
(Örücü & Selek, 2019)	SEMG Muscle Behavior	Monitor dynamic muscle contractions	Weightlifting
(Ma et al., 2018)	Inertial Measurement Unit (IMU)	Monitor body movement and identify the posture	Basketball
(Brueck et al., 2018)	Sweat Rate Sensing	Monitor the sweat rate in real time	Cycling
(Wang, Yuliang, et al., 2018)	Micro Inertial Measurement Unit	Monitor motion, especially on the wrist hand during spikes	Volleyball
(Claudia C et al., 2017)	Electrooculography (EOG)	Monitor attention control during games	Archery
(Lang, 2017)	Optical Heart Rate	Monitor volumetric changes in blood perfusion during cardiac cycles	Open to all sport
(Kuan et al., 2016)	Galvanic Skin Response (GSR)	Monitoring and detecting levels of relaxation	Shooters
(Thomas et al., 2016)	Strip-Base Glucose Meters	Monitor blood glucose concentration in athlete's body	Running and Cycling
(Fu & Liu, 2015)	Near-Infrared Blood Oxygen Saturation	Monitor and measure the oxygen level of the blood	Running

The primary goals of the monitoring systems are to monitor the athletes' anxiety conditions and to alert them of the need for precaution when they are in training or in competitions. Numerous sports currently apply athlete monitoring equipment to prevent injuries as a standard practice. These instruments are primarily intended for assessing training load (exposure) and a person's reaction to this exposure. A thorough analysis determines how these monitoring data and injury incidence relate. Prior work shows the importance of a preventive monitoring system regarding injury risk among elite athletes in weightlifting by using the SEMG muscle behavior monitoring system (Örücü & Selek, 2019). The changes in hamstring strength pattern when the load exceeds optimum weight show when the athlete may face higher risk of injury.

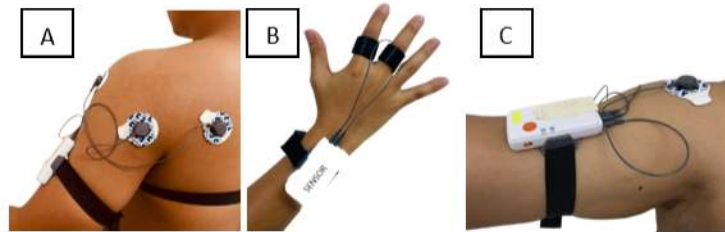


Fig. 1. Multiple sensors located on athlete's body for further integration with health monitoring system

Multiple sensors are included in one monitoring device, integrated to monitor the entire athlete's activities, and gathered under one monitoring system. Fig 1 shows several types of wearable sensors commonly used by coaches to obtain real-time data and monitor the changes in athletes' conditions. Fig. 1 (a) shows a sensor attached to the back of the shoulder for muscle tension measurement. Fig. 1 (b) shows a sensor located at the athlete's fingers to monitor skin reaction during gripping an object. Fig. 1 (c) shows the upper side of the shoulder to detect the muscle movement for weightlifting sports.

The monitoring results can be viewed by coaches and trainers regularly, and various parameters are monitored in real-time based on the anxiety monitoring big data platform, which integrates with the Internet of things (IoT) technology. IoT technology is a big data application model that provides the latest ideas to develop sports to be more competitive.

IoT based on Athlete Performance

In today's sports advancement, technology is at the centre of research. The Internet of Things (IoT) technology enables the targeted users to connect functions between sensors, microcontrollers, cloud systems, technical gadgets, and digital equipment. Applications based on IoT devices are drawing increasing attention, attributable to their capacity to cover numerous aspects of athlete conditions under one unified system. IoT technology is purposefully created to improve athlete performance through monitoring, evaluating, and analyzing sports demand. The athlete's performance can be tracked and monitored much more effectively by integrating IoT technology compared to manual or traditional methods. Fig. 2 illustrates the basic architecture of an IoT model based on an anxiety monitoring system for sports applications. This IoT architecture generally comprises four connection layers: the sensing layer, the networking layer, the data processing layer, and the end user, called the application layer.

