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(54) SYSTEM AND METHOD FOR ATHLETE PHYSIOLOGY MONITORING

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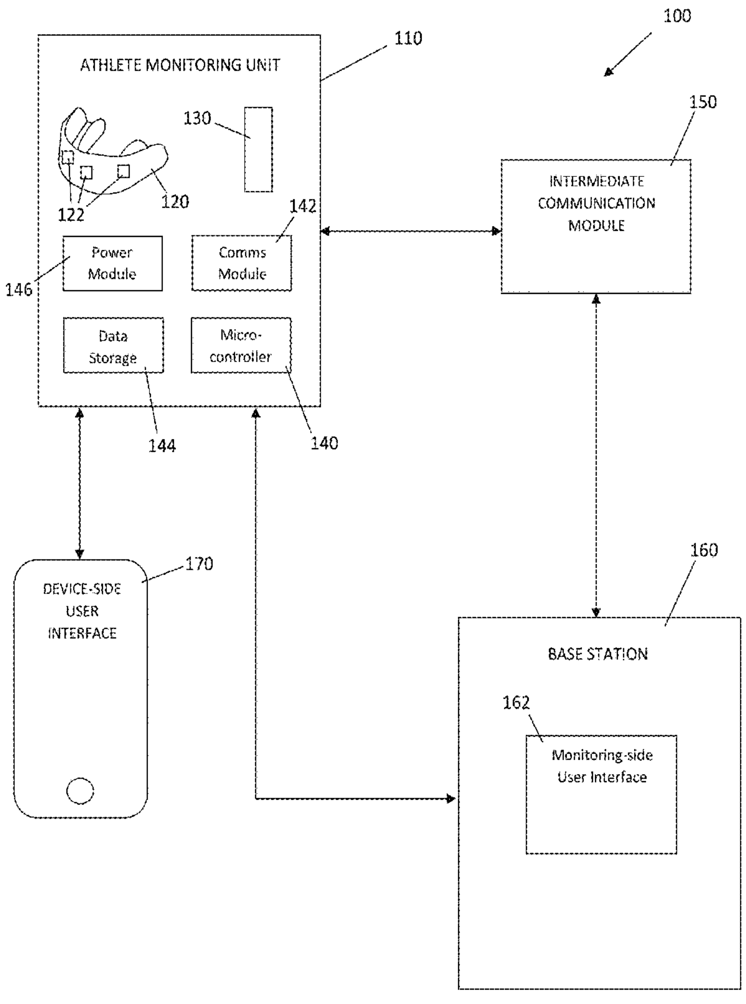
(57) **ABSTRACT**

Disclosed is a smart, physiology monitoring mouthguard (SPMM) system and method for capturing various physiological data of athletes in real-time for health monitoring. The system is configured to provide real-time and/or recorded physiological data of an athlete to a user, and may be configured to record physiological data of the athlete for later retrieval using sensors and communication systems. Sensors may be chosen based on the anticipated activity or sport, the health and age of the athlete, and size and power requirements of the device. Sensors may include accelerometers, gyroscopes, thermometers, hydrometers, pH, electrolyte (e.g., potassium, sodium, etc.) sensors, and the like. These and other sensors may be configured to measure different physiological data of the athlete, including impact, body temperature, hydration, illness, heart rate, and the like. In some embodiments, sensors on the mouthguard are integrated with external sensors (e.g., accelerometers on a helmet, chest-worn heart rate monitor) on the athlete to provide additional or more accurate physiological data.



