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Hu(10) **Pub. No.: US 2016/0089059 A1**(43) **Pub. Date: Mar. 31, 2016**(54) **SYSTEMS AND METHODS FOR POSTURE
AND VITAL SIGN MONITORING**(71) Applicant: **Darma Inc.**, Palo Alto, CA (US)(72) Inventor: **Junhao Hu**, Singapore (SG)(21) Appl. No.: **14/738,918**(22) Filed: **Jun. 14, 2015****Related U.S. Application Data**

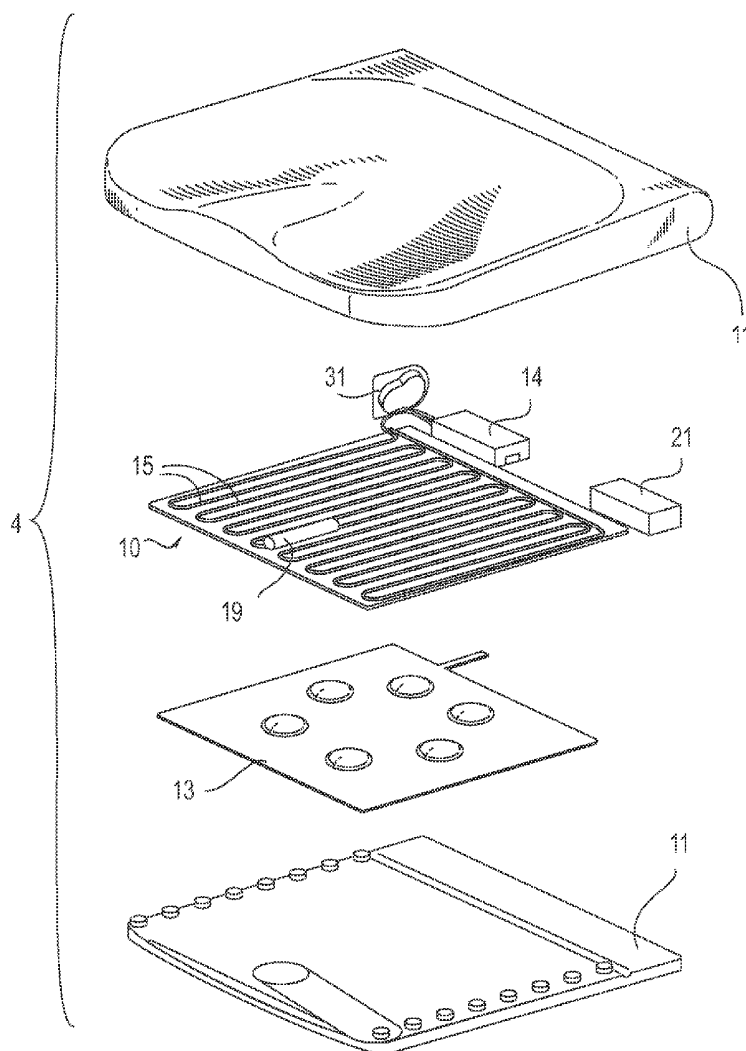
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(57)

ABSTRACT

Systems and methods of monitoring posture and vital signs are disclosed. In some embodiments, the system includes a cushion on which a user can sit. The cushion includes a first optical fiber sensor, a second sensor, and a first computing device. The system may further include a second computing device communicatively coupled to the first computing device and configured to receive sensor data from the first computing device. One or both of the first and second computing devices may operate to combine a signal indicative of the movement of the user with a signal indicative of the direction of movement of the user to determine a posture of the user. The system may provide feedback based on the user's posture and recommend actions to improve posture. The system may further monitor the user's heart rate, respiration rate, or other vital signs.