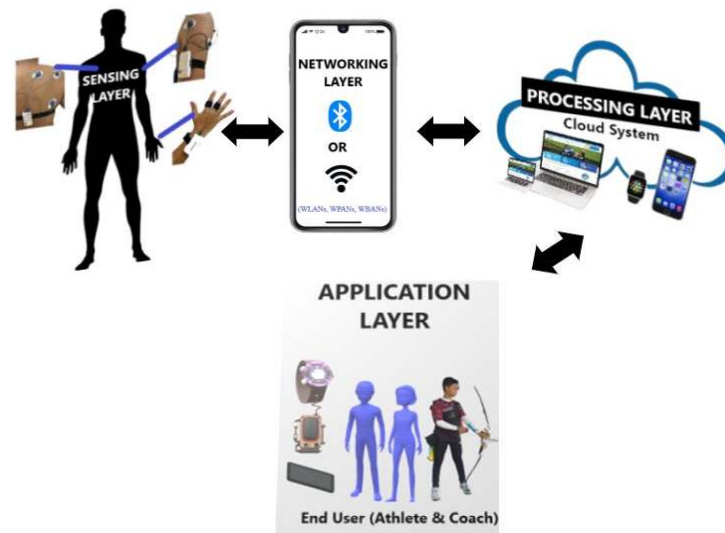


Fig 2. Basic architecture diagram of an IoT model

The implementation of IoT technology is gaining increasing attention in most industries, primarily due to its ability to launch work processes, reduce costs, and be able to control systems more effectively. The fundamental architecture of IoT model design can be classified into three or four layers, depending on the system's use. Brueck et al. (2018) indicated three architecture components of IoT for athletes' wireless sweat rate monitoring systems. The monitoring focuses on instantaneous sweat rate that consists of the sensing layer, networking layer and application layer. In this case, the data processing layer store data in the cloud system for further analysis. Some formal sectors that have implemented the IoT technology are construction (Kim et al., 2020), healthcare (Huifeng et al., 2020), security applications (Sylla et al., 2022), transportation (Bansal, 2020) and education (Stojanović et al., 2022), which have all used four layers of architectural components of IoT. In this review, the researcher focused on individual sports AMS that followed four layers of the basic architecture of an IoT's system. Hence, we outlined the function of the four layers involving the athlete as the user.

- i) The sensing layer is the streaming data collected by the physical sensor layer deployed across the body, involving the athlete's body. The input signals from the sensors from the attached to the athlete's body will then be passed through the sensor-based network layer. In this sensing layer, the anxiety parameters are identified.
- ii) The networking layer connects sensors to other network devices and servers using long-distance communication by using the cellular networks and short-distance communications wireless communication technology such as wireless local area networks (WLANs), wireless body networks (WBANs), and wireless personal area networks (WPANs). Its features efficiently classify and secure data transmission to corresponding data process units for the real-time collection of vast amounts of data generated by the sensing layer.
- iii) The data processing layer is also known as the cloud server. The server is the key to processing data and is responsible for storing and retrieving valuable data, analyses, and processing data mining in the recent advancement of cloud computing servers.
- iv) The application layer presents the processing data and results. This layer provides a human-computer interaction interface between human feedback information and the application for user demand in the actual production of the device.

Since every device and object can be explicitly recognized in the connection of the modern internet infrastructure, and offer significant benefits for athlete achievement, IoT technologies have a great potential to

influence the overall health monitoring in sports applications. These advantages often include sophisticated gadgets, monitoring screens, and systems with numerous sensor applications. IoT-based monitoring systems are primarily used in sports applications to monitor players' conditions and provide coaches with more accurate information about their conditions compared to manual observation. Recently, different approaches aim to take advantage of the monitoring capabilities in sport applications to develop anxiety monitoring techniques. Some representative research works are described hereafter. A study on the high jump sport by Muhammad Faris (2019) focused on real-time monitoring through a smartphone with an IoT-based solution rather than using a high-speed camera to detect the movement. The mobile app can communicate to the wearable device and cloud server. Simultaneously, coaches can monitor with the athlete's conditions through the monitoring signals from mobile apps during training and competitions. In all these AMSs, the monitoring device can derive the athlete data and send it to a cloud system, and the data can be read from any apps through any remote device. This is called athlete-technology interaction. Table 2 shows the contributions of IoT technology to sports applications.