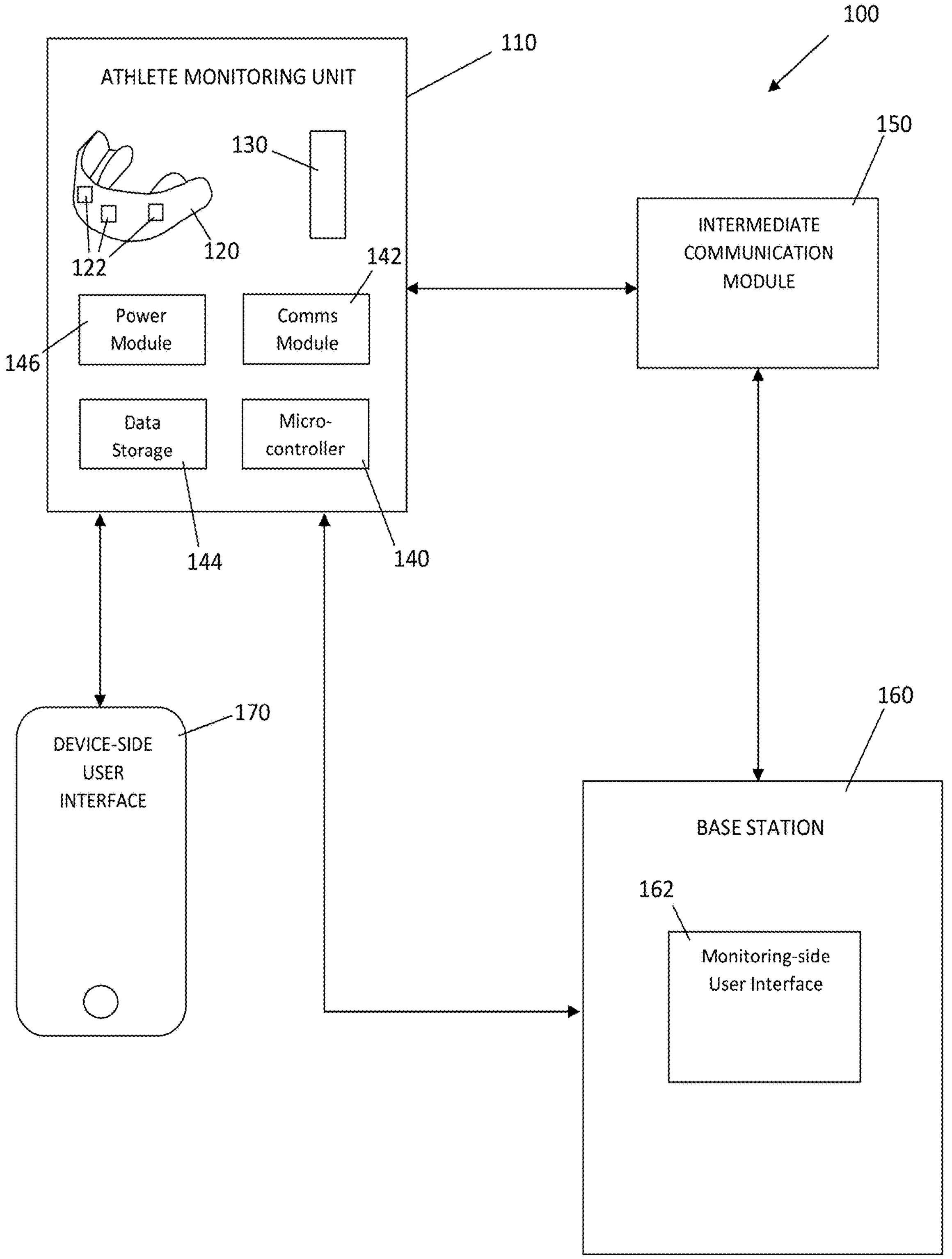

100
110
ATHLETE MONITORING UNIT
130
122
120
142
Power Module
Comms Module
146
Data Storage
Micro-controller
144
140
150
INTERMEDIATE COMMUNICATION MODULE
170
DEVICE-SIDE USER INTERFACE
160
BASE STATION
162
Monitoring-side User Interface

FIG. 1

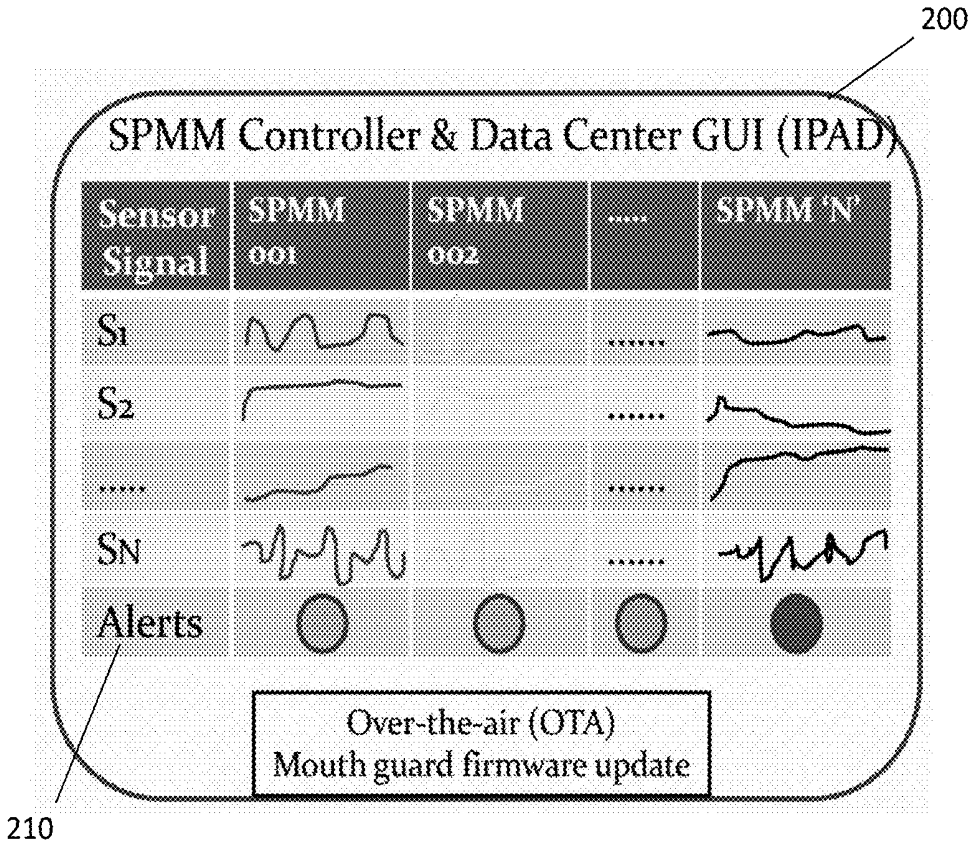

200
SPMM Controller & Data Center GUI (IPAD)
Sensor Signal
SPMM 001
SPMM 002
.....
SPMM 'N'
S1
S2
.....
SN
Alerts
Over-the-air (OTA)
Mouth guard firmware update
210