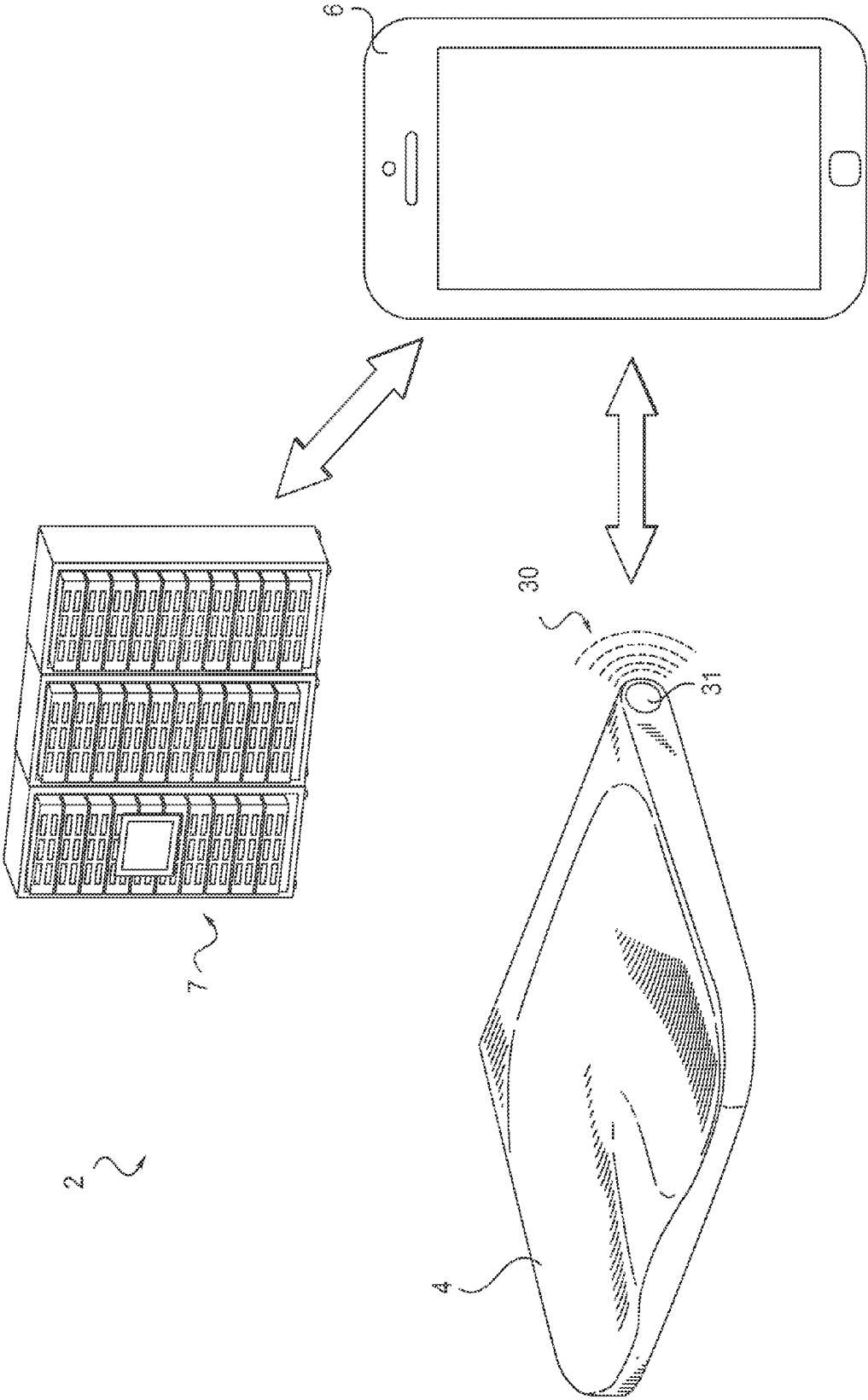


FIG. 1

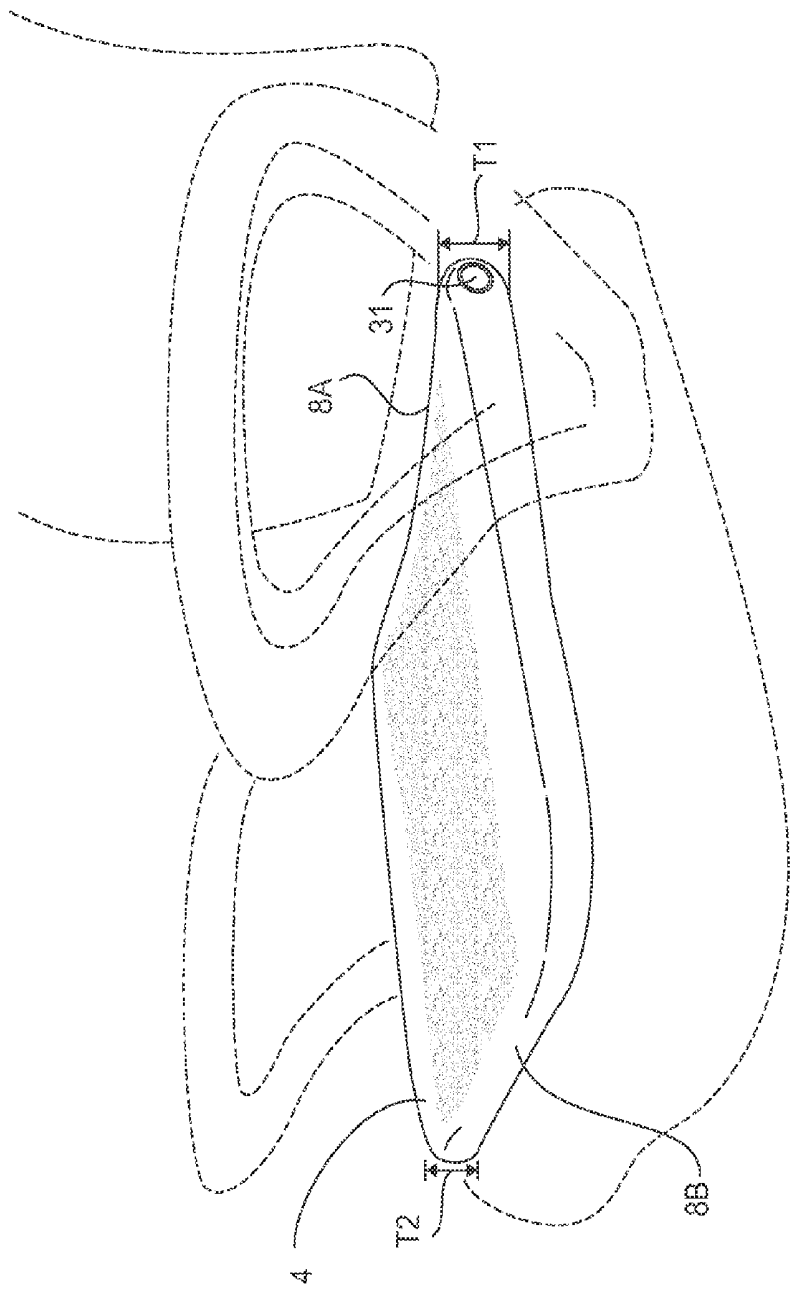


FIG. 2

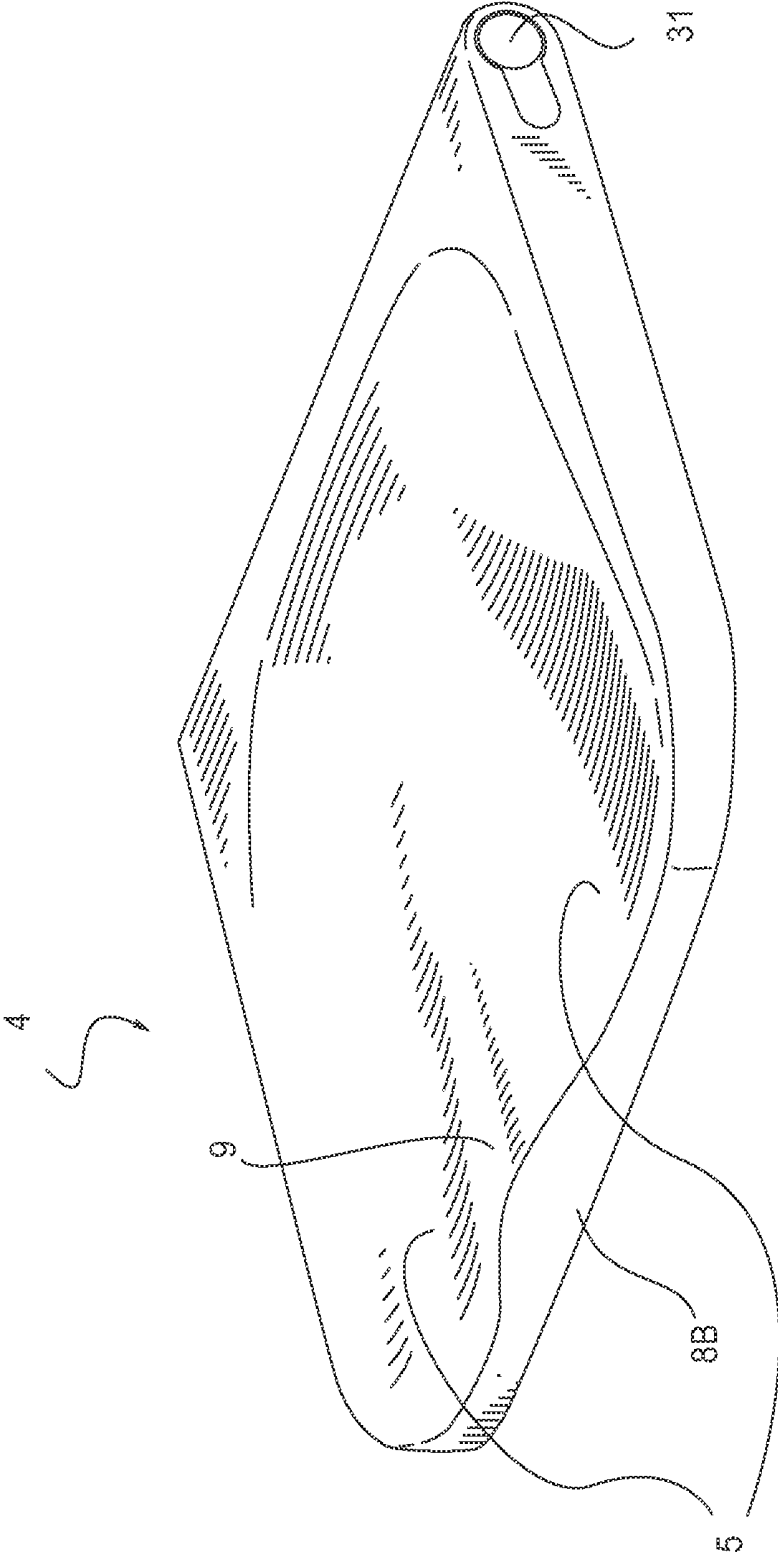


FIG. 3A

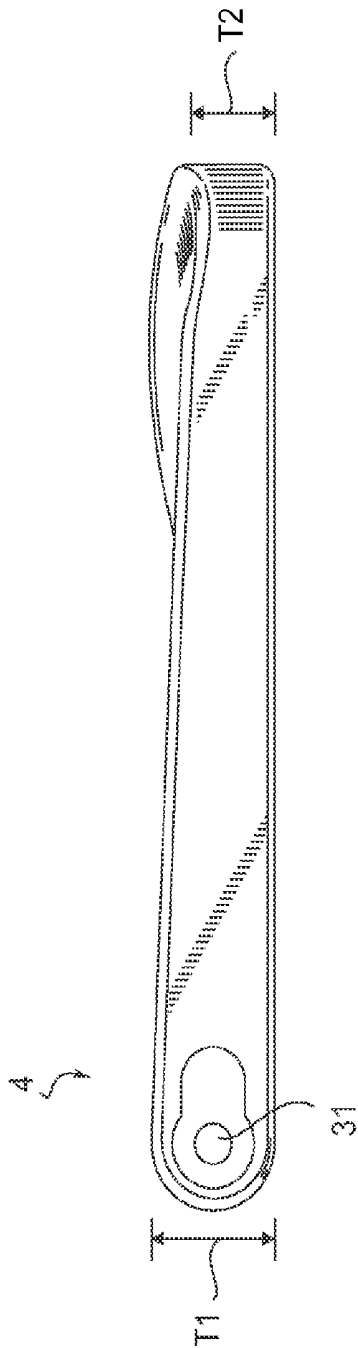


FIG. 3B

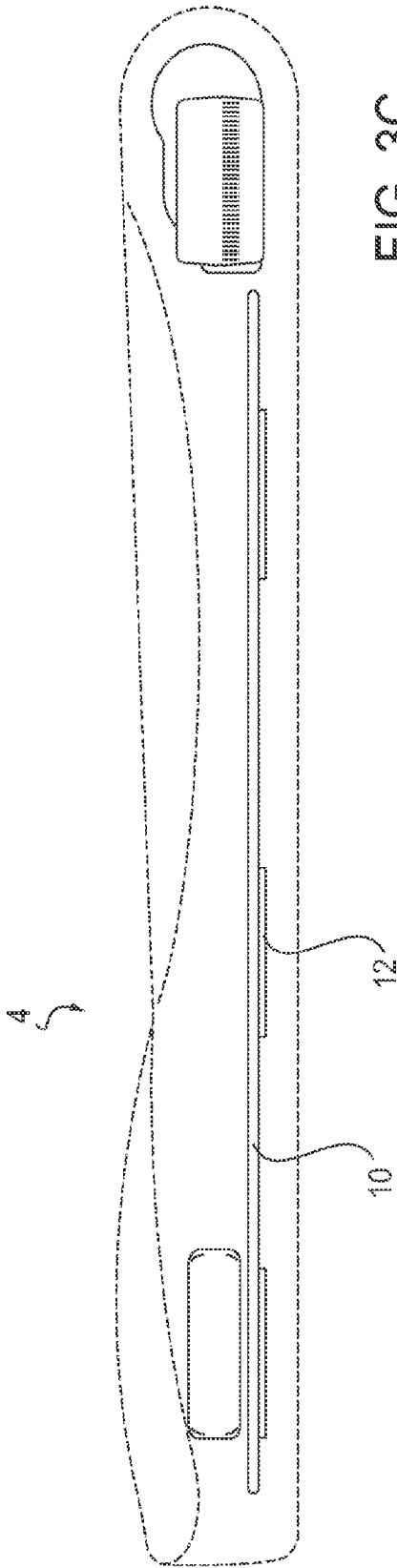


FIG. 3C

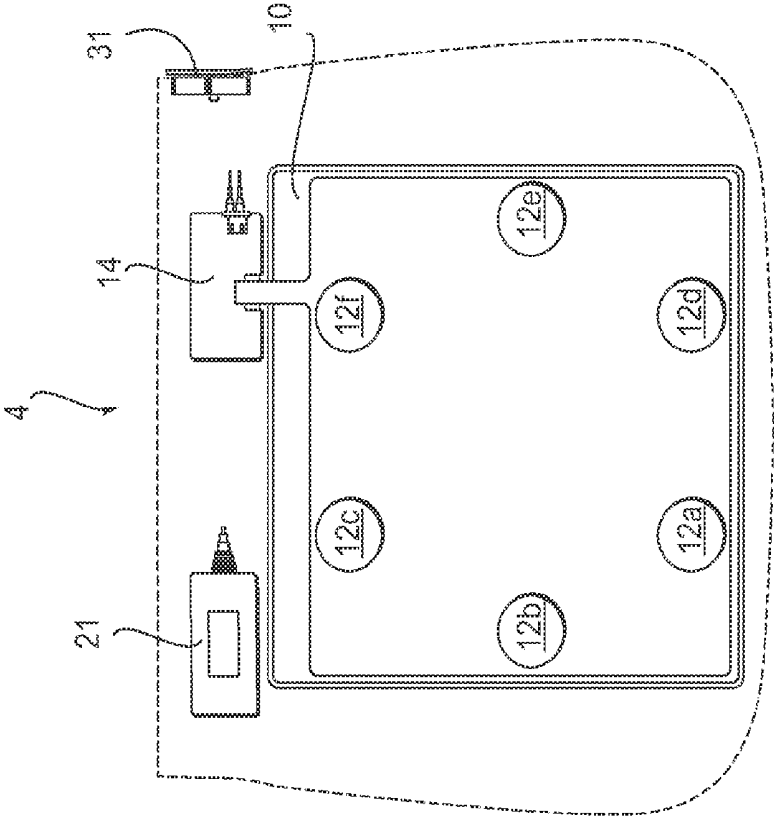


FIG. 3E

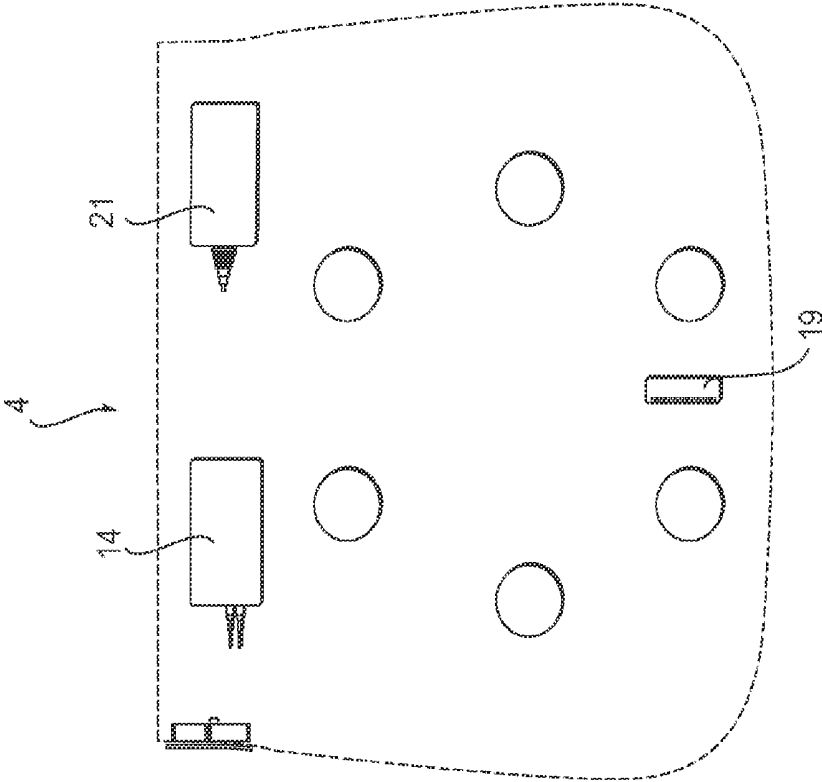


FIG. 3D

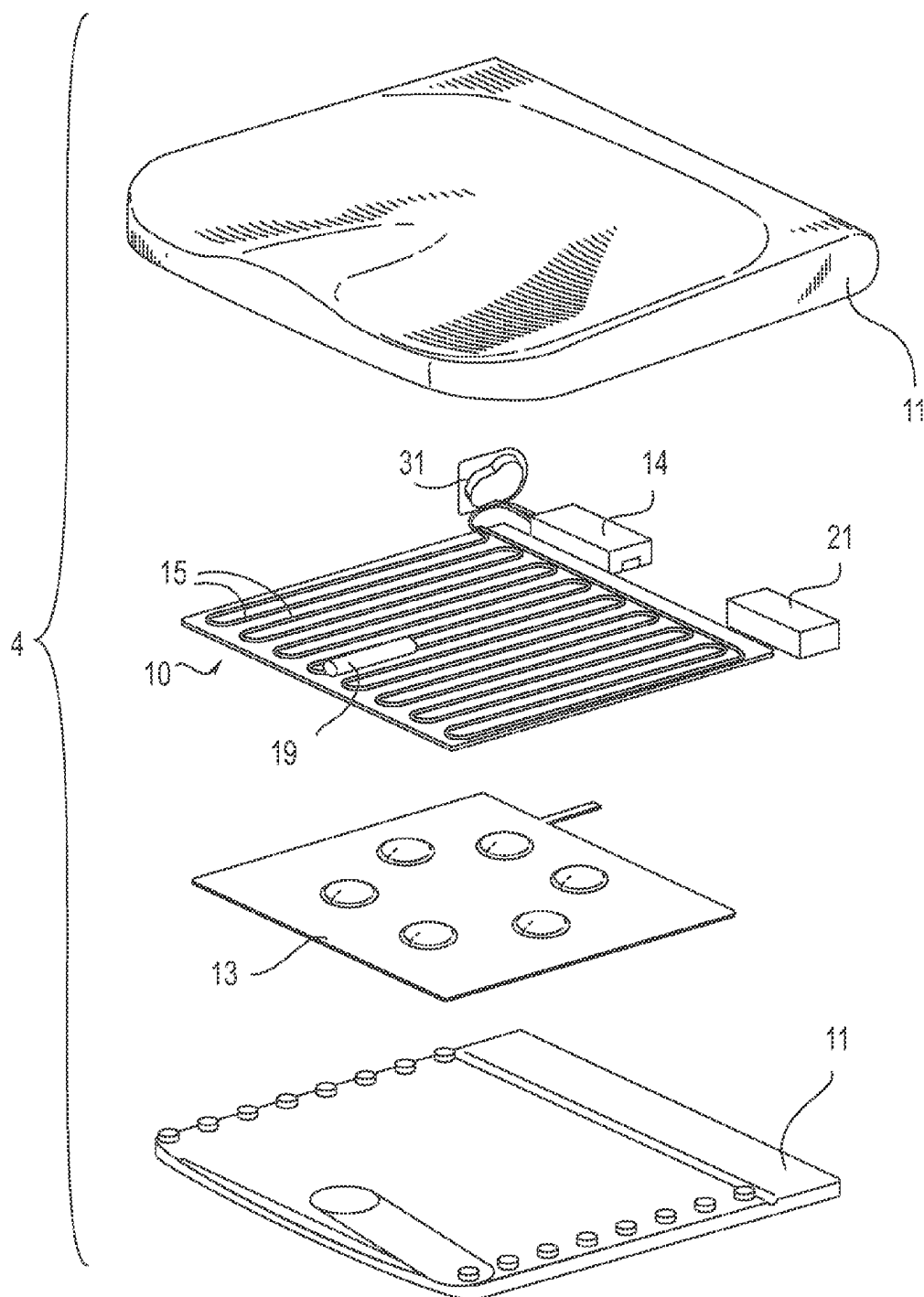


FIG. 3F

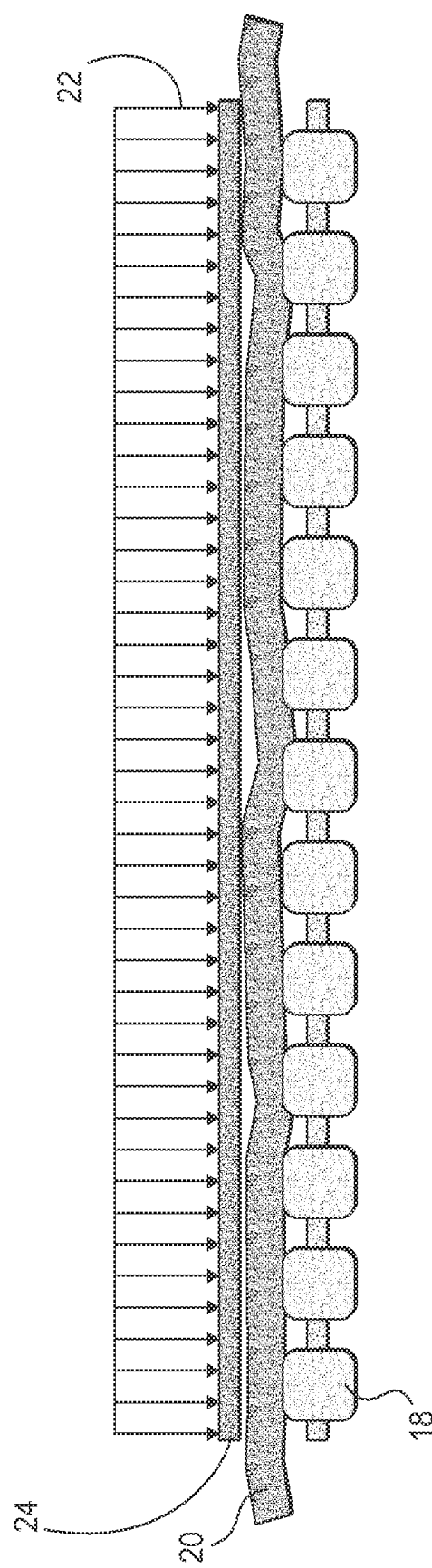
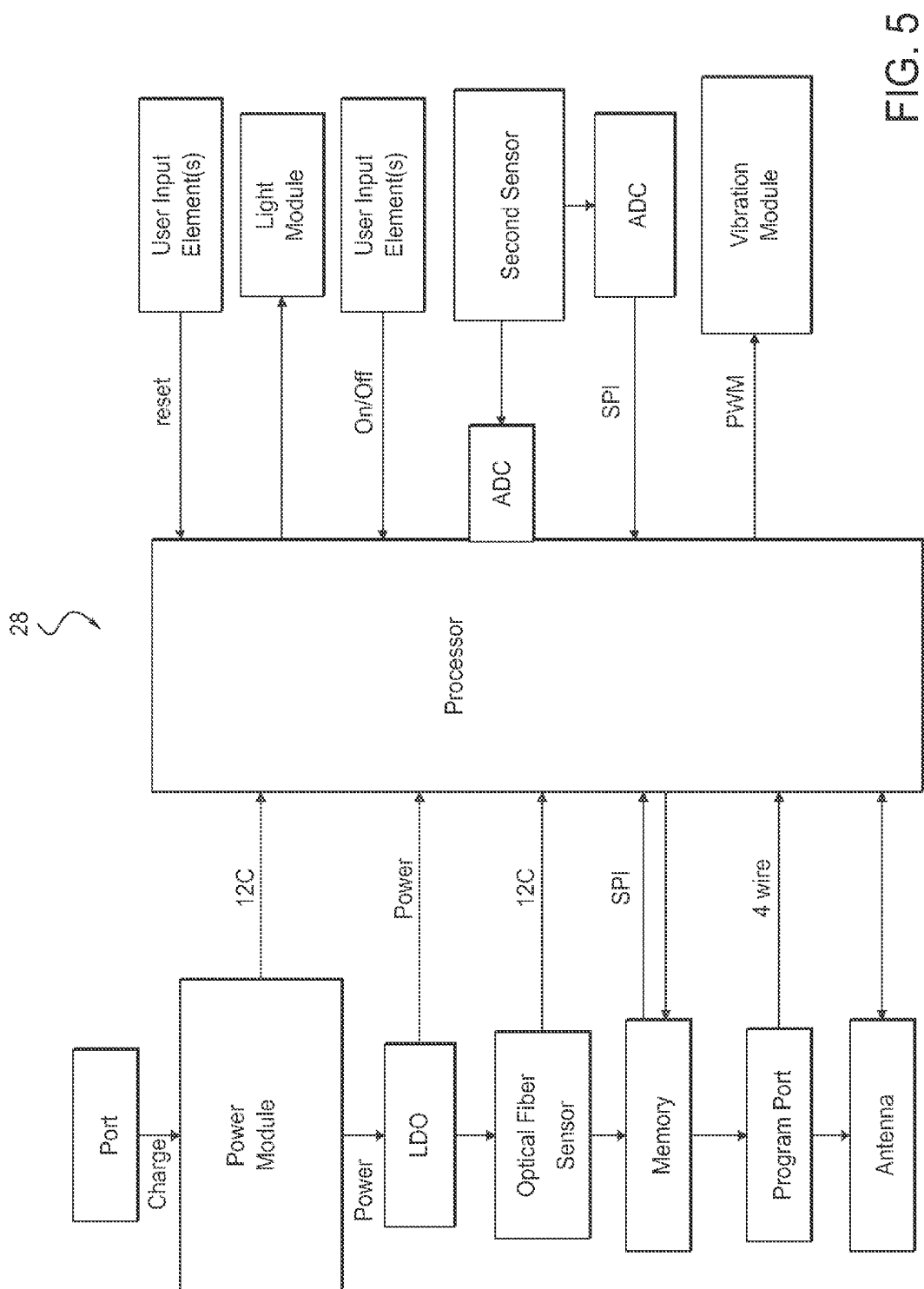


FIG. 4



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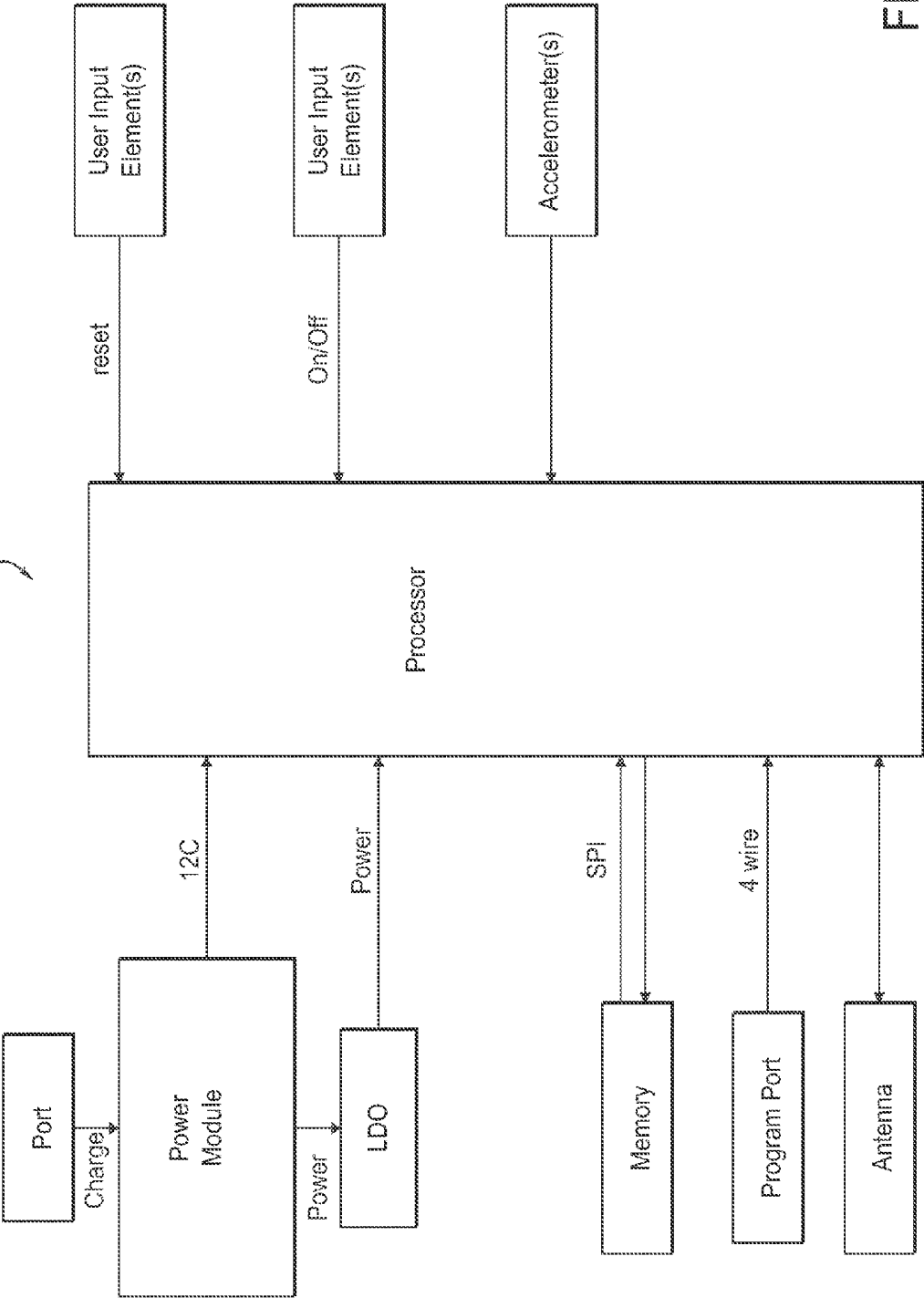