Table 2. Summarizes the contributions of IoT technology toward sports applications

Research Study	Description	Sport	IoT Application
(Iliadis et al., 2021)	Monitor physiological response and detect early health disorder	Cycling	mHealth and Wi-Fi
(Snyder et al., 2021)	Monitor the motion quality during alpine skiing by the accuracy	Skiing	Mobile Apps and Smartphone
(Mohtadzar et al., 2020)	Monitoring the athlete's body parameter (HR, SpO ₂)	Running	Zigbee and Bluetooth
(Scataglini et al., 2020)	Monitoring fitness performance activity	Running	Fitness tracking Apps
(Janssen et al., 2020)	Monitoring automatic adaptation of training and avoiding injuries	Running	Inspirun e-Coach app and Smartphone
(Muhammad Faris, 2019)	Monitoring athlete movement progress and tracking the performance	High Jump	Open HAB mobile and Bluetooth
(Zhang et al., 2019)	Monitoring by recognising the arm movements	Ping pong	WristMEMS, Bluetooth and Mobile
(Wang, Chen, et al., 2018)	Monitoring different badminton strokes and classifying skill levels	Badminton	Mobile apps, Bluetooth low energy (BLE) and Wi-Fi
(Brueck et al., 2018)	Monitoring sweat rate for athlete hydration detection	All sport	ThingSpeak web and Smartphone Apps
(Gharghan et al., 2016)	Monitoring and improving estimated distance	Cycling	Zigbee and Bluetooth
(Bai et al., 2016)	Monitoring and detecting the shooting attempts	Basketball	WeSPORT, Microsoft Band and Android system
(Mahmood et al., 2011)	Monitoring athlete heart rate by using light emitting diode (LED)	All sport	Zigbee and ANT+

Discussion

Every sport has its own set of criteria for determining victory. Multiple preparations are required for an athlete to become an expert in the sport in which he or she participates. Experienced athletes believe that physiological and psychological preparation are critical to maintaining consistent performance during training or competitions. For example, the sport of archery necessitates intense concentration to ensure that each archer is aims at a particular target (Tomor & Shah, 2015). Excessive anxiety has become a significant barrier to athlete performance (Horvath et al., 2022). Identifying early changes in both elements of anxiety is essential to optimize the overall performance of the athletes in the competitions, so that they can play with their optimal performance in the competitions. For example, the sport of archery requires a high focus to ensure that each archer is on a set target. Psychological factors such as anxiety, mind concentration, and body temperature and physiological parameters such as heart rate level, muscle activation, and skin conductance need to be given attention by athletes (Qiu et al., 2021). If these two main parameters are not achieved at optimal levels, the athlete will face inconsistent and debilitating performance and vice versa.

Coaches are concerned about these basic parameters in determining their athletes' performance. Ogan et al. (2015) reported that the athletes' ability to maintain and consistently perform throughout each training session would benefit from excellent monitoring of the critical parameter data. Therefore, the anxiety monitoring system may gather all the necessary parameter readings from the bio-signal sensor by incorporating IoT technology. Athletes and coaches more accurately gather data from the parameters with the help of sensor devices as sports technology advances. The review shows that the sensors can retrieve and analyse digital data from multiple parameters. By comparing and studying the IoT devices in sports anxiety monitoring systems, we can better understand that the configuration of the IoTs for health monitoring systems is different for each purpose. Researchers have focused on implementing and designing IoT sports health monitoring systems to enhance the current services for athlete performance and helping the coaches to analyze their athletes' conditions.

Conclusions

Various AMS-IoT devices are becoming more advanced, but the required sensors and devices are bulky due to incompatibility among the different sports disciplines. Through AMS, with the integration of IoT technology, we can determine an athlete's anxiety condition and adaptability during sports. The information

derived has essential practice, and is effective for athletes' daily sports training and fitness monitoring. The current listed AMS-IoT devices in this review can be used for regular health check-ups by the athletes, and apply to any sports discipline. The monitoring system is inexpensive and can be mass-produced. It will be handy for coaches who regularly monitor their athletes' health conditions and compare them with previous data to analyse overall performance. This review identified several biosensors for anxiety monitoring systems, intelligent processing from IoT technology and wearable devices for sport applications for athletes. To summarize the study review, this research presented beneficial information regarding anxiety monitoring systems for athletes, coaches, sports trainers, and policymakers operational in the field of sports. Based on this review, the researchers recommended that future research should facilitate the accessibility in terms of readings of various parameters from one device and applied them during actual training sessions and competitions. As possible recommendations for future work, developing an anxiety monitoring system may improve the characteristics of the device in terms of variation of parameter reading, the accuracy of data reading, and creating the alert systems for monitoring critical information. Additionally, focusing on the ergonomic design systems for athlete's comfort also merits further research.

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