FIG. 2

SYSTEM AND METHOD FOR ATHLETE PHYSIOLOGY MONITORING

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of U.S. Provisional Application No. 62/736,015 titled "Device for Athlete Physiology Monitoring," filed Sep. 25, 2018 by the inventors herein, which application is incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

[0002] The present invention relates generally to systems and methods for monitoring physiological conditions of athletes during athletic events, and more particularly to a system including at least a mouthguard equipped with one or more sensors and processors configured for real-time monitoring of a physiological data of an athlete.

BACKGROUND

[0003] Athletes of all types face risk of injury during practice, training, and competition. For example, professional football players frequently suffer injuries including fractures, sprains, and more dangerous head injuries, such as concussions. Throughout a sporting event, a player may experience a significant impact that jars their head on multiple occasions, creating a cumulative effect that exacerbates a brain injury, possible leading to a concussion or even more serious injury. Similarly, athletes can also be subject to the insidious effects of heat exhaustion and heatstroke. Again, similar to concussions, heatstroke and heat exhaustion are the results on the body due to cumulative exposure to high temperatures and can sometimes go undetected until the athlete is in an emergency situation. However, in the midst of competition, players, coaches, and other team staff may pay limited attention to the building risk of serious injury, leaving the athlete exposed to risk of serious and long-term injury.

[0004] It would therefore be advantageous to provide a system and method capable of monitoring the physiological conditions of an athlete in real-time during an athletic event, such that if they experience conditions that present significant risk to their health, team staff may intervene to take them off the field, give them an appropriate rest period, and if necessary seek immediate medical intervention to mitigate the risk of any injury progressing.

SUMMARY OF THE INVENTION

[0005] Disclosed herein is a system and method for capturing various physiological data associated with an athlete in real-time during an athletic event to detect the occurrence of a condition that risks the player's health, which system and method employ an athlete monitoring unit including at least a smart, physiology-monitoring mouthguard (SPMM) device. In certain configurations, the athlete monitoring unit is configured to provide real-time and/or recorded physiological data of an athlete to a user. The athlete monitoring unit may be configured to record physiological data for later retrieval. The athlete monitoring unit may further be configured as a compliant and/or moldable mouthguard, which is generally a convenient form factor for athletes and other users. The athlete monitoring unit may be configured to measure multiple physiologic parameters of an athlete. In certain configurations, each parameter is measured sequentially, while in other configurations, some parameters are measured simultaneously.

[0006] In an exemplary embodiment, a system is provided including a mouthguard having a substrate, a computing or data-acquisition platform, sensors, a device-side user interface, a monitoring-side user interface, a communication system, a data storage module, a power module, and software for data and/or signal processing. Some configurations may only include electronic systems on the athlete monitoring unit, such as a substrate, sensors, a power module, and a communication system and/or data storage module. Other configurations may only include electronic systems configured to operate with a mouthguard, such as by attaching sensors, a power module, and a communication system and/or data storage module to a typical mouthguard. Furthermore, electronic systems can include a printed circuit that is directly formed on or into the mouthguard substrate. Thus, the athlete monitoring unit and system can be configured to accommodate many cost and functional requirements.

[0007] In accordance with certain aspects of an exemplary embodiment, a system for monitoring the physiological condition of an athlete is provided, comprising: at least one athlete monitoring unit comprising a mouthguard, at least one sensor attached to the mouthguard, wherein the sensor is configured to sense a physiological condition of an athlete on which the athlete monitoring unit is worn, and a microcontroller in data communication with the at least one sensor; and a base station having a processor and a data memory, wherein the base station is in data communication with the athlete monitoring unit, the base station having computer executable code stored thereon configured to receive physiological data from the athlete monitoring unit, compare the physiological data received from the athlete monitoring unit with a preset threshold value for the physiological data, and upon a determination at the base station that the physiological data received from the athlete monitoring unit exceeds the threshold value, generate at the base station a human-discernable alert.