FIG. 6

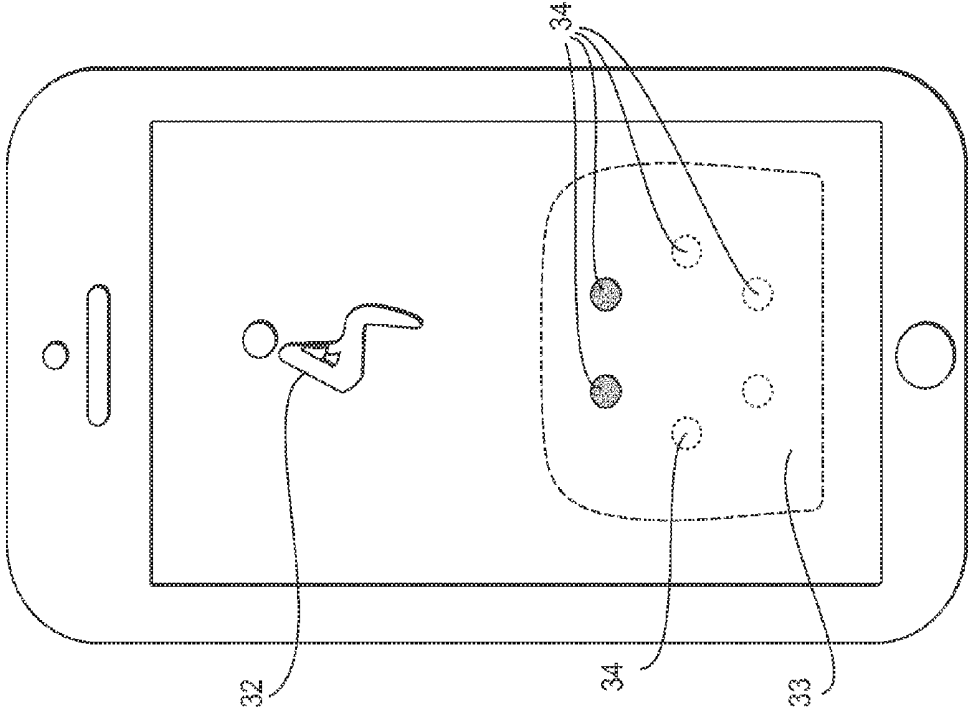


FIG. 7A

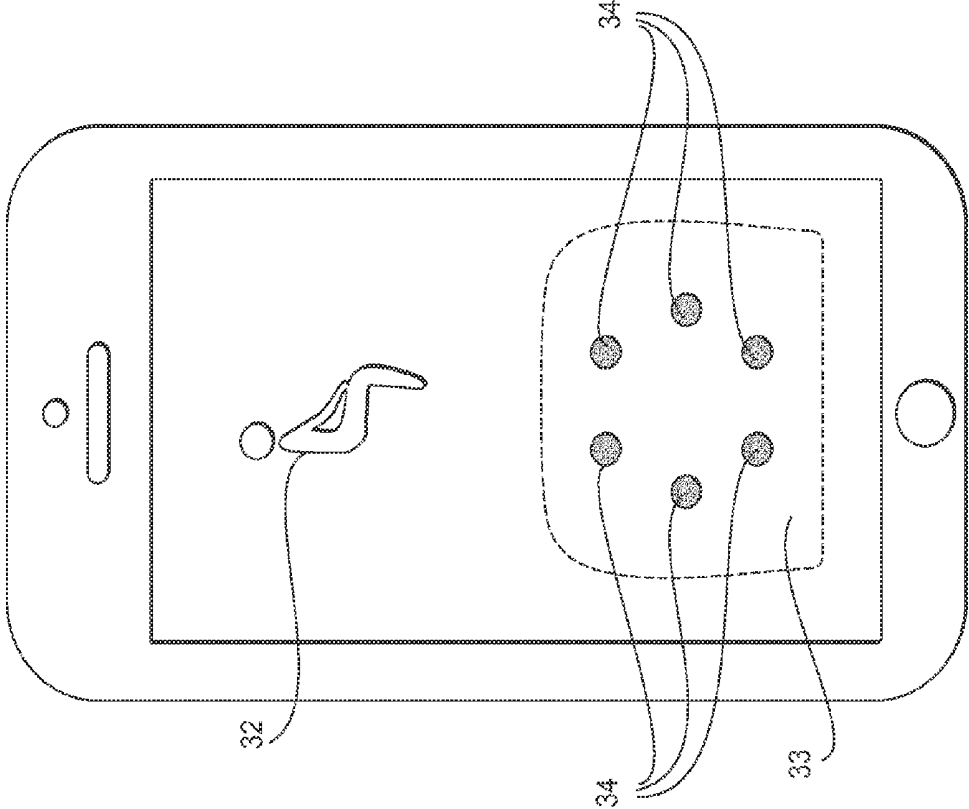


FIG. 7B

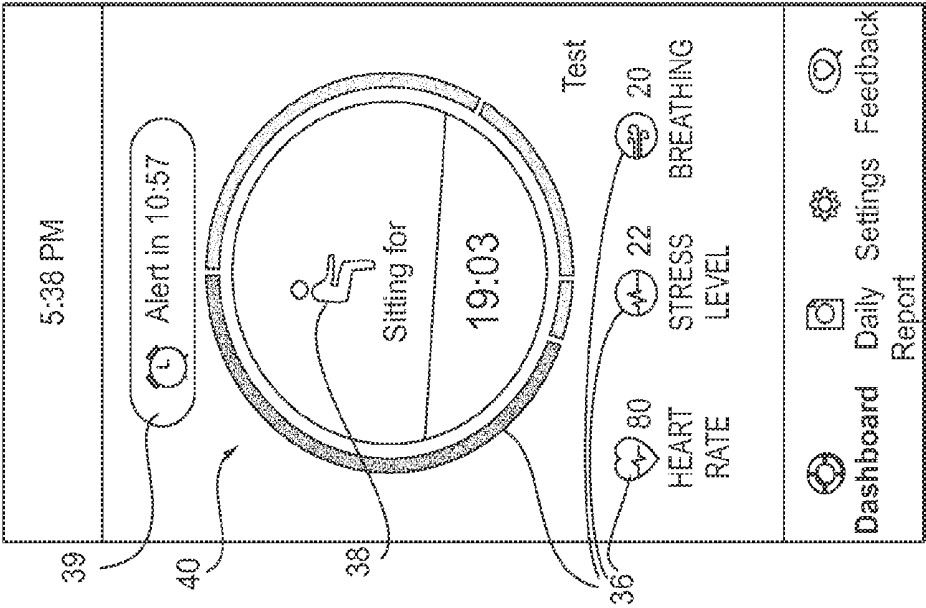


FIG. 8A

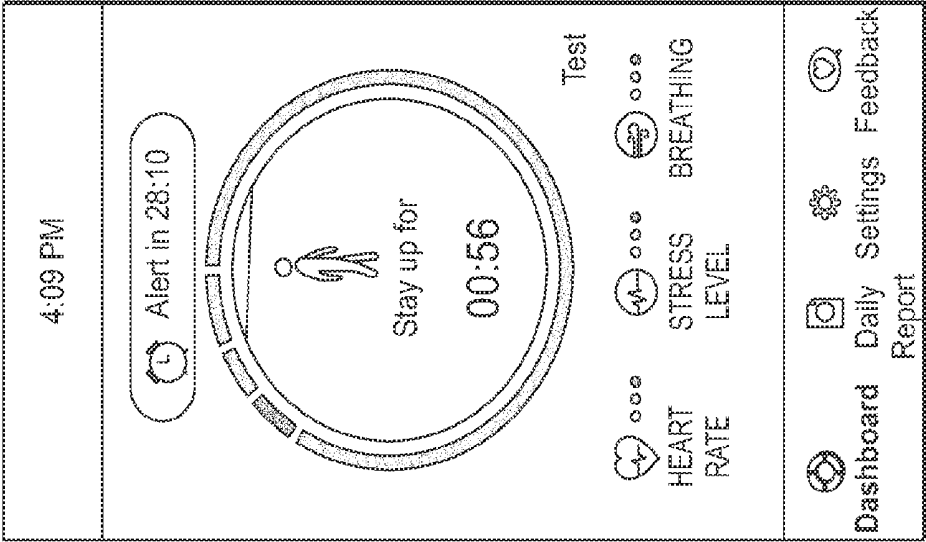


FIG. 8B

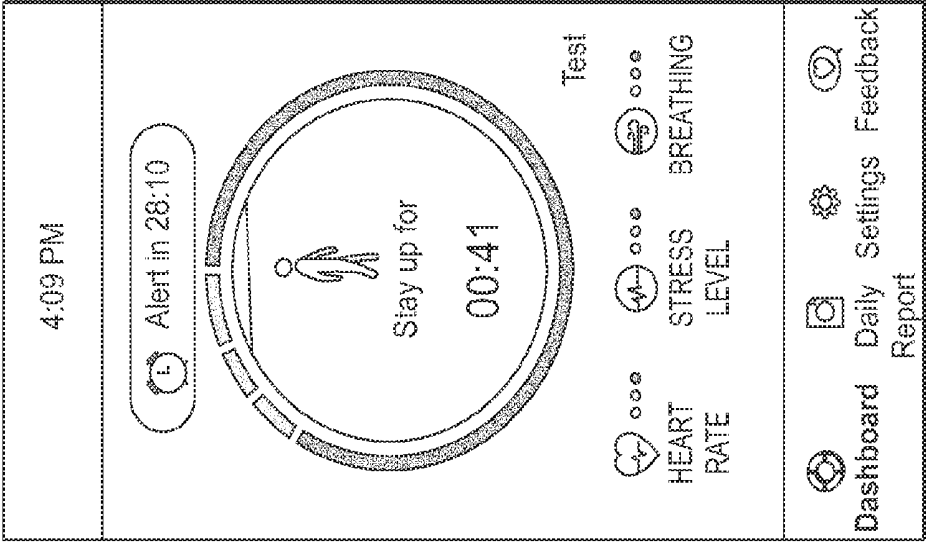


FIG. 8C

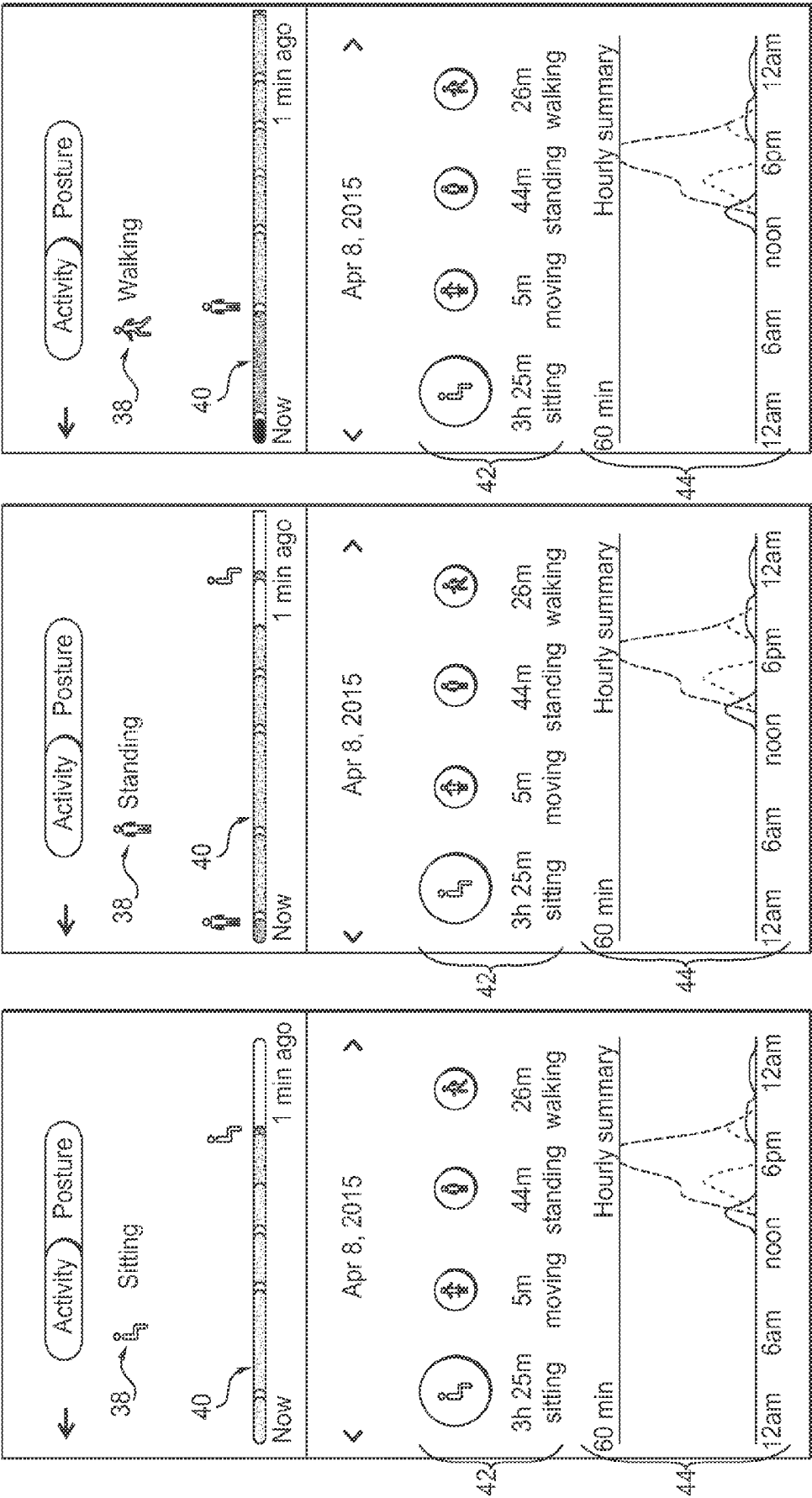


FIG. 8F

FIG. 8E

FIG. 8D

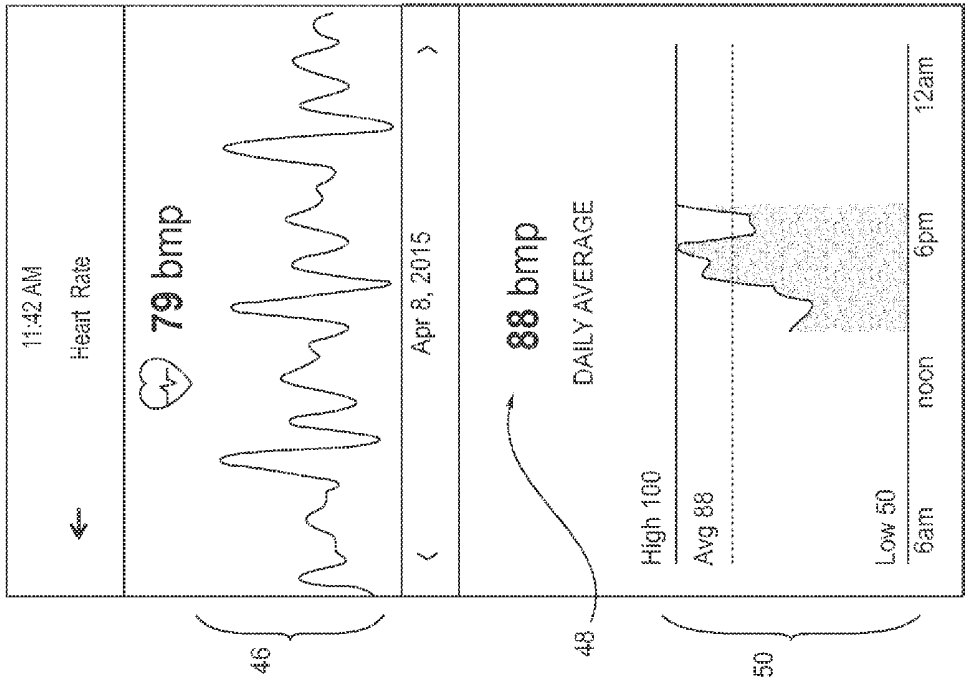


FIG. 8G

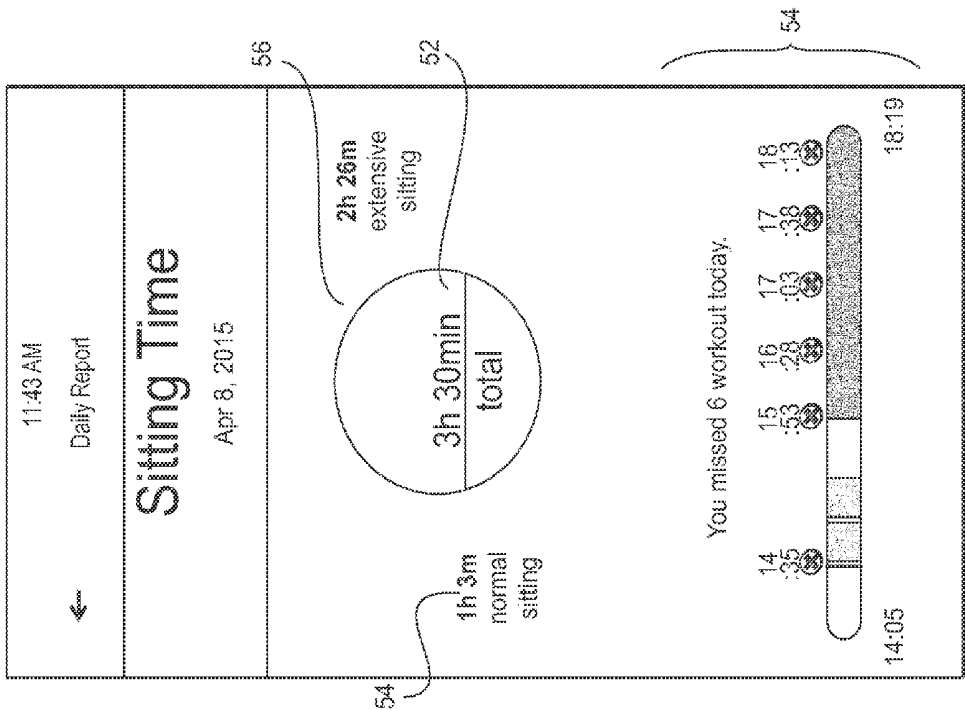


FIG. 8H

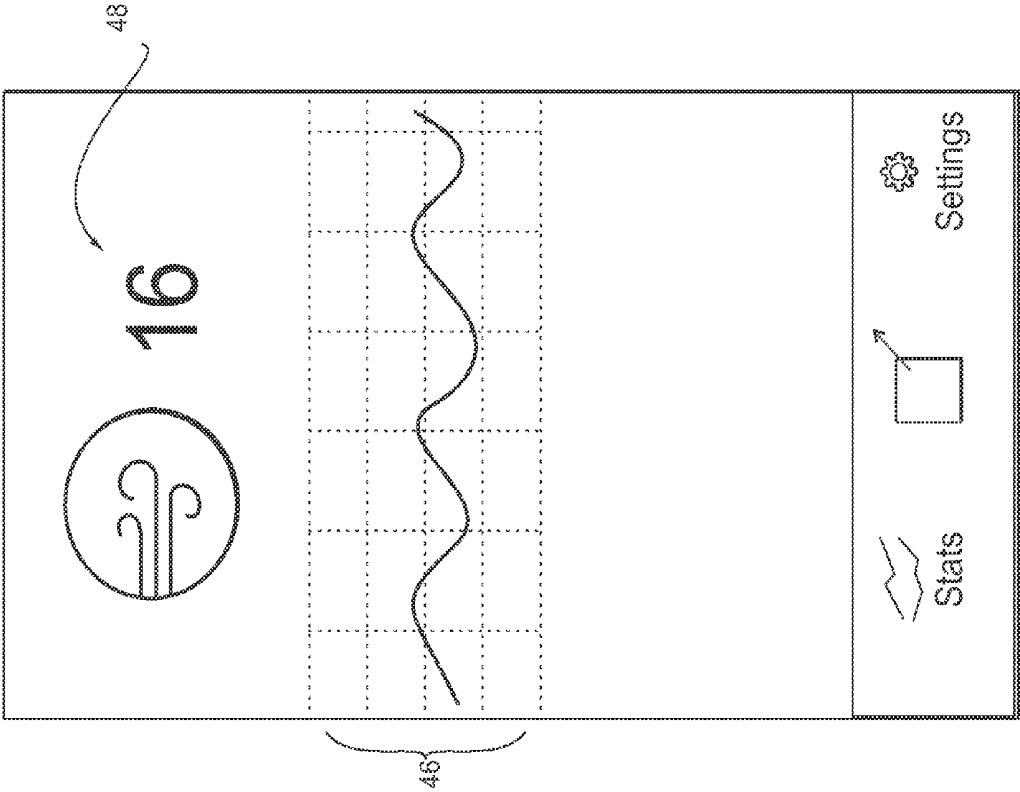


FIG. 8I

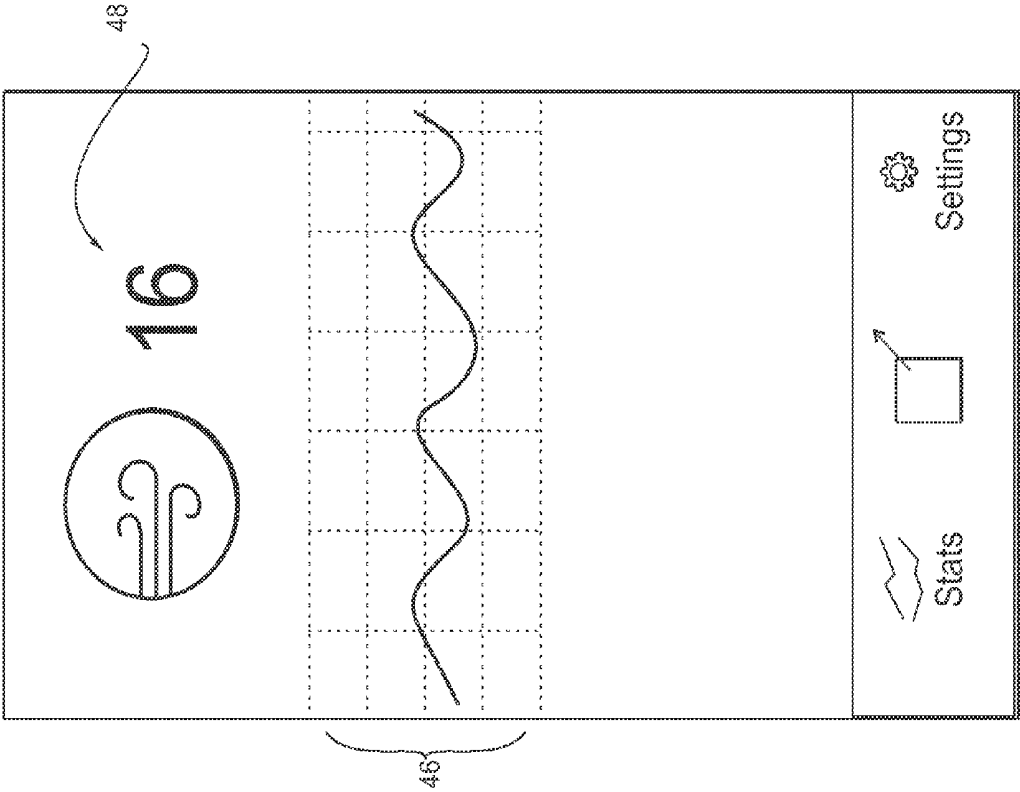


FIG. 8J

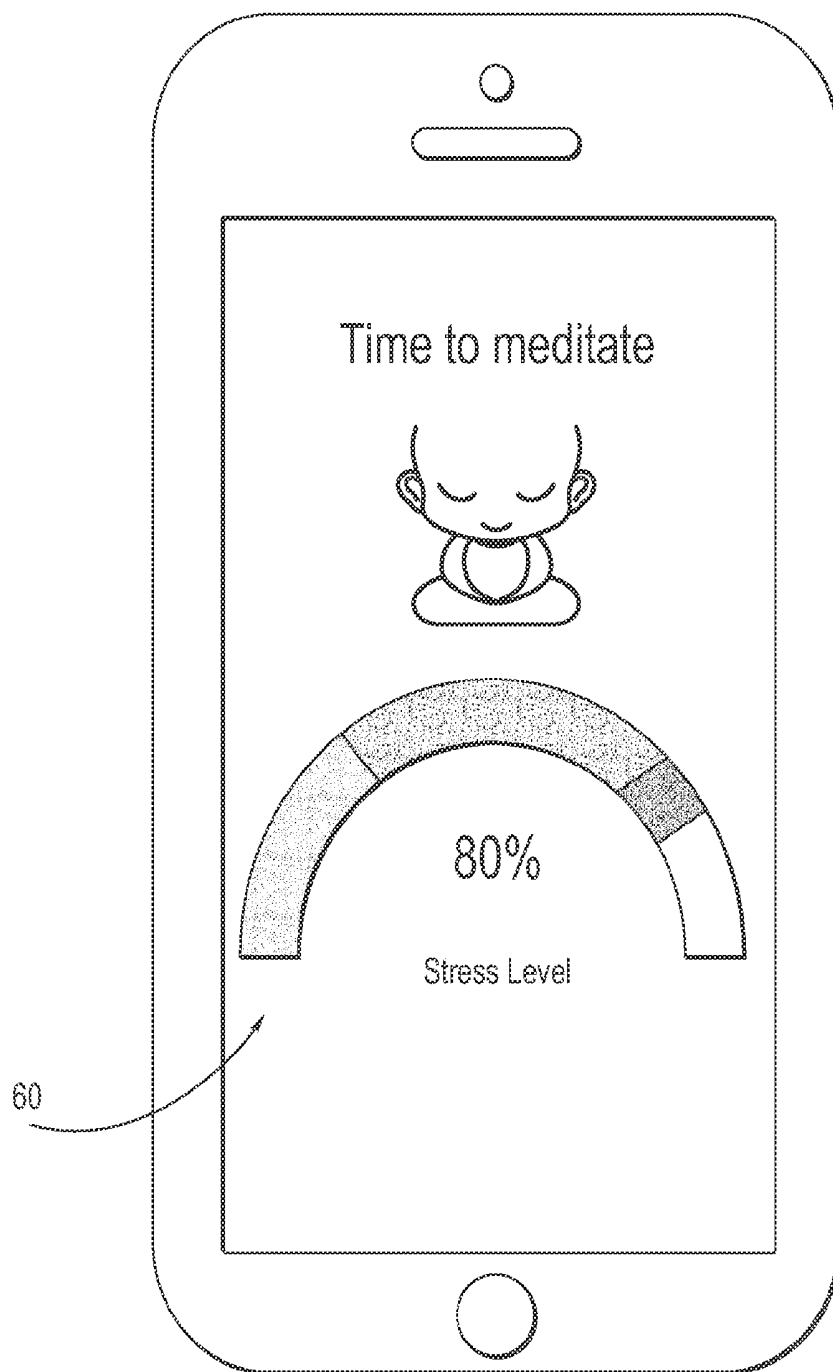


FIG. 9

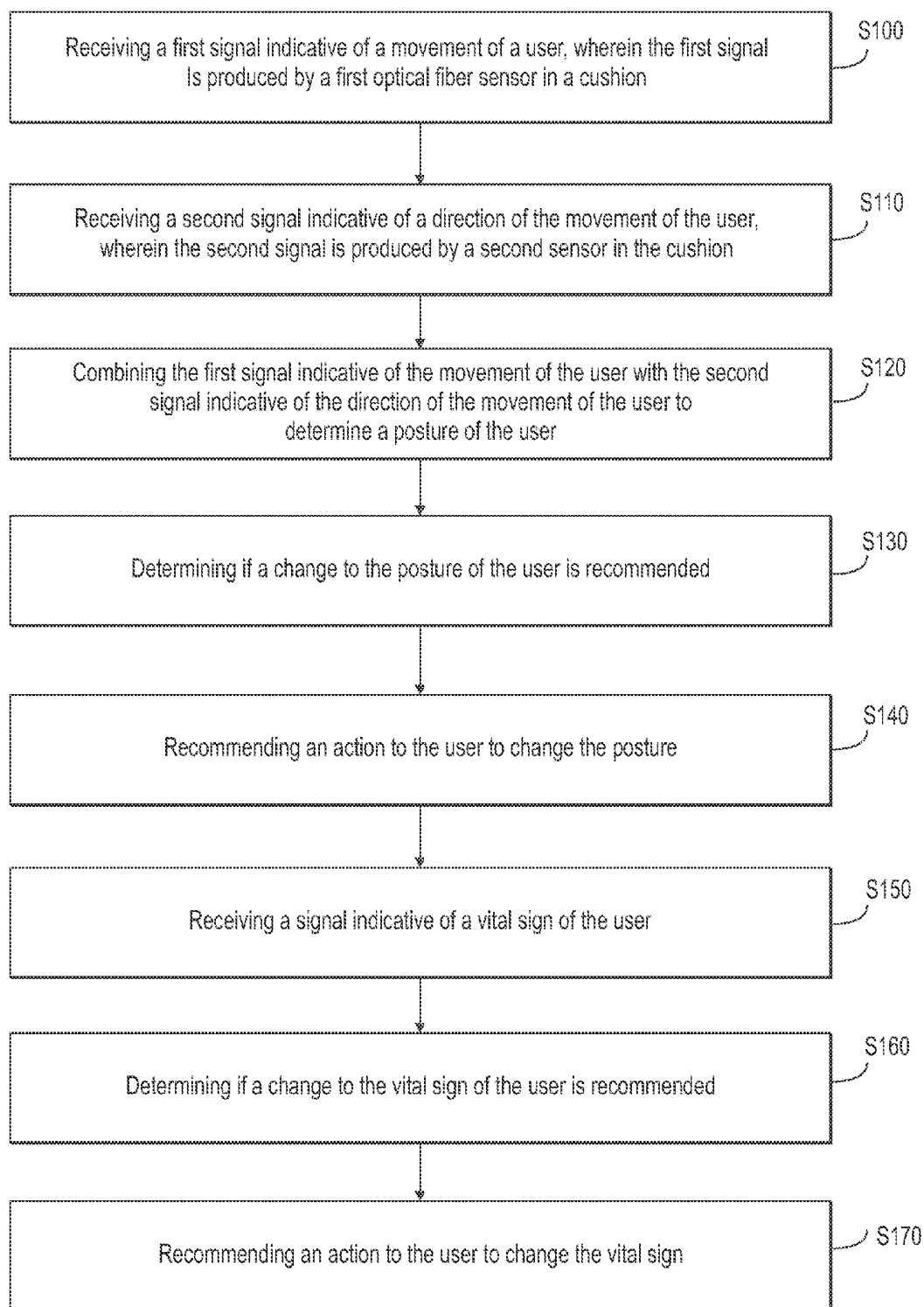


FIG. 10

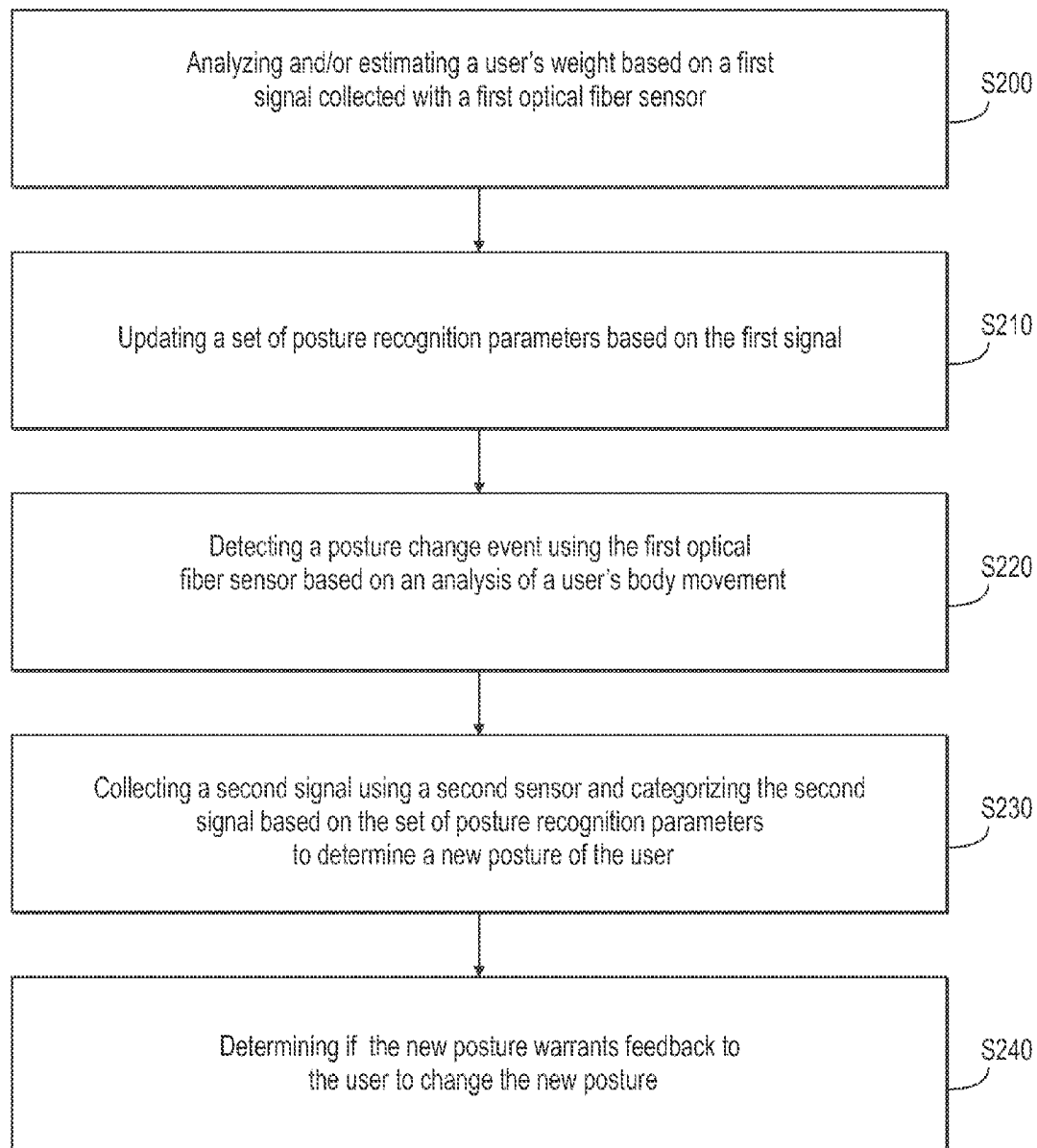


FIG. 11

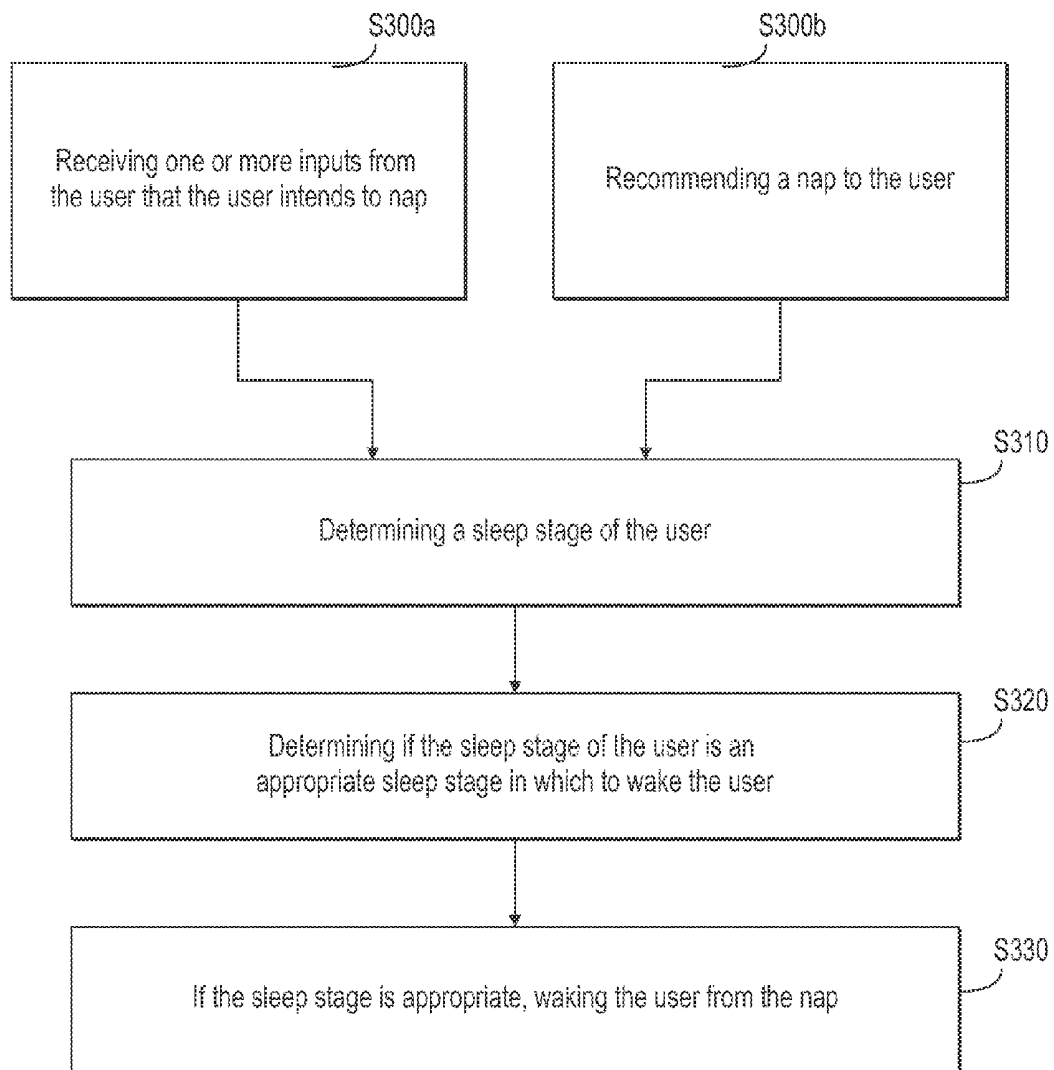


FIG. 12

SYSTEMS AND METHODS FOR POSTURE AND VITAL SIGN MONITORING

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority under 35 U.S.C. §119(e) to U.S. Provisional Appl. No. 62/057,237 entitled “Vital Signs Fiber Optic Sensor”, filed Sep. 30, 2014, the contents of which is herein incorporated by reference in its entirety.

INCORPORATION BY REFERENCE

[0002] All publications and patent applications mentioned in this specification are herein incorporated by reference in their entirety, as if each individual publication or patent application was specifically and individually indicated to be incorporated by reference in its entirety.

TECHNICAL FIELD

[0003] This invention relates generally to the fields of health and wellness, and more specifically to new and useful systems and methods for posture and vital sign monitoring.

BACKGROUND

[0004] The average American sits eleven hours per day. Further, roughly 23.5% of adults in the United States do not engage in physical activity. Physical inactivity accounts for approximately \$24 billion in direct medical spending. Increases in sedentary lifestyles are at least partially due to increased availability of desk jobs, videogame and television entertainment, and modern conveniences (e.g., elevators, motorized transportation, home or internet-based shopping, etc.). Leading a sedentary lifestyle is linked to increased morbidity as well as poor posture and increased stress, neck strain, heart disease, colon cancer, joint pain, and varicose veins, among other health issues.

[0005] Furthermore, inactivity and poor posture can lead to lower back pain and other back problems. Back pain can be debilitating for an individual and exacts a substantial economic cost on society—back pain is the most common cause of job-related disability and a leading contributor to missed work days. For many, back pain may be avoided or reduced by maintaining good posture, particularly during prolonged periods of sitting. While many people know the importance of good posture, it can be very difficult to remain mindful of resisting the pull of gravity on the spine when sitting for any extended period of time.

[0006] Currently, some portable devices, such as wireless heart rate monitors and other wearable devices, measure one or more vital signs. Other portable devices count steps or otherwise monitor an indicator of activity level. However, with existing consumer devices, it is difficult to monitor posture, to accurately measure vital signs, to remember to perform one or more physical activities, to know when it is appropriate or necessary to perform these activities, and to gauge individual progress. Thus, there is a need for new and useful systems and methods for posture and vital sign monitoring. This invention provides such new and useful systems and methods.

SUMMARY

[0007] Described herein are systems and methods for posture and vital sign monitoring. One aspect of the disclosure is directed to a system for posture monitoring, and optionally, vital sign monitoring. In general, the system for posture and vital sign monitoring includes a cushion. In some embodiments, the cushion is portable. In some embodiments, the cushion forms a portion of a chair, seat, sleeping pod, or couch. In some embodiments, the cushion further includes a memory foam layer.

[0008] In various embodiments, the cushion includes: a first optical fiber sensor configured to produce a first signal indicative of a movement of a user, a second sensor configured to produce a second signal indicative of a direction of the movement of the user, and a first computing device including a first processor and memory having a first set of instructions stored thereon.

[0009] In some embodiments, the first optical fiber sensor includes a one-layer deformer structure. In some embodiments, the second sensor is a second optical fiber sensor. In some embodiments, the second sensor is a pressure sensor. In some embodiments, the first optical fiber sensor or the second sensor is further configured to produce an additional signal indicative of a vital sign of the user. In some embodiments, the vital sign is a respiratory waveform and/or a cardiac waveform.

[0010] Optionally, in some embodiments, a system for posture and vital sign monitoring includes a second computing device. In some embodiments, the second computing device includes a smartphone, wearable computing device, tablet, laptop, other portable computing device, or a remote server.

