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(54) **Method and device for measuring a health status and physiological parameters of an user at rest and under movement**

(57) Method and device for measuring a health status and physiological parameters of and user at rest and under movement, to be worn on a wrist of a user. The device includes a securing band, at least one light source having a light emitting surface and at least one light receiver having a light receiving surface. The at least one light source and the at least one light receiver are arranged on the securing band of the device such that when worn, the at least one light emitting surface and the at least one light receiving surface substantially abut against the palmar side of the wrist of the user. The device further includes a pressing element projecting towards the side of the securing band facing the wrist such that the light emitting surface and/or the light receiving surface is pressed into the skin of the wrist, a second light source which is used for detection of movement and motion artefacts.

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Title: Method and device for measuring a health status and physiological parameters of an user at rest and under movement

TECHNICAL FIELD

The invention relates to a wrist worn device and a method for measuring a health status of a user. The health status may include a general fitness and/or compliance to an exercise schedule and/or specific physiological or health parameters at a desired value or bandwidth.

BACKGROUND

Wrist worn devices for measuring a health status of a user are known in the art. Unfortunately, such devices may be unreliable in measurement of certain physiological parameters in rest positions and certain physiological parameters under limited and more severe movement, and sometimes therefore report a health status that does not correspond to that of the user. These problems can be exacerbated while attempting to measure a health status of a user during exercise and/or before or after exercise and during movements of the skin, body and arms in general. The effect of the exercises, skin and body movements on the measurements is for many known devices today that these are not reliable and are largely influenced by (motion) artefacts and inaccurate measurements.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a more reliable device and method for measuring a health status and physiological parameters of a user at rest, under movement and during exercise and providing more comfortable solutions for carrying the device on the body on the skin for a longer time. Thereto, according to the invention a device for measuring a health status is provided. The device, to be worn on a wrist or forearm of a user, includes, a securing band, at least one light source having a light emitting surface and at

one light source and the at least one light receiver are arranged on the securing band of the device such that when worn, the at least one light emitting surface and the at least one light receiving surface substantially abut against the palmar side of the wrist of the user. According to an aspect of the invention, the device further includes a static or adjustable pressing element, projecting towards the side of the securing band facing the wrist or forearm, such that the light emitting surface and/or the light receiving surface is pressed into the skin of the wrist. The light emitting surface and/or the light receiving surface can e.g. be positioned on the top of the pressing element.

According to another main aspect of the invention the device includes a plurality of light emitting and light receiving surfaces, which can be used to perform measurements of physiological parameters such as heart rate, heart rate variability and heart rate recovery, oxygen saturation (SpO2), respiration rates, CO2 values and a separate set or sets of light emitting surfaces and receivers with a different wavelength than the ones used for illuminating of the blood vessels the above mentioned and measurements of parameters, which can be used for the specific detection of motion artefacts and movement. These specific light emitters have either a low penetration depth in the skin (400-550 nm) and or a high water absorption rate (1100-1400 nm). The parallel detection of small or bigger motion artefacts can be used in algorithms and software processing to detect at all time the heart rate of the wearer of the device under movement from and within the received light signals. These light emitters and if necessary receivers can be covered with polarizers to filter the light emitted and received in such a way and under such angle that specific movement can be detected. Therefore a polarisation filter is placed on the light source resulting in a light beam polarised in one direction. The light reflected on the skin rotates the polarisation direction of the light by ninety degrees. By placing a polarisation filter on the optical sensor turned by ninety degrees in reference to the polarisation filter at the light source, the sensor is more sensitive to the reflected light and less to the scattered light

through the tissue. This embodiment will enable detection of heart rates under medium and more severe movement of body, arm en device on arm, due to the ability to distinguish in the signals between movement or motion artefacts and heart rate values.

According to another two main objects of the invention the device contains two solutions to limit or omit the influences of circumferential, ambient light. The first solution hereto consists of flexible deformable non-transparent skirt around the light emitting and light receiving surfaces, touching the skin and following the contour of the skin and blocking penetration of all ambient light. The second solution is the use of modulation of light in the system to subtract possible ambient light values from the measurements being made by the light receiving surfaces.

According to another main object of the invention the parallel sensing of heart rate values and high motion artefacts and movement with specific light emitting and light receiving surfaces will make it possible to asses physical exercise, movement and activity, if necessary combined with accelerometer data, GPS data, tri-angulation GSM positioning data and other available means.

According to another main object of the invention the device can contain one or more of the mentioned specific and adjustable solutions for applying pressure on the skin in the area of the light emitting and light receiving surfaces.

The pressing element provides the advantage that the light emitting surface(s) and/or the light receiving surface(s) can be pressed into the skin of the wrist to the desired extent. This allows for better coupling of light into the wrist and/or out of the wrist. Better coupling of light can improve a signal to noise ratio and/or a signal intensity. Also, the pressing element aids in preventing the light emitting surface(s) and/or the light receiving surface(s) from sliding across the skin and from detaching from the skin during

movement, resulting from the skin and device interaction, exercising, sports and all other human activities