[0008] In accordance with further aspects of an exemplary embodiment, a method for monitoring athlete physiological data is provided, comprising: providing at least one athlete monitoring unit comprising a mouthguard, at least one sensor attached to the mouthguard, wherein the sensor is configured to sense a physiological condition of an athlete on which the athlete monitoring unit is worn, and a microcontroller in data communication with the at least one sensor; and providing a base station having a processor and a data memory, wherein the base station is in data communication with the athlete monitoring unit; receiving at the base station physiological data from the athlete monitoring unit; comparing at the base station the physiological data received from the athlete monitoring unit with a preset threshold value for the physiological data; and upon a determination at the base station that the physiological data received from the athlete monitoring unit exceeds the threshold value, generating at the base station a human-discernable alert.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The novel features of the invention are set forth with particularity in the appended claims. A better understanding of the features and advantages of the present invention will be obtained by reference to the following detailed description that sets forth illustrative embodiments, in which the principles of the invention are utilized. The present invention is illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings, in which like reference numerals refer to similar elements, and in which:

[0010] FIG. **1** is a schematic view of a system for monitoring the physiological condition of an athlete according to certain aspects of an embodiment of the invention.

[0011] FIG. **2** is a schematic view of an exemplary user interface for use with the system of FIG. **1**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0012] The following detailed description is provided to gain a comprehensive understanding of the methods, apparatuses and/or systems described herein. Various changes, modifications, and equivalents of the systems, apparatuses and/or methods described herein will suggest themselves to those of ordinary skill in the art.

[0013] Descriptions of well-known functions and structures are omitted to enhance clarity and conciseness. The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the present disclosure. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. Furthermore, the use of the terms a, an, etc. does not denote a limitation of quantity, but rather denotes the presence of at least one of the referenced items.

[0014] The use of the terms "first", "second", and the like does not imply any particular order, but they are included to identify individual elements. Moreover, the use of the terms first, second, etc. does not denote any order of importance, but rather the terms first, second, etc. are used to distinguish one element from another. It will be further understood that the terms "comprises" and/or "comprising", or "includes" and/or "including" when used in this specification, specify the presence of stated features, regions, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, regions, integers, steps, operations, elements, components, and/or groups thereof.

[0015] Although some features may be described with respect to individual exemplary embodiments, aspects need not be limited thereto such that features from one or more exemplary embodiments may be combinable with other features from one or more exemplary embodiments.

[0016] Provided herein is a system and method for capturing various physiological data associated with an athlete in real-time during an athletic event to detect the occurrence of a condition that risks the player's health, which system and method employ a smart, physiology-monitoring mouthguard (SPMM) device. With particular reference to FIG. **1** and in accordance with certain aspects of an exemplary embodiment, system **100** includes at least one athlete monitoring unit **110** including a mouthguard **120** that conforms to an athlete's mouth, and more particularly their upper teeth. Mouthguard **120** includes at least one mouthguard-mounted sensor **122**, and optionally a plurality of mouthguard-mounted sensors **122**, for detecting physiological conditions experienced by the athlete during an athletic event. In accordance with certain aspects of an embodiment, athlete monitoring unit **110** may include multiple integrated sensors, including both mouthguard-mounted sensors **122** and other body-worn sensors **130**, as discussed in greater detail below, that may be customized or selected for each athlete. In certain configurations, athlete monitoring unit **110** includes a microcontroller **140** that is in data communication with sensors **122** and **130**. While FIG. **1** shows microcontroller **140** positioned remotely from mouthguard **120**, microcontroller **140** may in certain configurations be integrated within mouthguard **120**. Microcontroller **140** may receive signals (e.g., signals indicative of physiological conditions experienced by the athlete) from sensors **122** and **130**, and may control each such sensor's operation (e.g., turn each sensor on and/or off).

[0017] In an exemplary embodiment, the sensors **122** and **130** are multiplexed to microcontroller **140** using, by way of non-limiting example, BLUETOOTH® connectivity, although other wireless or wired communication protocols may likewise be employed as will be apparent to those of ordinary skill in the art. Microcontroller **140** is likewise preferably in data communication with a base station **160** through a communication module **142** of athlete monitoring unit **110**. Microcontroller **140** is preferably configured to process physiological data and signals, and to transmit such data and signals to base station **160**. Microcontroller **140** is preferably configured to store data in a data storage module **144**, transmit such data to base station **160**, and/or delete physiological data from data storage module **144**, as described in further detail below. Likewise, base station **160** is preferably configured to employ command and control functions (e.g., system **100** set-up or initialization), perform real-time data collection and routing, perform real-time physiology monitoring and alerting, provide a graphical user interface, and perform any desired post-processing of data received from athlete monitoring unit **110**.

[0018] Preferably, athlete monitoring unit **110** also includes a power module **146**, such as a rechargeable battery, for powering the components of athlete monitoring unit **110**.