[0011] In some embodiments, the second computing device is communicatively coupled to the first computing device. In some embodiments, the first computing device and the second computing device communicate wirelessly. In some embodiments, the second computing device includes a second processor and memory having a second set of instructions stored thereon. In some embodiments, execution of the first and second set of instructions causes a method to be performed including: transmitting data from the first computing device to the second computing device; combining the first signal indicative of the movement of the user with the second signal indicative of the direction of the movement of the user to determine a posture of the user; determining if a change to the posture of the user is recommended; and if change to the posture of the user is recommended, recommending an action to the user via the second computing device. In some embodiments, an action recommended to a user includes standing, walking, correcting posture, and/or stretching.

[0012] Another aspect of the disclosure is directed to a method for posture monitoring, and optionally, vital sign monitoring. In various embodiments, the computerized method for posture and vital sign monitoring includes: receiving a first signal indicative of a movement of a user; receiving a second signal indicative of a direction of the movement of the user; combining the first signal indicative of the movement of the user with the second signal indicative of the direction of the movement of the user to determine a posture of the user; determining if a change to the posture of the user is recommended; and if change to the posture of the user is recommended, recommending an action to the user to change the posture.

[0013] In some embodiments, the first signal is produced by a first optical fiber sensor in a cushion. In some embodiments, the second signal is produced by a second sensor in the cushion. The second sensor may be another optical fiber sensor, a pressure sensor, or other suitable sensor. In some embodiments, the action recommended to the user includes standing, walking, stretching, and/or correcting posture.

[0014] In some embodiments, a computerized method for posture and vital sign monitoring includes identifying if the user is sitting upright with a neutral spine position or if the user is leaning forward, leaning backward, leaning left, leaning right, slouching, and/or otherwise sitting in a position other than the neutral spine position.

[0015] In some embodiments, a computerized method for posture and vital sign monitoring includes generating an alert on the first or second computing device if change to the posture of the user is recommended.

[0016] In some embodiments, a computerized method for posture and vital sign monitoring includes receiving an additional signal indicative of a vital sign of the user. In some embodiments, the additional signal is produced by the first optical fiber sensor or the second sensor. In some embodiments, the vital sign is a respiratory waveform and/or a cardiac waveform of the user. In some embodiments, a computerized method for posture and vital sign monitoring includes determining a stress level of the user based, at least in part, on a change in a variability of the cardiac waveform. In some embodiments, a computerized method for posture and vital sign monitoring includes determining if a change to the vital sign is recommended; and if change to the vital sign of the user is recommended, recommending an action to the user to change the vital sign. In some embodiments, the action recommended to the user includes standing, walking, stretching, and/or controlled/deliberate breathing. In some embodiments, a computerized method for posture and vital sign monitoring includes generating an alert on the first or second computing device if change to the vital sign is recommended.

[0017] In some embodiments, a computerized method for posture and vital sign monitoring includes monitoring a sleep cycle of the user based on the first signal, the second signal, and/or the additional signal. In some embodiments, a computerized method for posture and vital sign monitoring includes generating a stimulation signal to stimulate a vibrator within the cushion. In some embodiments, the stimulation signal is generated during an appropriate sleep cycle stage of the user and is generated, for example, to awaken the user.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] FIG. 1 illustrates a schematic diagram of one embodiment of a system for posture and vital sign monitoring;

[0019] FIG. 2 illustrates a perspective view of one embodiment of a cushion for posture and vital sign monitoring positioned on an office chair;

[0020] FIG. 3A illustrates a top perspective view of an exterior surface of one embodiment of a cushion for posture and vital sign monitoring;

[0021] FIG. 3B illustrates a left side view of an exterior surface of the cushion embodiment of FIG. 3A;

[0022] FIG. 3C illustrates a schematic right side view of an interior of the cushion embodiment of FIG. 3A;

[0023] FIGS. 3D and 3E illustrate a schematic top and bottom view, respectively, of an interior of the cushion embodiment of FIG. 3A;

[0024] FIG. 3F illustrates an exploded view of the internal layers of the cushion of FIG. 3A;

[0025] FIG. 4 illustrates a partial cross-sectional view of one embodiment of a cushion for posture and vital sign monitoring;

[0026] FIG. 5 illustrates a block diagram of one embodiment of a first or cushion computing device for posture and vital sign monitoring;

[0027] FIG. 6 illustrates a block diagram of one embodiment of a second or portable computing device for posture and vital sign monitoring;

[0028] FIGS. 7A and 7B illustrate various example views of one embodiment of a graphical user interface for monitoring and correcting posture;

[0029] FIGS. 8A-8J illustrate various example views of one embodiment of a graphical user interface for physical activity and vital sign monitoring;