[0019] In certain configurations, microcontroller **140** directly communicates with base station **160**, while in other configurations microcontroller **140** indirectly communicates with base station **160**. Such communications may be wireless or wired communications. For example, microcontroller **140** may wirelessly communicate with base station **160** using a BLUETOOTH® connection (or radio, Wi-Fi, or other wireless connection) employed by communication module **142** in accordance with well-known wireless communication protocols and infrastructure, to transmit physiological data from athlete monitoring unit **110** to base station **160**. As a further example, microcontroller **140** may communicate with an intermediate communication module **150** that further communicates with base station **160**. Intermediate communication module **150** may, by way of non-limiting example, be a body- or equipment-worn repeater module having a higher power transmitter module and more power capacity (e.g., an additional battery) that can communicate physiological data to base station **160** under a variety of challenging communication environments (e.g., poor signal quality due to noise, relative locations of microcontrollers **140**, intermediate modules **150** and/or base stations **160**, interference, weather, etc.). Alternatively or additionally, intermediate communication modules **150** may be positioned on an athletic field or other area surrounding the athletes at optimal positions between the athletes and base station **160**. Thus, microcontroller **140** may comprise a low-power microcontroller configured to increase the efficiency and reduce the power requirements of athlete monitoring unit **110**.

[0020] In certain configurations, more than one intermediate communication module **150** may be provided that communicate between athlete monitoring unit **110** and base station **160**. In other configurations, each intermediate communication module **150** and/or microcontroller **140** may only communicate with predetermined intermediate communication modules and/or base stations **150**. In still other configurations, each intermediate communication module **150** and/or microcontroller **140** may communicate with a variable set of intermediate communication modules **150** and/or base stations **160** depending upon a variety of factors (e.g., signal quality due to noise, relative locations of microcontrollers **140**, intermediate communication modules **150**, and/or base stations **160**, interference, weather, etc.). By way of non-limiting example, each microcontroller **140** and/or intermediate communication module **150** may communicate with intermediate communication modules **150** that are spatially close to the athlete's athlete monitoring unit **110** at particular moments.

[0021] In other configurations, system **100** many include multiple base stations **160**. In some configurations, base station **160** may comprise a smartphone or tablet device, while in other configurations base station **160** may comprise a desktop computer, laptop, receiver, or the like. Base station **160** may be configured to record and display incoming data. In another configuration, base station **160** may be configured to activate alerts when triggered by particular physiological data or conditions. For example, for a device measuring physiological data including high acceleration (high-G-force) or impacts to an athlete (e.g., from an athlete monitoring unit **110** having a sensor **122** and/or **130** for measuring acceleration such as an accelerometer or gyroscope, as further described below), a base station **160** may be configured to issue an alert when the athlete experiences a certain number of occurrences within a predetermined duration (e.g., a single sporting event). The alert may indicate a change of the athlete's status, for example, from "unmarked" to "in-danger," such that coaches, health professionals, authorities, etc. can intervene as necessary. Other configurations of the system can include similar algorithms for other sensors (as further described below).

[0022] In one configuration, the system **100** monitors for concussions of an athlete. For example, the system **100** monitors for concussions by measuring impact forces via acceleration measurements. Athlete monitoring unit **110** may include a three-axis accelerometer to measure acceleration, which can be recorded directly in data storage module **144**, which may comprise (by way of non-limiting example) a non-volatile memory. In other configurations, data can be streamed or transmitted to remote base station **160**, which may comprise (by way of non-limiting example) an off-field central team data collection system (as described above; see also Table 2, below). In still other configurations, the acceleration data can be simultaneously streamed or transmitted to base station **160** and recorded in a storage module at base station **160**.

[0023] In an exemplary embodiment, acceleration data is only recorded or streamed when the accelerometer(s) of athlete monitoring unit **110** measure an impact force exceeding a pre-set threshold (on-demand operation), such as an impact event. For example, data may only be recorded or streamed for a collection interval after an impact event. The collection interval for each impact event can last from several seconds preceding the event and throughout the event, to a time after the event. For example, the collection interval may be 1 second before the event and 5 seconds after the event, and in another example, the collection interval may be 2 seconds before the impact event and 10 seconds after the impact event. The system may readily be adapted to provide for longer or shorter data collection durations as may be deemed appropriate for a particular athletic event. Each occurrence of an impact event may be time-stamped, processed, or synced at one of the base stations **160**. Thus, operating on-demand may reduce power consumption of the device and increase battery life of the device.

[0024] In an exemplary embodiment, the substrate of mouthguard **120** is similar to a typical mouthguard, such as those used during athletic activities (e.g., football). Some mouthguards include an attachment strap that is configured to couple to a helmet or jersey. Thus, some configurations herein may include wiring that is integrated with an attachment strap attaching mouthguard **120** to the athlete's helmet, jersey, pads, or other equipment for power module and/or communication systems further integrated with the athlete's helmet, jersey, pads, or other equipment (such as described below). In another configuration, the mouthguard may be custom designed for a particular athlete, and in yet another configuration the mouthguard may be custom designed to house electronic systems of the device-side platform (such as the microcontroller, sensors, etc.) to protect the electronic systems while allowing sufficient measurement of physiological data and safety of the athlete. The mouthguard **120** may be manufactured according to typical methods, such as injection molding, additive manufacturing, and the like.

[0025] In accordance with certain features of an exemplary embodiment, sensors **122** and **130** may be configured to measure physiological data of the athlete. The sensors **122** and **130** are configured to sufficiently and reliably provide signals for monitoring the health of the athlete. Different types of sensors **122** and **130** may be chosen based on the anticipated activity or sport, the health and age of the athlete, and size and power requirements of the system **100**. For example, the sensors **122** and **130** may include accelerometers (e.g., multiple three-axis accelerometers, as discussed above), gyroscopes, thermometers, hydrometers, pH sensors, electrolyte (e.g., potassium, sodium, etc.) sensors, heart rate monitors, and the like, the construction of which are known to those skilled in the art. These and other sensors may be configured to measure different physiological data of the athlete, including impact, body temperature, hydration, illness, heart rate, and the like. In some configurations, sensors **122** on the mouthguard **120** are integrated with external sensors **130** on the athlete to provide additional or more accurate physiological data. For example, physiological data from accelerometers on the mouthguard **120** can be integrated with physiological data from accelerometers on the athlete's helmet (e.g., via the microcontroller **140**) to more accurately determine impact forces relative to the head. As a further example, physiological data from the mouthguard **120** can be integrated with physiological data from heart rate monitors or temperature sensors on the athlete (e.g., on the athlete's body, jersey, pads, helmet, or the like, via the microcontroller **140**) to more accurately determine the athlete's temperature or overall health. Some sensors **122** and **130** may be monitored continuously, while other sensors **122** and **130** may be monitored discretely or intermittently.

[0026] In an exemplary embodiment, system **100** includes at least one base station **160**, as discussed above. Base station **160** (or, computing/data-acquisition platform or monitoring-side platform) is preferably configured to receive all of the physiological data transmitted from the athlete monitoring unit **110**. Base station **160** may be further configured to process the received physiological data, such as according to a set of pre-defined rules or algorithms. Furthermore, base station **160** may be configured to issue alerts, such as determined by the rules or algorithms regarding the status of the athlete (e.g., "unmarked," "in danger", or the like). Still further, some configurations of base station **160** may display the physiological data, along with any alerts, or cause other devices (e.g., smartphone of a healthcare provider) to display alerts or physiological data. FIG. **2** is an exemplary view of a display screen from a user interface of base station **160**, which may (by way of non-limiting example) provide for each sensor **122** and **130** of each athlete monitoring unit **110** a display of data (e.g., numeric values, graphs, or other indicia as may be appropriate for the sensed physiological condition) associated with each sensor, along with an "Alerts" indicator **210** associated with each athlete monitoring unit **100** to provide a quickly identifiable indicia of an overall physiological condition of the athlete (e.g., distinct color indicators to indicate unmarked, in danger, and the like). By way of non-limiting example, base station **160** may comprise a smartphone (e.g., an Android®- or iOS®-based phone or tablet), a personal PC or laptop, or the like. Still further, each base station **160** may be configured to receive physiological data from and operate many athlete monitoring units **110** at a particular time.

[0027] In an exemplary embodiment, system **100** may have adjustable settings of the electronics on the athlete monitoring unit **110**. For example, the system may include a device-side user interface (UI) **170**, such as a graphical user interface, in data communication with athlete monitoring unit **110**. The device-side UI **170** may be configured to adjust a selection of many settings, such as change data signal sensitivity, trigger thresholds, device initialization (e.g., how to turn on each athlete monitoring unit **110** or start data monitoring/acquisition), setup parameters, establishing a unique identification (an identifiable tag, e.g., a radiofrequency or bar code tag) for each athlete monitoring unit per athlete, and the like. In an exemplary embodiment, the device-side UI **170** operates on a PC or laptop (although other embodiments operate on a smartphone, tablet, or the like), which transmits settings to the athlete monitoring unit **110**. While FIG. **1** shows device side UI **170** implemented on a computing device that is separate from base station **160**, device side UI **170** may alternatively be operated as an executable software module on base station **160** without departing from the spirit and scope of the invention.

[0028] In an exemplary embodiment, the system **100** may also have adjustable settings of the base station **160** (monitoring-side). For example, the system **100** may include a monitoring side user interface **162**, such as a graphical user interface, on the base station **160** (as depicted in FIG. **2**). The monitoring-side UI **162** may be configured to receive, process, and transmit physiological data, initialize other components (e.g., individual athlete monitoring units **110**, intermediate modules **150**, other base stations **160**, etc.), start and/or stop data monitoring or acquisition, raise data-dependent alerts, maintain time-base for athlete monitoring units **110**, monitor battery levels, initiate communications with healthcare providers, register individual athlete monitoring units **110** (e.g., using RFID), and the like.

[0029] In an exemplary embodiment, the communications system comprises a BLUETOOTH® low-energy (BLE) system. For example, typical BLE systems have approximate transmission capabilities shown in Table 1, below. In some configurations that require long transmission distances, such as for motorsport applications, higher-powered alternative technologies (e.g., radio transmission) can be used. In other configurations, the communications system can operate with external repeaters in communication with higher-powered radios or other BLE devices. In still other configurations, a wireless sensor network (WSN) architecture can be used for connectivity to the base station **160**.