[0030] FIG. 9 illustrates one embodiment of a graphical user interface for stress level monitoring and coaching;

[0031] FIG. 10 illustrates a flow chart of one embodiment of a method for posture monitoring and vital sign monitoring;

[0032] FIG. 11 illustrates a flow chart of one embodiment of a computer-implemented method for determining a posture of a user; and

[0033] FIG. 12 illustrates a flow chart of one embodiment of a method for influencing a user's nap based on one or more monitored vital signs.

DETAILED DESCRIPTION

[0034] The following description of certain embodiments of the invention is not intended to limit the invention to these embodiments, but rather to enable any person skilled in the art to make and use this invention. Disclosed herein are systems and methods for posture and vital sign monitoring.

[0035] In general, a system for posture and vital sign monitoring is used by a person (i.e., a user) at home, in an office (e.g., while working, waiting for or during an appointment, etc.), in a motorized vehicle, at a sporting event (e.g., an arena, field, coliseum, park, gym, range, rink, stadium, velodrome, etc.) or in any other location.

[0036] In some embodiments, a vital sign includes one or more of a heart rate, respiration rate, temperature, and blood pressure of a user. In some embodiments, the vital sign includes a cardiac waveform and/or respiration waveform.

[0037] In some embodiments, posture includes one or more of a position, a movement, and a direction of movement of a user. For example, a posture of a user may include a hunchback (i.e. kyphosis), a scoliotic spine, rounded shoulders, flatback, swayback (i.e. lordosis), leaning forward, leaning backward, leaning left, leaning right, sitting upright, twisting, slouching, or any other deviation from a healthy, neutral spine position. The neutral spine position is characterized in a healthy spine as an optimal position of three natural curves of the spine: a cervical (i.e., neck) region involving cervical vertebrae C1-C7, a thoracic (i.e., mid-back) region involving thoracic vertebrae T1-T12, and a lumbar (i.e., lower back) region involving lumbar vertebrae L1-L5. In a healthy back, the ideal position of: the cervical region is anteriorly convex, the thoracic region is posteriorly convex, and the lumbar region is anteriorly convex.

[0038] In some embodiments, a system for posture and vital sign monitoring includes monitoring a physical attribute of the user, for example, a total weight, weight distribution, or body mass index (BMI) of the user. In some embodiments, a

system for posture and vital sign monitoring includes determining and monitoring a stress level, heart rate variability, and/or respiration rate variability of the user.

[0039] In some embodiments, an average, minimum, maximum, healthy, and/or unhealthy vital sign and/or posture is determined by the system monitoring the user over time. For example, the system may calibrate to the user by monitoring the user for a time period (e.g., hour, day, week, etc.) to determine the normal variability in the user's cardiac and respiration waveforms and posture and to detect deviations from the normal variability. Alternatively or additionally, the system may compare a user's posture and cardiac and respiration waveforms to individuals in the user's same age group, sex group, ethnic group, social class, work environment, location, and/or any other comparable group to identify deviations from normal or healthy values.

Systems and Devices

[0040] FIG. 1 illustrates one embodiment of a system 2 for posture and vital sign monitoring. The system 2 includes a cushion 4 including a first optical fiber sensor and a second sensor, a first computing device in the cushion 4, and a second computing device 6 communicatively coupled (e.g., via Bluetooth, low-energy Bluetooth, other radiofrequency, etc.) to the first computing device. In some embodiments, there is two-way communication between the first computing device in the cushion and the second computing device. The system 2 functions to measure a posture and/or vital sign of the user and helps or enables the user to adjust the posture and/or vital sign. In some embodiments, a system 2 for posture and vital sign monitoring further includes a remote computing device 7 (e.g., server). The first and/or second computing device has two-way communication capability (e.g., via Wi-Fi, CDMA, other cellular protocol, other radiofrequency, other wireless protocol) with the remote server. The remote server may receive, store, and/or analyze one or more signals acquired by the first and/or second computing device from the optical fiber sensor and/or the second sensor.

[0041] Various embodiments of a system 2 for posture and vital sign monitoring includes a cushion 4. The cushion 4 functions to house: two or more sensors for measuring posture and/or one or more vital signs of the user, and a first computing device. In some embodiments, the cushion forms a portion of a chair, seat, sleeping pod, mattress, and/or couch. In some embodiments, such as the embodiment of a cushion shown in FIG. 2, the cushion is a portable seat cushion configured for placement on chairs (e.g., in an office, at home, etc.), bleachers, car seats, airplane seats, and/or other existing seat structures. In other embodiments, the cushion is integrated into an office chair, armchair, sofa, car seat, airplane seat, sleeping pod, mattress, or other structure. In some embodiments, the system includes multiple cushions, for example, two or more of: a backrest, two armrests, a seat, and a leg rest (e.g., ottoman, recliner, etc.).