TABLE 1

Bluetooth Class, Power, and Range

Device Class	Transmit Power	Intended Range
Class 3	1 mW	less than 10 meters
Class 2	2.5 mW	10 meters, (33 feet)
Class 1	100 mW	100 meters (330 Ft.)

[0030] In an exemplary embodiment, as discussed above, the data storage module **144** is configured to store physiological data on the athlete monitoring unit **110**. The data storage module **144** may comprise different types of storage, such as on-board random-access-memory, microSD cards (e.g., permanently installed), and may be supplemented by storage at the base station **160**, and/or storage on a remote server (e.g., the cloud). Alternatively, all data may be stored at the base station **160** and/or storage on a remote server instead of being worn by that athlete as a part of athlete monitoring unit **110**. Physiological data may be stored (or synced to a base station **160**) in the data storage modules **144** continuously or intermittently depending on many factors, such as power capacity, range from a base station **160**, physiological data and respective thresholds, etc. For example, the athlete monitoring unit **110** may store (record) and communicate physiological data for a duration before, during, and after an impact event (as described above). Furthermore, the athlete monitoring unit **110** may be configured to store or communicate data periodically. Still further, the athlete monitoring unit **110** may be configured to store (record) or communicate data according to other schemes that would be understood by persons of ordinary skill in the art.

[0031] In an exemplary embodiment, the power module **146** of the athlete monitoring unit **110** is configured to have sufficient power to support operations of the athlete monitoring unit **110** for at least one full sporting event (e.g., a football game). The amount of power consumption is generally a function of the operations of the athlete monitoring unit **110**, such as sampling rates of the sensors **122** and **130** and the communications requirements (e.g., active transmission rate, "on" time, distance from base station **160**, obstructions and interference, etc.). For example, during athletic events with venues (e.g., soccer, football, lacrosse, and the like), direct communication from the athlete monitoring unit **110** to the base station **160** can be enabled via BLE. Table 2, below, describes typical dimensions of some exemplary athletic activities. Thus, the power module **146** of athlete monitoring unit **110** may include an on-board battery, such as a button battery or a lithium-ion battery. As a further example, for athletic events with a larger venue or field-of-play (e.g., motorsports) that require additional power, the power module **146** of athlete monitoring unit **110** may include an on-board battery and an auxiliary battery (e.g., at least one lithium-ion battery) on the athlete (e.g., in the helmet, jersey, pads, or the like) that is coupled to an intermediate communication module **150**, such as a repeater, for long distance communication to a base station **160** (such as described above). By way of non-limiting example, such a repeater may be a Class 1 BLUETOOTH® module, or other mid-range communications module, as described above. In at least some configurations, each of the batteries are rechargeable. In some configurations, the batteries are rechargeable using an induction charging system. In still other configurations, the athlete monitoring unit **110** is configured to scavenge or harvest energy, such as from the athlete, the athlete monitoring unit **110**, and/or the environment, to recharge batteries and/or power the device. For example, the athlete monitoring unit **110** may include piezoelectric materials that generate electric voltage in response to mechanical stresses, such as by an athlete biting the mouthguard **120**.

TABLE 2

Dimensions of Various Sports Venues[1]

Dimensions Venue	Length, Ft.	Width, Ft.
Football field	360	160
Soccer Field	330 ≤ L ≤ 363	211 ≤ W ≤ 248
Basketball Court (NBA)	94	50
Tennis Court[2]	78	27
Lacrosse	330	180
Baseball (Outfield Wall)	250 ≤ OW ≤ 421	NA
Hockey	200	85
Track & Field[3]	216	108

NOTES:

[1]It should be noted that for sports where the base station can be located on the field-of-play center-line, the required transmission distance is only +/− half of the court dimension, i.e., for a football application with the base station located on the center line the required transmission range is approximately +/−180 feet. In this case, the 180 ft. dimension fits readily within the 330 ft. BLE specification, whereas the 360 ft. field dimension does not.

[2]Tennis court widths for 'doubles' matches extends to 36 ft.

[3]Track median dimensions.

[0032] Having now fully set forth the preferred embodiments and certain modifications of the concept underlying the present invention, various other embodiments as well as certain variations and modifications of the embodiments herein shown and described will obviously occur to those skilled in the art upon becoming familiar with said underlying concept. Thus, it should be understood, therefore, that the invention may be practiced otherwise than as specifically set forth herein.

What is claimed is:

1. A system for monitoring the physiological condition of an athlete, comprising:

at least one athlete monitoring unit comprising:

a mouthguard;

at least one sensor attached to said mouthguard, wherein said sensor is configured to sense a physiological condition of an athlete on which said athlete monitoring unit is worn; and

a microcontroller in data communication with said at least one sensor; and

a base station having a processor and a data memory, wherein said base station is in data communication with said athlete monitoring unit, said base station having computer executable code stored thereon configured to:

receive physiological data from said athlete monitoring unit;

compare said physiological data received from said athlete monitoring unit with a preset threshold value for said physiological data; and

upon a determination at said base station that said physiological data received from said athlete monitoring unit exceeds said threshold value, generate at said base station a human-discernable alert.

2. The system of claim **1**, wherein said computer executable code stored on said base station is further configured to:

determine at said base station whether said physiological data received from said athlete monitoring unit over a specified period of time exceeds a threshold cumulative value for said physiological data; and

upon a determination that said physiological data received form said athlete monitoring unit over a specified period of time exceeds a threshold cumulative value for said physiological data, generate at said base station a human-discernable alert.

3. The system of claim **1**, said microcontroller further comprising a processor and said athlete monitoring unit further comprising a data storage module and a communication module.

4. The system of claim **3**, wherein said processor of said microcontroller further comprises computer executable code stored thereon configured to:

continuously record at said data storage module data received from said at least one sensor;

determine at said microcontroller whether data received from said at least one sensor at a specific time exceeds a threshold value;

upon a determination that said data received from said at least one sensor at a specific time exceeds said threshold value, cause said communication module to transmit to said base station a collection of said data received from said at least one sensor and stored in said data storage module, wherein said collection of said data further comprises data from before, during, and after said specific time.

5. The system of claim **4**, wherein said microcontroller is further configured to delete physiological data from said data storage module during time periods in which said data received form said at least one sensor does not exceed said threshold value.

6. The system of claim **1**, wherein said athlete monitoring unit further comprises at least a second sensor attached to equipment worn by said athlete other than said mouthguard.

7. The system of claim **6**, wherein said first and second sensors comprise accelerometers.

8. The system of claim **7**, wherein said second accelerometer is affixed to a helmet worn by said athlete.

9. The system of claim **6**, wherein said first and second sensors are selected from the group consisting of accelerometers, gyroscopes, thermometers, hydrometers, pH sensors, electrolyte sensors, and heart rate monitors.

10. The system of claim **9**, wherein said computer executable code on said base station is further configured to detect from data received from said first and second sensors at least one physiological condition of said athlete selected from the group consisting of head impact, body temperature, body hydration, illness, and heart rate.

11. The system of claim **1**, further comprising an intermediate communication module in data communication with said athlete monitoring unit and said base station, wherein said intermediate communication module is configured to forward data received from said athlete monitoring unit to said base station.

12. The system of claim **1**, wherein said microcontroller is worn by said athlete separate from said mouthguard, said athlete monitoring unit further comprising wiring interconnecting said mouthguard with said microcontroller, wherein said wiring is affixed to an attachment strap extending between said mouthguard and equipment worn by said athlete.

13. The system of claim **1**, further comprising a device-side user interface in data communication with said athlete monitoring unit, said device-side user interface having computer executable code configured to:

modify data signal sensitivity at said athlete monitoring unit;

set threshold data levels at said athlete monitoring unit;

initialize said athlete monitoring unit; and

establish a unique identified for each athlete monitoring unit.

14. The system of claim **13**, wherein said computer executable code of said base station is further configured to:

provide at said base station further a monitoring-side user interface, wherein said monitoring-side user interface is further configured to:

start and stop monitoring and data acquisition of said system;

generate data-dependent alerts at said base unit;

maintain a time-base for said athlete monitoring units;

monitor battery levels of said athlete monitoring units;

initiate communications with healthcare providers in response to data received from said at least one athlete monitoring unit; and

register individual athlete monitoring units to said system.

15. A method for monitoring athlete physiological data, comprising:

providing at least one athlete monitoring unit comprising:

a mouthguard;

at least one sensor attached to said mouthguard, wherein said sensor is configured to sense a physiological condition of an athlete on which said athlete monitoring unit is worn; and

a microcontroller in data communication with said at least one sensor; and

providing a base station having a processor and a data memory, wherein said base station is in data communication with said athlete monitoring unit;

receiving at said base station physiological data from said athlete monitoring unit;

comparing at said base station said physiological data received from said athlete monitoring unit with a preset threshold value for said physiological data; and

upon a determination at said base station that said physiological data received from said athlete monitoring unit exceeds said threshold value, generating at said base station a human-discernable alert.

* * * * *

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摘要(译)

公开了一种智能的生理监测护齿（SPMM）系统和方法，用于实时捕获运动员的各种生理数据以进行健康监测。 该系统被配置为向用户提供运动员的实时和/或记录的生理数据，并且可以被配置为记录运动员的生理数据以用于以后使用传感器和通信系统进行检索。 可以基于预期的活动或运动，运动员的健康状况和年龄以及设备的尺寸和功率要求来选择传感器。 传感器可以包括加速计，陀螺仪，温度计，比重计，pH，电解质（例如，钾，钠等）传感器等。 这些传感器和其他传感器可以被配置为测量运动员的不同生理数据，包括冲击，体温，水合作用，疾病，心率等。 在一些实施例中，护齿器上的传感器与运动员上的外部传感器（例如，头盔上的加速度计，戴在胸前的心率监视器）集成在一起，以提供附加的或更准确的生理数据。