[0042] In some embodiments, as shown, for example, in FIGS. 1 and 2, the cushion includes one or more user input elements 31, for example, on an exterior surface of the cushion. For example, the cushion may include one or more buttons, sliders, or toggle switches to turn on/off power to the computing device within the cushion or to adjust the settings to a wireless communication module 30, a vibration module, and/or any other feature or module of the system. In some embodiments, a user input element may include a button,

slider, or toggle switch for resetting the system, for example to manufacturing settings or to a previous user setting.

[0043] In some embodiments, for example, the cushion embodiments of FIG. 2 and FIGS. 3A-3F, the cushion 4 is shaped, contoured, or grooved for increasing comfort of a user sitting on or using the cushion. For example, the cushion may include a posterior thickness T_1 and an anterior thickness T_2 . In one embodiment, T_1 is greater than T_2 . In another embodiment, T_2 is greater than T_1 . In still another embodiment, T_1 equals T_2 . In some embodiments, as shown, for example, in FIG. 3A, the posterior portion 8a of the cushion 4 includes substantially squared edges, while the anterior portion 8b of the cushion 4 includes substantially rounded edges. Alternatively, in some embodiments, both the posterior 8a and anterior 8b portions of the cushion 4 may include substantially squared edges; both the posterior 8a and anterior 8b portions of the cushion 4 may include substantially rounded edges; or the posterior portion 8a may be rounded while the anterior portion 8b is squared.

[0044] In some embodiments, as shown in FIG. 3A, an anterior portion 8b of the cushion 4 includes one or more dimpled regions 5. In one embodiment, an anterior portion 8b of the cushion 4 includes two dimpled regions 5. In some embodiments, a center region 9 between two or more dimpled regions is raised, so that an upper leg region or a buttock cheek of a user is positioned or situated in each dimpled region 5 of the cushion 4, for example, to improve comfort and/or proper positioning of the user while the user is seated on the cushion 4.

[0045] In some embodiments, the cushion 4 includes material on an exterior surface of the cushion. The material may include cotton, linen, polyester, rayon, denim, velvet, corduroy, silk, wool, leather, polyvinyl chloride (i.e., vinyl), artificial leather (e.g., poromeric imitation leather, Corfam, Koskin, Leatherette, etc.), suede or microsuede, or any other material. In some embodiments, the material is washable, stain-resistant, fire-resistant (i.e. flame retardant), weather-resistant (e.g., sun-resistant), wrinkle-resistant, and/or water-resistant. In some embodiments, the material is breathable to permit airflow into the cushion such that one or more sensors, electronics, and/or computing devices disposed in the cushion do not overheat.

[0046] In some embodiments, the cushion includes multiple internal layers, for example, as visible in FIGS. 3C-3F. In some such embodiments, the top and/or bottoms layers 11 of the cushion include memory foam (i.e. visco-elastic polyurethane foam), natural latex foam, wool, cotton, or any other material that provides a deformable, squishy, spongy, soft, and/or supportive structure to the cushion, for example for comfort and support of the user. In some embodiments, the one or more comfort and/or supportive layers are configured to propagate forces exerted on the cushion to enable the measuring of pressure applied to the cushion surface using one or more sensors disposed in the cushion. Further, in some such embodiments, a second layer 13 includes one or more sensors, for example pressure sensors 12, and a third layer 15 includes one or more sensors, for example optical fiber sensors 10. In some embodiments, the second layer 13 includes one or more optical fiber sensors 10 and the third layer 15 includes one or more pressure sensors 12. In other embodiments, two or more layers of optical fiber sensors are provided. In other embodiments, one or more pressure sensors and one or more optical fiber sensors are disposed together on or in a single layer.

[0047] In some embodiments, as shown in FIGS. 3D-3F, the cushion 4 includes multiple sensors (e.g., two, three, four, five, six, seven, eight, nine, ten, etc.) for measuring one or more vital signs and a posture of the user. In one embodiment, the cushion includes two sensors. In some embodiments, the one or more sensors are electromagnetic sensors, piezoelectric sensors, gyroscopic sensors, linear encoders, photoelectric sensors, pressure sensors, optical fiber sensors, any other type of sensor, or any combination of the aforementioned sensors.

[0048] In some embodiments, one or more first sensors 10 are optical fiber sensors and one or more second sensors 12 are pressure sensors. Alternatively, in one such embodiment, the first and second sensors are both optical fiber sensors. In some embodiments, the first optical fiber sensor is configured to produce a first signal indicative of a change in force (i.e., movement) of a user and the second sensor (e.g., pressure sensor, optical fiber sensor, etc.) is configured to produce a second signal indicative of a direction of the movement of the user, such that the first and second signals, when combined, indicate a posture of the user.

[0049] Posture is determined, in part, by pelvic tilt. Tilt or rotation in an individual's pelvis may cause changes to the curvatures of the lumbar, thoracic, and/or cervical regions of the spine. Similarly, changes to the curvature of the lumbar, thoracic, and/or cervical regions may lead to rotation of the pelvis. For example, rotating a pelvis in a forward tilting position (i.e., an anteverted position) causes an increase in the lumbar curvature. Anterior rotation of the pelvis can result in a swayback posture (i.e., lordosis). Slouching leads the pelvis to rotate towards a backward tilting position (i.e., a retroverted position). When an individual is sitting on a surface, changes in rotation or tilt of the pelvis result in changes in pressure and force distribution on the surface. Thus, in some embodiments, posture is determined by using a combination of fiber optics sensors and/or pressure sensors to detect applied pressures, forces, and/or changes in applied pressures or forces on the cushion.

[0050] Additionally or alternatively, in some embodiments, the first optical fiber sensor is sufficiently sensitive to detect both macro- and micro-movements of the user (i.e., relatively large and small changes in force) such that the signal generated by the first optical fiber sensor may additionally be indicative of breathing, a beating heart, and/or one or more other vital functions of the user.

[0051] In some embodiments that include at least one optical fiber sensor 10, for example, as shown in FIG. 3F, the optical fiber sensor 10 is formed of an optical fiber. The optical fiber has a first end coupled to a light source (e.g., LED, OLED, incandescent, etc.) and a second end coupled to an optical signal receiver. In some embodiments, the light source and optical signal receiver are coupled to or integrated with the printed circuit board and/or cushion computing device 14, as shown in FIG. 3F. The light source is configured to emit a light wave into the optical fiber. The optical fiber sensor 10 is positioned such that an application of force on a surface of the cushion causes the optical fiber to deform or microbend, which in turn influences propagation of the light wave through the optical fiber. The optical signal receiver is configured to detect changes in light wave propagation. The changes in light wave propagation are processed and analyzed by the first and/or second computing device to determine a position and/or vital sign of the user. For example, in the presence of an external force generated by body weight,

heartbeat, respiration, and/or body movement, the force is distributed on the optical fiber and deformer. These forces will microbend the optical fiber causing significant light loss with some residual light propagating through the optical fiber due to the microbending effect. The optical signal receiver receives the residual light. The residual light is processed to identify a change in force and thereby determine a body weight, heartbeat/respiration, and/or body movement/position of the user.

[0052] In some embodiments, the optical fiber sensor includes a single or double deformer structure. An embodiment of a cushion having an optical fiber sensor with a single layer deformer structure is shown in FIG. 4. A single layer deformer 18 may be configured to achieve the highest vital sign and posture detection sensitivity under absolute light loss caused by body weight, while a double deformer may be configured to achieve the highest light loss for a given applied force. The single deformer layer 18 balances the absolute force caused, for example, by body weight with the relatively small force changes caused, for example, by heart beats, respiration, and small shifts in posture. Use of a single deformer 18 enables extraction of faint ballistography signals and respiration waveforms from the high noise background caused by body movements. The deformer 18 may be formed of mesh (e.g., interwoven monofilaments, wires, threads, ribbons, or the like). The single layer deformer 18 functions to achieve micro bending of the optical fiber 20 and increased sensitivity of detection of cardiac and respiration waveforms and body movement. As shown in FIG. 4, when an outside force, indicated by the arrows 22 (e.g., body weight, heart rate, respiration rate, movement, etc.), is applied to the cushion and the cushion's internal optical fiber 20, the force 22 is distributed throughout the upper cover 24 and the optical fiber 20 and is not concentrated on the center of the fiber. In one embodiment, a polymeric open mesh fabric is used as the single layer deformer and a plain fabric is applied on top of a multimode optical fiber to uniformly distribute any force applied on the sensor. Alternatively, in some embodiments, the optical fiber sensor does not include a deformer 18.

[0053] In some embodiments, a system for posture and/or vital sign monitoring includes one or more second sensors 12, for example, one or more pressure sensors. The second sensor functions, in combination with the optical fiber sensor 10, to determine a posture of the user. As shown in FIGS. 3D-3F, a plurality of second sensors, for example, six pressure sensors, are provided. In some embodiments, less than six pressure sensors (e.g., five, four, three, two, one) or more than six pressure sensors (e.g., seven, eight, nine, ten, eleven, twelve, etc.) are provided for measuring a direction of movement of the user. In some embodiments, the pressure sensor 12 is an absolute pressure sensor, a gauge pressure sensor, a vacuum pressure sensor, a differential pressure sensor, or a sealed pressure sensor. In some embodiments, the pressure sensor includes a force-sensing resistor. In some embodiments, the pressure sensor is responsive in the 20 Kg to 150 Kg range or any subrange therebetween. For example, in some embodiments, the pressure sensor is responsive between 20-30 Kg, 30-40 Kg, 40-50 Kg, 50-60 Kg, 60-70 Kg, 70-80 Kg, 80-90 Kg, 90-100 Kg, 100-110 Kg, 110-120 Kg, 120-130 Kg, 130-140 Kg, or 140-150 Kg. In one embodiment, the pressure sensor is responsive between 40 Kg and 100 Kg.

[0054] In some embodiments, one or more pressure sensors are arranged in a pattern on an interior layer of the cushion 4. In one embodiment, the pattern includes a substantially hex-

agonal pattern, for example, as shown in FIGS. 3D-3F. In another embodiment, the pattern includes a square or rectangular pattern. For example, in one such embodiment, a first set of three pressure sensors are substantially parallel to a second set of three pressure sensors, which are substantially parallel to a third set of three pressure sensors. Alternatively, one or more pressure sensors may be positioned on a perimeter of an interior layer of the cushion in a square or rectangular pattern. In another embodiment, the pattern includes a substantially circular pattern, for example defining a circumference of a circle.

[0055] In some embodiments, as shown in FIG. 1, a system 2 for posture and/or vital sign monitoring includes, at least, first and second computing devices. The first computing device is disposed within the cushion 4 and is referred to herein as the cushion computing device. (See, for example, the cushion computing device 14 visible in FIGS. 3D-3F.) The second computing device 6, referred to herein as the portable computing device, may include a smartphone, wearable computing device (e.g., watch, bracelet, headband, necklace, etc.), tablet, laptop, or other portable computing device. In some embodiments, although referred to as a portable computing device, the second computing device 6 may be a remote server. In other embodiments, the system also includes a third computing device 7. In such embodiments, the third computing device, referred to herein as a remote computing device, may be a web server, an application server, a database server, and/or any other suitable computing device.

[0056] In various embodiments, there is one-way or two-way communication between the cushion computing device and the portable computing device, the cushion computing device and the remote computing device, and/or the portable computing device and the remote computing device. Two or more computing devices of the system may communicate wirelessly using Bluetooth, Wi-Fi, CDMA, other cellular protocol, other radiofrequency, or another wireless protocol.

[0057] In some embodiments, the cushion computing device (in the cushion 4), portable computing device 6, and remote computing device 7 each include a processor, for example a microcontroller, and memory having instructions stored thereon. The processor functions to execute the operating instructions of the system. The operating instructions of the system may include instructions for receiving one or more signals from one or more sensors, processing the signals, and determining a posture and/or vital sign of the user from the processed signals.

[0058] In some embodiments, a cushion computing device and a portable computing device each include a processor, which is embedded on a printed circuit board (PCB) and communicatively coupled (e.g., via a hardwired connection) to one or more system components (e.g., power module, user input elements, light module, vibration module, optical fiber sensor, second sensor, etc.). In some embodiments, the processor is a low-energy microcontroller.

[0059] FIG. 5 provides one example of a cushion computing device 28 that may be found within the cushion 4 of FIG. 1. FIG. 6 provides one example of a portable computing device 29. One skilled in the art will appreciate that the illustrated components are functional components, and the various functional components may be embodied within one or more structural elements. For example, the functional components of the cushion computing device 28 are embodied

within the PCB/computing device unit 14, the power module 21, and the vibration module 19 within the cushion 4 of FIGS. 3D-3F.

[0060] In some embodiments, as shown in FIGS. 5 and 6, the cushion computing device 28 and the portable computing device 29 each include or are coupled to a power module. The power module functions to provide electricity to one or more system components to enable operation of the one or more system components. In some embodiments, the power module includes an internal power source, for example, a battery (e.g., non-rechargeable, rechargeable, etc.), an inductive power source, a kinetic charger, and/or one or more solar panels. In some such embodiments, the cushion computing device 28 may be powered by an external power source or the internal power source may be recharged, for example, by ultraviolet light, movement of a user, or an electromagnetic field. In some embodiments, the cushion 28 and/or portable 29 computing device may be recharged by coupling the power module to an external power source, for example, using a power cord (e.g., IEEE 1394, universal serial bus (USB), Thunderbolt, Lightning, Ethernet, etc.) removably insertable into a port on the power module. In some embodiments, as shown in FIGS. 3A and 3B, the cushion computing device 28 and the portable computing device 29 each include an antenna for transmitting and receiving data wirelessly. The antenna, may include, for example, an antenna configured to transmit data to, and receive data from, another computer via Wi-Fi, CDMA, other cellular protocol, other radiofrequency, other wireless protocol). In various embodiments, the antennas enable communication between the cushion computing device 28, the portable computing device 29, and optionally, a remote computing device.

[0061] In some embodiments, as shown in FIG. 5, the cushion computing device 28 includes one or more user input elements. In some embodiments, the one or more user input elements are accessible on an exterior surface of the cushion or, alternatively, disposed in the cushion and only accessible after accessing the interior of the cushion or dismantling the cushion. For example, the cushion computing device may include one or more buttons, sliders, or toggle switches to turn on/off power to one or more system components, wireless communication 30 (e.g., data transmission via Bluetooth, low-energy Bluetooth, other radiofrequency technology, etc.) to one or more system components, a vibration module (e.g., to wake a user from a nap), and/or any other feature or module of the system. In some embodiments, a user input element may include a button, slider, or toggle switch for resetting the system, for example to manufacturing settings or to a previous user setting.

[0062] In some embodiments, as shown in FIG. 6, the portable computing device 29 includes one or more user input elements. For example, the portable computing device may include one or more manual and/or virtual buttons, sliders, or toggle switches on an exterior surface or on a graphical user interface (GUI) of the portable computing device. The one or more user input elements may turn on/off: power to one or more system components, wireless communication (e.g., data transmission via Bluetooth, low-energy Bluetooth, other radiofrequency technology, etc.) to one or more system components, a vibration module (e.g., to wake a user from a nap) of the cushion computing device, and/or any other feature or module of the system. In some embodiments, a user input element may include a button, slider, or toggle switch for resetting the system, for example to manufacturing settings or

to a previous user setting. In some embodiments, a user input element is used to toggle between different GUIs or to access different features of the software on the portable computing device.

[0063] In some embodiments, as shown in FIG. 5, the cushion computing device 28 includes a light module including one or more lights (e.g., LED, OLED, incandescent, etc.) visible from an exterior of the cushion, for example, to indicate a connectivity and/or power status of the cushion computing device and/or other electronics in the cushion. In some embodiments, a red, orange, or yellow light indicates varying degrees of low battery/power; a green light indicates good battery power and/or fully charged, and a blue light indicates a wireless (e.g., Bluetooth, low-energy Bluetooth, other radiofrequency, etc.) connection to one or more other system components. In some embodiments, the user input element 31 includes, is adjacent to, or is surrounded by, the light module; in some such embodiments, a light indicator may be illuminated in an “on” state, emitting, for example, emitting a green glow. In some embodiments, in an “off” state, the light indicator may not be illuminated or may emit a different color, for example, red.

[0064] In some embodiments, as shown in FIG. 3A, the cushion computing device 28 includes a vibration module. (The vibration module may be remote from, but electrically coupled to the remainder of the cushion computing device, for example, as is the case for the vibration module 19 shown in FIGS. 3D and 3F.) The vibration module may function to wake a user from a nap, for example, during an appropriate phase of the sleep cycle (e.g., REM, non-REM). Alternatively or additionally, the vibration module may function to massage a user, for example, to relax a user when a user’s heart rate, respiration rate, or stress level reach a pre-determined or pre-defined threshold. Further, in some embodiments, the vibration module functions as a tactile alert to remind a user, for example, to stand up or sit up straight when slouching, prolonged durations of sitting, or changes in vital signs indicative of stress are detected. In some embodiments, the vibration module includes an eccentric rotating mass (ERM) actuator. For example, a direct current (DC) motor drives a gear including a weight positioned off-center on the gear. Driving rotation of the gear including the weight using the DC motor results in vibration. In some embodiments, the vibration module includes a linear resonant actuator (LRA). For example, a magnetic field is generated by a voice coil which interacts with a magnet and a weight suspended on a spring. As the magnetic field varies with the applied drive signal, the magnet and weight are accelerated up and down as they interact with the spring resulting in vibration.

[0065] In some embodiments, as shown in FIGS. 5 and 6, the cushion computing device 28 and/or portable computing device 29 includes a program port. The program port functions to receive one or more programs for operating the system, for example through a port (e.g., IEEE 1394, universal serial bus (USB), Thunderbolt, Lightning, Mini Display, DVI, HDMI, Serial, Parallel, Ethernet, Coaxial, VGA, or PS/2). In some embodiments, a program includes instructions: for determining a vital sign and/or posture based on one or more sensor signals; for creating an alert, including instructions specifying alert frequency, types, and/or triggers (e.g., to correct a vital sign and/or posture of the user); for creating a recommendation, including instructions specifying recommendation frequency, types, and/or triggers (e.g., to correct a vital sign and/or posture of the user); or related to a

power level of the system, a vibration module status, a light module status, or any other operational feature of the system.

[0066] In some embodiments, as shown in FIGS. 5 and 6, the cushion computing device 28 and/or portable computing device 29 further includes a low-dropout (LDO) regulator. An LDO regulator is a direct current (DC) linear voltage regulator, which functions to regulate the output voltage even when the supply voltage is very close to the output voltage. Further, in some embodiments, the system includes a different type of DC-to-DC regulator or an alternating current (AC)-to-DC regulator.

[0067] In some embodiments, as shown in FIG. 5, the cushion computing device 28 includes one or more analog to digital converters (ADC) to convert one or more analog signals acquired for example from a sensor, to one or more digital signals to be processed and analyzed by the cushion and/or portable computing device.

[0068] In some embodiments, as shown in FIG. 6, the portable computing device 29 further includes an accelerometer. The accelerometer in the portable computing device functions to determine if a user is standing, walking, and/or moving. In some embodiments, two or more accelerometers may be used in the portable computing device to determine a step frequency or rate of the user, for example while the user is walking. Alternatively, a mechanical or electrical pedometer may be used to determine step frequency or rate of the user. Alternatively, a gyroscope may be provided in the portable computing device and function to detect user motion.

[0069] In some embodiments, as shown in FIGS. 7A-9, the portable computing device includes one or more graphical user interfaces (GUIs). A GUI on the portable computing device functions to track one or more vital signs and/or postures of a user at a defined time and/or over a period of time (e.g., hour, day, week, month, year, etc.), to provide a recommendation to the user (e.g., suggestion for correcting posture or vital sign, etc.), and/or alert a user to an unhealthy posture and/or vital sign (e.g., an increased heart rate, an increased respiration rate, a changed variability in heart rate, or a position in which the user is leaning forward, leaning backward, leaning left, leaning right, slouching, etc.). In some embodiments, one or more GUIs may include a menu bar, for example for switching between one or more GUI screens or pages, adjusting one or more user settings, altering one or more program settings, adjusting types or timings of notifications delivered by the system, and/or changing any other parameter of the system.

[0070] In one embodiment, as shown in FIGS. 7A-7B, a GUI of the cushion and/or portable computing device includes a cartoon, icon, or avatar 32 indicating a position, movement, and/or posture of the user and a cartoon or icon of one or more sensors 34 positioned on a cushion 33, the cartoon or icon is configured to indicate and display a corresponding location of pressure on the physical cushion 4. In various embodiments, the information displayed in the GUI is in real-time or substantially real-time, such that the GUI provides a digital representation of a user’s current seated position, as detected by the one or more sensors of the cushion 33. In some embodiments, the GUI may encourage the user to apply pressure evenly to all sensors 34 in the cushion 33, for example, by displaying a notification when pressure is not applied evenly and/or indicating which sensors are not receiving detectable pressure and which sensors are receiving detectable pressure. In some such embodiments, the GUI is configured to display an indicator of a relative amount of force

being exerted on each sensor. For example, in some embodiments, the sensors on the GUI include a dark color or hue when indicating significant pressure and a lighter color or hue when indicating less pressure. In some embodiments, the sensors on the GUI blink or flash when receiving too much or too little pressure. In some embodiments, the GUI may be yellow, orange, or red when the user has an incorrect or unhealthy posture (e.g., is leaning forward, leaning backward, leaning left, leaning right, twisting, slouching, etc.) and green when the user has a good or adequate posture (e.g., is sitting upright in a neutral position).

[0071] In some embodiments, as shown in FIGS. 8A-8J, one or more GUIs include an indication **36** of a heart rate, respiration rate, stress level, and/or activity level of a user. As shown in FIG. 8A-8C, the GUI includes a heart rate, stress level, and respiration rate for a user while sitting (FIG. 8A), standing (FIG. 8B), and/or walking (FIG. 8C). Further, the GUI may include a cartoon, icon, or avatar **38** indicating the activity being performed by the user (e.g., sitting, standing, walking, etc.) and a progress indicator **40** (e.g., bar, circle, etc.) indicating a progression of time and/or a length of time (e.g., seconds, minutes, hours, etc.) elapsed while the user has been in a particular position or activity. In some embodiments, the progress indicator **40** provides a countdown of time remaining in an activity before the user is recommended or permitted to switch activities. In some embodiments, one or more GUIs further includes alert element **39**. Alert element **39** indicates to the user a remaining amount of time before the portable computing device suggests or recommends an activity change (e.g., sitting to standing, standing to walking, walking to sitting, etc.). For example, the portable computing device may elicit an audible, tactile, or visual alert to the user indicating that a change in activity is recommended. In some embodiments, the application on the portable computing device is configured to push alerts and other notifications to a user even when the user does not have the GUI open on the portable computing device.

[0072] In some embodiments, as shown in FIGS. 8D-8F, one or more GUIs may display a total or an average duration **42** (e.g., seconds, minutes, hours, etc.) of each activity (e.g., sitting (FIG. 8D), standing (FIG. 8E), moving, walking (FIG. 8F), etc.) the user performed in a defined time period (e.g., hour, day, week, etc.). For example, an average duration of an activity may be depicted on the GUI using shapes, such that the size, color, configuration (e.g., circle, square, triangle, rectangle, diamond, etc.), or any of other parameter of the shape indicates the relative duration of an activity, as compared to the duration of other activities. For example, a relatively large shape may indicate a substantial length of time and a smaller shape may indicate a shorter length of time. In some embodiments, each kind of tracked activity is depicted with a different color of shape, for example, a red shape may indicate sitting, orange may indicate moving, green may indicate standing, and blue may indicate walking. In some embodiments, as shown in FIGS. 8D-8F, the GUI includes a graphical representation **44** (e.g., line graph, pie chart, histogram, table, pictograph, bar graph, etc.) of a user's activity. For example, the x-axis may indicate a time of day (e.g., 9:00 AM, 12:00 PM, 3:00 PM, 5:00 PM, etc.) and the y-axis may indicate a duration of an activity. Alternatively, the x-axis may indicate a type of activity and the y-axis may indicate a duration of the activity. Further, in some embodiments, different activities are plotted on the same graphical representa-

tion using different colors, shapes, line textures (e.g., dotted, segmented, solid, etc.), or any other distinguishing feature.

[0073] In some embodiments, as shown in FIGS. 8G, **81**, and **8J**, one or more GUIs display one or more cardiac and/or respiration waveforms **46** of a user over a period of time (e.g., minutes, hours, days, weeks, etc.). For example, as shown in FIGS. 5G, 6A, and 6B, an average heartbeat or respiration rate **48** (e.g., hourly, daily, weekly, etc. average) is determined and depicted based on the cardiac or respiration waveform, respectively, for a defined time period. In some embodiments, as shown in FIG. 8G, one or more GUIs includes a graphical representation **50** (e.g., line graph, pie chart, histogram, table, pictograph, bar graph, etc.) of an average heartbeat and/or respiration rate or a heartbeat and/or respiration rate over time of a user derived from the cardiac and/or respiration waveform, for example, to indicate fluctuations (e.g., maximum, minimum, variation over time, etc.) in the heart and/or respiration rate of the user over a period of time or an average heart and/or respiration rate of the user during a period of time.

[0074] Further, in some embodiments, as shown in FIG. 8H, one or more GUIs include a goal view indicating a target or goal of a user. For example, the GUI may indicate a desired amount **52** (e.g., time, frequency, number) of exercise of a user and the actual amount **54** the user exercised. In some embodiments, the GUI represents the information in a pie chart **56** or a timeline **58** indicating missed exercise times and/or total missed time periods of exercise.

[0075] In one embodiment, as shown in FIG. 9, a GUI indicates a stress level of a user and coaches the user towards a reduced stress level. In some embodiments, the stress level is determined by the heart rate and/or respiration rate of the user relative to a user's minimum, average, and maximum observed/measured heart rate and/or respiration rate. Alternatively, in some embodiments, a stress level of a user is detected by an increase in variability in a user's heart rate and/or respiration rate. A recommendation to the user may be displayed on the GUI to encourage the user to breathe slowly, take bigger/deeper breaths, meditate, contact a massage service, attend a yoga or meditation class, or any other recommendation to reduce the user's stress. In some embodiments, the GUI indicates the progress of the user towards reducing his/her stress, for example, using a progress indicator **60** and/or percent stress relative to the initially observed/measured stress level.

[0076] In some embodiments, a user may share his/her vital sign(s), activity level, and/or posture information with one or more social networks (e.g., Facebook®, Twitter®, LinkedIn®, Instagram®, etc.) or through email or messaging using the cushion and/or portable computing device. A user may transmit his/her average heart rate, respiration rate, posture, and/or stress level; activity level or goal activity level for a period of time; cardiac and/or respiration waveforms; one or more services the user is using as recommended by the system (e.g., to decrease stress, improve posture, etc.); or any other information the user wishes to share.

Methods

[0077] As shown in FIG. 10, a computerized method for posture and vital sign monitoring of one embodiment includes receiving a first signal indicative of a movement of a user **S100**, receiving a second signal indicative of a direction of the movement of the user **S110**, combining the first signal indicative of the movement of the user with the second signal indicative of the direction of the movement of the user to

determine a posture of the user **S120**, determining if a change to the posture of the user is recommended **S130**, and if a change to the posture of the user is recommended, recommending an action to the user to change the posture **S140**. The method functions to measure a posture of the user and enable a user to change his/her posture based on a recommendation from the system.

[0078] As shown in FIG. 10, one embodiment of a computerized method for posture and vital sign monitoring includes **S100**, which recites receiving a first signal indicative of a movement of a user. **S100** functions to collect movement data about a user, for example using an optical fiber sensor. The optical fiber sensor is disposed in a cushion, such as, for example, any cushion embodiment described elsewhere herein. Deformation or bending of the optical fiber in the cushion results in differential light wave propagation through the optical fiber. The optical signal receiver coupled to the optical fiber is configured to detect changes in the light wave propagation. The optical signal receiver of various embodiments is electrically coupled to, or forms a portion of, a cushion computing device. In various embodiments, the cushion computing device processor receives signals indicative of changes in light wave propagation (e.g., signals indicative of a movement of a user) from the optical signal receiver.

[0079] As shown in FIG. 10, one embodiment of a computerized method for posture and vital sign monitoring includes **S110**, which recites receiving a second signal indicative of a direction of the movement of the user. **S110** functions to collect data about a direction of movement of a user, for example using a pressure sensor. One or more pressure sensors are disposed in a cushion, and each measures pressure exerted on an exterior surface of the cushion by the user. The degree of deformation of a force collector (e.g., diaphragm, piston, bourdon tube, bellows, etc.) in the pressure sensor induced by the user is detected (e.g., optically, piezoelectrically, electromagnetically, etc.). In various embodiments, each pressure sensor is electrically coupled to the cushion computing device, and the detected pressure signals are received by the cushion computing device.

[0080] As shown in FIG. 10, one embodiment of a computerized method for posture and vital sign monitoring includes **S120**, which recites combining the first signal indicative of the movement of the user with the second signal indicative of the direction of the movement of the user to determine a posture of the user. **S120** functions to determine a posture of the user by combining signals indicative of movement (i.e., movement data) and signals indicative of direction (i.e., direction of movement data) to determine if there has been a change to a user's weight distribution or pelvic tilt, and thus, to determine if a user is in a neutral posture or is leaning forward, leaning backward, leaning left, leaning right, slouching, or otherwise deviating from the neutral posture.

[0081] For example, with reference to the sensor configuration shown in FIG. 3E, if the user is leaning forward, more pressure will be detected by the two anterior sensors **12a**, **12d** than by the other sensors. Further, in one embodiment, if the user is leaning backward, more pressure will be detected by the two posterior sensors **12c**, **12f** than by the other sensors. In one embodiment, if the user is leaning to the left, more pressure will be detected by the three sensors **12a**, **12b**, **12c** on the left than by the other sensors. In one embodiment, if the user is leaning to the right, more pressure will be detected by the three sensors **12d**, **12e**, **12f** on the right than by the other sensors. In one embodiment, if the user is slouching, the

user's pelvis will be rotated towards a backward tilting position (i.e., a retroverted position) and an increase in pressure will be detected by the posterior sensors **12c**, **12f**. In one embodiment, if the user is sitting upright, pressure will be substantially evenly distributed between all six sensors **12a**, **12b**, **12c**, **12d**, **12e**, **12f**, **12g** or distributed between all six sensors in accordance with an acceptable ratio of pressure distributions. In some embodiments, **S120** is performed on and by the cushion computing device; in other embodiments, it is performed on and by the portable computing device or by a combination of the cushion and portable computing device.

[0082] In some embodiments, **S120** is performed by the cushion computing device. In such embodiments, the raw optical sensor signal and the raw pressure sensor signal are received, processed, and combined by the cushion computing device. In other embodiments, **S120** is performed by the portable computing device. In such embodiments, following receipt of the raw signals by the cushion computing device, the signals are at least minimally processed by the cushion computing device, for example, to convert from analog to digital signals. Additional processing, such as filtering the signals to remove noise and artifacts, may be performed by the cushion computing device or the portable computing device. In such embodiments, the partially or fully processed signals are transmitted to the portable computing device for performance of **S120**. The partially or fully processed signals may be transmitted via a wired connection (e.g., a cable) or a wireless connection (e.g., Bluetooth, low-energy Bluetooth, or other radiofrequency protocol). In still other embodiments, **S120** is performed by a remote computing device. In such embodiments, the partially or fully processed signals may be received by the portable computing device, optionally processed further, and transmitted from the portable computing device to the remote computing device for performance of **S120**. The signals may be transmitted to the remote computing device via a Wi-Fi, CDMA, other cellular, other radiofrequency, or other wireless connection.

[0083] As shown in FIG. 10, one embodiment of a computerized method for posture and vital sign monitoring includes **S130**, which recites determining if a change to the posture of the user is recommended. In some embodiments, determining if a change in posture is recommended includes assessing whether the user is deviating from a neutral spine position. As described above, the first and second signals are received, processed, and analyzed by the cushion, portable, and/or remote computing devices to determine a posture of the user. In some embodiments, data indicative of the posture of the user is compared to a database of acceptable and/or unacceptable posture data to determine if the analyzed user data is within an acceptable range and whether that posture needs correction and/or improvement. In some embodiments, the database is stored within the remote computing device. In other embodiments, the database is stored directly on the portable computing device. In some embodiments, the database of acceptable and/or unacceptable posture data includes data collected from the user's past use history. In other embodiments, the database of acceptable and/or unacceptable posture data includes data collected from a plurality of other users. In other embodiments, the database includes medically recommended values or ranges of values.

[0084] As shown in FIG. 10, one embodiment of a computerized method for posture and vital sign monitoring includes **S140**, which recites if change to the posture of the user is recommended, recommending an action to the user to change

the posture. **S140** functions to provide recommendations, action items, and/or resources to the user so that the user can correct and/or improve his/her posture. In some embodiments, a recommendation or action item includes suggesting that the user stand, walk, stretch, move, correct posture (e.g., with coaching from system), or any other activity. In some embodiments, the system recommends or suggests a resource, for example, one or more media (e.g., book, website, podcast, etc.) links for education on posture, healthy activities, and/or outcomes of healthy or unhealthy posture. In some embodiments, the system recommends or suggests a service to the user, for example, a massage, chiropractor, exercise coach, yoga class, gym, spa, or any other service. In various embodiments, recommendations are pulled from a database, for example, a database stored within the remote computing device or the portable computing device. In some embodiments, each recommendation is linked within the database to a particular detected posture or a necessary change in posture. In some embodiments, the recommendations are additionally or alternatively linked to a user's profile and/or demographic data. For example, certain recommendations may be coupled to slouching, such that when the system detects a slouching user, one or more relevant recommendations are presented to the user. In some embodiments, if the system detects that a user was responsive to a particular recommendation, that particular recommendation may be saved and recommended to the user in the future when slouching is again detected.

[0085] In some embodiments, a computerized method for posture and vital sign monitoring includes **S150**, which recites receiving a signal indicative of a vital sign of the user. For example, the vital sign signal may be produced by the first optical fiber sensor or a second sensor. In some embodiments, one or more of the sensors, such as the optical fiber sensor, are sensitive enough to detect micro-movements indicative of breathing, a beating heart, or other vital function. In some embodiments, the vital sign includes a respiratory waveform and/or a cardiac waveform of the user. From these waveforms, a breathing rate and/or heart rate, respectively, can be detected and tracked. Further, in some embodiments, a stress level of the user is determined based, at least in part, on a change in a variability of the cardiac waveform and/or respiration waveform. For example, the system may calibrate to the user by monitoring the user for a time period (e.g., hour, day, week, etc.) to determine the variability in the user's cardiac and/or respiration waveforms. Alternatively or additionally, the system may compare a user's cardiac and/or respiration waveforms to individuals in the user's same age group, sex group, ethnic group, social class, work environment, location, or any other comparable group. Based on this calibration and/or comparison, the system may determine a stress level of the user. In some embodiments, after determining a vital sign and/or stress level of the user, the system performs **S160**, which recites determining if a change to the vital sign is recommended, and if change to the vital sign of the user is recommended, the system recommends an action to the user to change the vital sign, as shown at **S170**. The recommendation functions to provide suggestions, action items, and/or resources to the user so that the user can correct and/or improve his/her stress level and/or vital signs. In some embodiments, a recommendation or action item includes suggesting that the user nap, wake-up, stand, walk, stretch, move, breathe slowly and/or deeply (e.g., with coaching from system), meditate, or any other activity. In some embodiments,

the system recommends or suggests a resource, for example, one or more media (e.g., book, website, podcast, etc.) links for education on stress, healthy activities, and/or outcomes of healthy or unhealthy stress levels and/or vital signs. In some embodiments, the system recommends or suggests a service to the user, for example, a massage, chiropractor, exercise coach, yoga class, gym, spa, meditation class, therapist, or any other service.

[0086] In some embodiments, a computerized method for posture and vital sign monitoring includes generating an alert on the cushion or portable computing device if change to the posture, stress level, and/or vital sign of the user is recommended. An alert may be generated to indicate to the user that he/she is experiencing unhealthy posture, stress levels, and/or vital signs that require adjustment, correction, and/or improvement. The system may alert the user on the cushion and/or the portable computing device using auditory, haptic/tactile, visual, and/or olfactory alerts. For example, an auditory alert may include a voice command or alert or a tonal alert (e.g., beep, ding, etc.) generated at the cushion or portable computing device. A tactile or haptic alert may include: vibration of the cushion computing device, portable computing device, and/or cushion; and/or a warming sensation in the cushion (e.g., by one or more heat emitters or heating elements in the cushion). A visual alert may include a message (e.g., SMS, push notification, badge notification, etc.) on a display screen of the cushion and/or portable computing device; and/or a light indicator (e.g., red, yellow, orange, green, etc.) generated by an LED or other light emitter on or coupled to the cushion computing device and/or portable computing device. An olfactory alert may include emission of one or more aromatic compounds from the cushion. Release of the aromatic compound may be induced by passing electricity, and thereby heat, through conductive traces or heating a set of electric coils, for example similar to a heating blanket, in the cushion such that the heat causes the aromatic compound to transition from a liquid state to a vapor/gaseous state that can be perceived by the olfactory system of the user. Alternatively or additionally, the cushion may include a compartment including an aromatic perfume or compound such that the compound is released (e.g. sprayed into the air) during set times, for example when a user's stress level reaches an unhealthy level. In some embodiments, to reduce stress levels and/or vital signs of the user, the cushion may release lavender, jasmine, chamomile, sandalwood, or mint scents. In some embodiments, to energize or encourage a user, for example to wake-up, stand-up, walk, and/or move, the cushion may release citrus or rosemary scents.

[0087] In some embodiments, as shown in FIG. 11, a computer-implemented method for determining a posture of a user includes one or more functions performed by the system to determine and, if necessary, correct a posture of the user. In some embodiments, an optical fiber sensor and second sensor are embedded into a cushion and configured to acquire the vibration and movement signals generated from a user's body. For example, a posture recognition algorithm may be applied to the collected signals from the optical fiber sensor and second sensor to classify the current posture. Such an algorithm identifies data indicative of the current posture and compares the data to pre-defined posture data sets stored within the first, second, and/or third computing device. In some embodiments, the posture recognition algorithm matches scores between the current posture data and the pre-defined posture data sets, identifying the pre-defined data

set that most closely matches the current posture data. In various embodiments, each pre-defined posture data set correlates to a different form of posture. In some embodiments, feedback is generated based on the recognized and analyzed posture status of the user.

[0088] In one such embodiment, as shown in FIG. 9, a computer-implemented method for determining a posture of a user includes analyzing and/or estimating a user's weight based on a first signal collected with a first optical fiber sensor **S200**, updating a set of posture recognition parameters based on the first signal **S210**, detecting a posture change event based on an analysis of a user's body movement using the first optical fiber sensor **S220**, collecting a second signal using a second sensor and categorizing the second signal based on the set of posture recognition parameters to determine a new posture of the user **S230**, and determining if the new posture warrants feedback to the user to change the new posture **S240**.

[0089] For example, the signal collected by one or more optic fiber sensors is indicative of an amount of deformation on the optic fiber, which is itself indicative of an amount of force applied to the cushion; thus, the signal can be analyzed to determine an estimation of the user's weight. The estimate of the user's weight informs a set of posture recognition parameters. The set of posture recognition parameters may include, for example, posture classifier coefficients, threshold values for each posture category/classification, etc. As an example, once an estimate of a user's weight is determined, the system may use the user's weight and one or more posture recognition parameters and/or equations to calculate an amount of pressure or force that would be exerted on one or more second sensors if a user were seated in a healthy, neutral posture. This calculated pressure or force is referred to herein as the expected neutral pressure or force. In some embodiments, the system executes a posture recognition algorithm in which the actual pressure or force detected at one or more second sensors is compared to the expected neutral pressure or force to determine if a user is currently seated in a healthy, neutral posture.

[0090] The optic fiber signal is additionally used in various embodiments to detect a posture change event. A posture change event may be detected when there is a change in the optic fiber signal resulting from a change in the deformation of the optic fiber. A change in the deformation of the optic fiber may result any time there is a shift in a user's weight distribution. A detected posture change event will trigger the new posture recognition algorithm. In some embodiments, the new posture recognition algorithm includes categorizing a second signal collected by one or more second sensors. For example, the second signal may be categorized by a pre-trained posture model and a posture recognition algorithm controlled by the set of posture recognition parameters.

[0091] In some embodiments, the posture model is pre-trained by learning from a large set of training samples collected by the cushion computing device. During the training phase, the training samples are collected from multiple users sitting in defined posture positions or categories during the data collection. The collected training samples are then analyzed and a set of normalized features is extracted from each training sample. With the extracted feature set and the corresponding collected posture category set, the posture model is refined by applying multiple machine learning algorithms and/or techniques. In some embodiments, the second signal is pre-processed and analyzed, at least in part, using a posture recognition algorithm. A set of normalized features is

extracted from the second signal using the same method as that during the training phase. The extracted feature set is then input into the pre-trained model to determine the posture category of the second signal. Posture recognition parameters include model parameters, such as the weights of each feature, the classifier coefficients, and the thresholds of each posture category, which are set during a user weight estimation phase using the optical fiber data. In some embodiments, a posture recommendation algorithm generates feedback to the user when it is determined that the user is not sitting in a neutral posture. The feedback may be generated when a reminder and/or guidance is determined by the system to be necessary to change the new posture of the user. In one such embodiment, a set of continuous (or frequently acquired) posture statuses are stored in a data structure (e.g., circular buffer, cyclic buffer, or ring buffer) on the third computing device, the second computing device, and/or the first computing device. Such posture statuses may be analyzed to determine if a reminder and/or guidance should be triggered and sent to the user on the second computing device to change the posture of the user.

[0092] In some embodiments, a computerized method for posture and vital sign monitoring includes monitoring a sleep cycle of the user based on one or more of the first signal, second signal, and third signal. Such a method may function to determine: a posture and/or vital sign of the user, when it is appropriate to wake a user from a nap, and/or one or more health conditions of the user. For example, the system may distinguish between REM and non-REM sleep cycles of the user based on a respiration rate and/or heart rate of the user. Such a system may be able to alert a user if frequent disruptions are occurring in the user's sleep cycle. In some embodiments, the system generates a signal to stimulate a vibrator within the cushion or to release an aromatic compound from the cushion, for example to wake the user during an appropriate sleep cycle stage of the user.

[0093] FIG. 11 illustrates a flow chart of one embodiment of a method for monitoring one or more vital signs of a user during a nap while the user is seated on the cushion. In some embodiments, the method includes receiving one or more inputs from the user that the user intends to nap **S300a**. For example, the user may select a range for the nap length (e.g., 15-20 minutes, 20-30 minutes, 30-60 minutes, etc.) and input the range for the nap length into the portable computing device. Alternatively, in some embodiments, the cushion and/or portable computing device may recommend a nap to the user **S300b**. For example, the cushion and/or portable computing device may detect a heightened stress level of the user or a slower heart and/or respiration rate of the user indicating that the user may benefit from a nap and alert, notify, or otherwise recommend a nap to the user. The alert or notification may include a push notification, SMS, other visual notification, audible alarm, tactile indication, or other notification to the user that the user should nap. In some embodiments, the system may facilitate the user falling asleep, for example by playing soothing music, releasing calming scents, gently massaging the user using the cushion, or any other type of facilitation. In some embodiments, the method includes determining a sleep stage of the user **S310**. Using one or more vital signs detected by the optical fiber sensor and/or second sensor, the cushion and/or portable computing device may distinguish between REM and non-REM sleep cycles and/or when the user is experiencing lighter and deeper sleeping periods. In some embodiments, the method includes deter-

mining if the sleep stage of the user is an appropriate sleep stage in which to wake the user **S320**. For example, the system may determine that the user is experiencing lighter sleep and/or a non-REM sleep cycle and wake the user during this lighter sleep period and/or non-REM sleep cycle. In some embodiments, the system wakes the user within the user's chosen range of nap lengths when the user is experiencing lighter sleep and/or a non-REM sleep cycle, for example, to minimize a user feeling groggy, disoriented, or not well-rested from the nap. In some embodiments, the method includes waking the user from the nap if the sleep stage is appropriate **S330**. For example, the system may determine that the user is within the appropriate nap length range and experiencing lighter sleep and/or a non-REM sleep cycle, and that the user could be woken with minimal side effects (e.g., grogginess, sleepiness, etc.). In some embodiments, the system wakes the user using the vibration module, other tactile signal, an auditory signal (e.g., alarm, music from the cushion and/or portable computing device, etc.), an olfactory signal, or another signal, as described above. In some embodiments, the auditory signal starts at a low decibel level and escalates to a higher decibel level to gently and gradually wake the user from the nap.

[0094] The systems and methods of the preferred embodiment and variations thereof can be embodied and/or implemented at least in part as a machine configured to receive a computer-readable medium storing computer-readable instructions. The instructions are preferably executed by computer-executable components preferably integrated with the system and one or more portions of the processor on the cushion and/or portable computing device. The computer-readable medium can be stored on any suitable computer-readable media such as RAMs, ROMs, flash memory, EEPROMs, optical devices (e.g., CD or DVD), hard drives, floppy drives, or any suitable device. The computer-executable component is preferably a general or application-specific processor, but any suitable dedicated hardware or hardware/firmware combination can alternatively or additionally execute the instructions.

[0095] As used in the description and claims, the singular form "a," "an" and "the" include both singular and plural references unless the context clearly dictates otherwise. For example, the term "a sensor" may include, and is contemplated to include, a plurality of sensors. At times, the claims and disclosure may include terms such as "a plurality," "one or more," or "at least one;" however, the absence of such terms is not intended to mean, and should not be interpreted to mean, that a plurality is not conceived.

[0096] The term "about" or "approximately," when used before a numerical designation or range (e.g., to define a length or pressure), indicates approximations which may vary by (+) or (−) 5%, 1% or 0.1%. All numerical ranges provided herein are inclusive of the stated start and end numbers. The term "substantially" indicates mostly (i.e., greater than 50%) or essentially all of a device, substance, or composition.

[0097] As used herein, the term "comprising" or "comprises" is intended to mean that the devices, systems, and methods include the recited elements, and may additionally include any other elements. "Consisting essentially of" shall mean that the devices, systems, and methods include the recited elements and exclude other elements of essential significance to the combination for the stated purpose. Thus, a system or method consisting essentially of the elements as defined herein would not exclude other materials, features, or

steps that do not materially affect the basic and novel characteristic(s) of the claimed invention. "Consisting of" shall mean that the devices, systems, and methods include the recited elements and exclude anything more than a trivial or inconsequential element or step. Embodiments defined by each of these transitional terms are within the scope of this disclosure.

[0098] The examples and illustrations included herein show, by way of illustration and not of limitation, specific embodiments in which the subject matter may be practiced. Other embodiments may be utilized and derived therefrom, such that structural and logical substitutions and changes may be made without departing from the scope of this disclosure. Such embodiments of the inventive subject matter may be referred to herein individually or collectively by the term "invention" merely for convenience and without intending to voluntarily limit the scope of this application to any single invention or inventive concept, if more than one is disclosed. Thus, although specific embodiments have been illustrated and described herein, any arrangement calculated to achieve the same purpose may be substituted for the specific embodiments shown. This disclosure is intended to cover any and all adaptations or variations of various embodiments. Combinations of the above embodiments, and other embodiments not specifically described herein, will be apparent to those of skill in the art upon reviewing the above description.

What is claimed is:

1. A system for posture monitoring, comprising:

a cushion comprising:

- a first optical fiber sensor configured to produce a first signal indicative of a movement of a user,
- a second sensor configured to produce a second signal indicative of a direction of the movement of the user, and
- a first computing device comprising a first processor and memory having a first set of instructions stored thereon; and

a second computing device, wherein the second computing device is communicatively coupled to the first computing device, and wherein the second computing device comprises a second processor and memory having a second set of instructions stored thereon, wherein execution of the first and second set of instructions causes a method to be performed comprising:

- transmitting data from the first computing device to the second computing device,
- combining the first signal indicative of the movement of the user with the second signal indicative of the direction of the movement of the user to determine a posture of the user,
- determining if a change to the posture of the user is recommended, and
- if change to the posture of the user is recommended, recommending an action to the user via the second computing device.

2. The system of claim 1, wherein the second sensor is a second optical fiber sensor.

3. The system of claim 1, wherein the second sensor is a pressure sensor.

4. The system of claim 1, wherein the first optical fiber sensor or the second sensor is further configured to produce a third signal indicative of a vital sign of the user.

5. The system of claim 4, wherein the vital sign is one or more of a respiratory waveform and a cardiac waveform.

6. The system of claim 1, wherein the action comprises one or more of standing, walking, correcting posture, and stretching.

7. The system of claim 1, wherein the cushion is portable.

8. The system of claim 1, wherein the cushion forms a portion of a chair, seat, sleeping pod, or couch.

9. The system of claim 1, wherein the first computing device and the second computing device communicate wirelessly.

10. The system of claim 1, wherein the second computing device comprises a smartphone, wearable computing device, tablet, laptop, other portable computing device, or a remote server.

11. The system of claim 1, wherein the first optical fiber sensor comprises a one-layer deformer structure.

12. The system of claim 1, wherein the cushion further comprises a memory foam layer.

13. A computerized method for posture monitoring, comprising:

receiving a first signal indicative of a movement of a user, wherein the first signal is produced by a first optical fiber sensor in a cushion;

receiving a second signal indicative of a direction of the movement of the user, wherein the second signal is produced by a second sensor in the cushion;

combining the first signal indicative of the movement of the user with the second signal indicative of the direction of the movement of the user to determine a posture of the user;

determining if a change to the posture of the user is recommended; and

if change to the posture of the user is recommended, recommending an action to the user to change the posture.

14. The computerized method of claim 13, wherein the action includes one or more of standing, walking, stretching, and correcting posture.

15. The computerized method of claim 13, further comprising identifying if the user is leaning forward, leaning backward, leaning left, leaning right, sitting upright, or slouching.

16. The computerized method of claim 15, further comprising generating an alert on the first or second computing device if change to the posture of the user is recommended.

17. The computerized method of claim 13, further comprising receiving a third signal indicative of a vital sign of the user, wherein the third signal is produced by the first optical fiber sensor or the second sensor.

18. The computerized method of claim 17, wherein the vital sign is one or more of a respiratory waveform and a cardiac waveform of the user.

19. The computerized method of claim 18, further comprising determining a stress level of the user based, at least in part, on a change in a variability of the cardiac waveform.

20. The computerized method of claim 17, further comprising monitoring a sleep cycle of the user based on one or more of the first signal, second signal, and third signal.

21. The computerized method of claim 20, further comprising generating a signal to stimulate a vibrator within the cushion, wherein the signal is generated during an appropriate sleep cycle stage of the user.

22. The computerized method of claim 17, further comprising:

determining if a change to the vital sign is recommended; and

if change to the vital sign of the user is recommended, recommending a second action to the user to change the vital sign.

23. The computerized method of claim 18, wherein the second action includes one or more of standing, walking, stretching, and breathing coaching.

24. The computerized method of claim 18, further comprising generating an alert on the first or second computing device if change to the vital sign is recommended.

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摘要(译)

公开了监测姿势和生命体征的系统和方法。在一些实施例中，该系统包括用户可坐在其上的垫子。衬垫包括第一光纤传感器，第二传感器和第一计算设备。该系统还可以包括第二计算设备，该第二计算设备通信地耦合到第一计算设备并且被配置为从第一计算设备接收传感器数据。第一和第二计算设备中的一个或两个可以操作以将指示用户的移动的信号与指示用户的移动方向的信号组合以确定用户的姿势。系统可以基于用户的姿势提供反馈并且建议改善姿势的动作。该系统可以进一步监测用户的心率，呼吸率或其他生命体征。