The pressing element can be a passive element, such as a solid element or a resilient element, such as a foam element or a spring element or a combination of both, is adjustable and can be a solid or resilient element or a combination of both which slides up and down in a corresponding cylinder, housing or second element in predetermined or limitless variable positions, a clamp or beam lever which is positioned on the right point of the wrist and is exerting more pressure force after fastening of the securing band or via a separate mechanism or combinations of any of the above. Hence, the pressing element requires no power, but still allows for an increased force pressing the light emitting surface(s) and/or the light receiving surface(s) into the skin, either via manual adjustment of the band of the wrist worn device and or the adjustment of the pressing element itself in one or more directions and or help of an additional mechanically operating element. The pressing element can have a domed shape, such as a e.g rounded, pyramidal shape; a hemispherical shape; a semioval shape; a, e.g. rounded, lozenge shape, a square or rectangular shape, or any irregular shape. The pressing force of the pressing element can be adjustable, e.g. by use of a selected one of a set of interchangeable pressing elements, e.g. having different heights, spring constants, etc. The pressing force of the pressing element can also be adjustable by use of a selected one of a set of interchangeable resilient elements in the pressing elements. The pressing force of the pressing element can also be adjustable by mechanical adjustment of the pressing element, e.g. of a height of the pressing element, such as by telescopic action, a movement or adjustment of two corresponding elements in which one of them can translated and or rotated in one or more directions to the other (e.g. a piston system, a screw thread system, a press and click system with a spring, a non-linear sliding system with curved elements, a combination of any of the above etc.), clamp or beam lever pressing system etc. Finally the pressing force of the

pressing element can also be adjustable by adjustment of the tightness or looseness band of the wrist-worm device in a more tightened or loosened fashion with a clasp, a screw thread or another type of mechanically adjustable system.

The positioning of the pressing element within the device can be such that, when worn, the pressing element is positioned to be on top of one or both of the main arteries, in the wrist. These locations are free from tendons so that the pressing force is extra effective.

According to an aspect of the invention, the pressing element is, at least partially, interposed between the securing band and the light emitting surface and/or the light receiving surface. The light emitting surface and/or the light receiving surface are mounted on a carrier, and the pressing element can be, at least partially, interposed between the securing band and the carrier or are completely integrated into one part. The pressing element can be included in a tunnel. The tunnel can be part of the securing band. It is also possible that the tunnel is attached to the securing band, preferably on the side facing the skin.

According to an aspect of the invention, the pressing element can be movably interposed between the securing band and the light emitting surface and/or the light receiving surface. The pressing element can also be, at least partially, movably interposed between the securing band and the carrier. The pressing element can be movably interposed between walls of the tunnel, or between a wall of the tunnel and the securing band. The pressing element being movably interposed allows the pressing element to be positioned in a circumferential and/or axial direction of the securing band. Hence, the pressing element can be positioned to an optimum position, e.g. directly over an artery or another position on the wrist. Optionally, the pressing element is slidingly interposed. Thereto, the surface of the pressing element and/or a surface of the securing band, carrier and/or tunnel facing the pressing element can have a low friction to enable easy sliding.

According to an aspect of the invention, the pressing element has a positioning means projecting outside the securing band, when worn, to allow positioning and re-positioning of the pressing element. The positioning means can be a lever extending beyond a side of the securing band, and/or extending radially through the securing band.

According to an aspect of the invention, the securing band includes a stretchable material enabling a tight securing and delivering a force pressing the pressing element into the skin of the wrist. Hence the pressing element projecting towards the skin can effectively pressed into the skin by an elastic force generated by the securing band. The securing band may comprise a stretchable textile and or foam material, which is permeable to water vapour and gasses, allowing ventilation of the skin. Optionally the foam material on the wrist side is covered with a material allowing absorption of moisture. Alternatively, or additionally, a part of the securing band that is positioned against the back of the wrist has a higher stiffness and/or lower resilience than the part of the securing band that is positioned against the inner side of the wrist. This may help in providing an effective pressing force on the pressing element.

According to an aspect of the invention, the device further also can include a deformable non-transparent plastic, rubber, polymer or metal element or a combination of these elements, projecting itself towards the side of the securing band facing the wrist or forearm, such that the light emitting surface and/or the light receiving surface are shielded from all sides between skin and the device itself from ambient, surrounding light and are if necessary pressed with this deformable part into the skin of the wrist. This deformable non-transparent element which can deform due to its material properties and or specific shape and will block the surrounding, ambient or environmental light, allows comfortable wearing of the wrist worn device without too high pressures causing discomfort. It completely shields the light emitting and light receiving surfaces from surrounding natural and or artificial light, it provides

due to it's compression and higher friction characteristics a stable interface to the skin, reducing motion and other artefacts and enabling stable heart rate, SpO2 and other physiological signals.

According to an aspect, the device further includes a control unit arranged for determining a health status, such as a physiological parameter, such as heart rate, heart rate variability, heart rate recovery and/or oxygen saturation, CO2 saturation, respiration rates from a signal representative of an amount of light received by the light receiver.

When measuring e.g. the oxygen saturation, the so called SpO2 value, it is preferred to minimise the optical path lengths for irradiating the wrist and for detecting the radiation from the wrist. Minimising such path lengths helps minimise the effect of movement artefacts on the determination of the oxygen saturation. Preferably, (only) light emitting surfaces and light receiving surfaces that are in close proximity to one another are used for determining the oxygen saturation, e.g. neighbouring light emitting surfaces and light receiving surfaces. When multiple light emitting surfaces and multiple light receiving surfaces are used in the device, it may be preferred to not activate all light emitting surfaces at the same time, but to activate the light emitting surfaces in groups or one at a time, so as to minimise the effect of light receiving surfaces receiving light emitted by far away light emitting surfaces.

Another method to achieve this controlled optical path is to manually or mechanically block the light emitters, which are not in the proximity of the light receiving surface intended for the oxygen saturation determination, e.g. via use of a tunnel shaped element in the band which can cover part of the light emitting surfaces or via use of separate slab of material which can be folded over the light emitting surfaces which have to be covered, or via another mechanism such as a turnable unit which has one or more

openings for the light emitting and light receiving surfaces which can be turned manually, semi-automatically or automatically.

According to an aspect, the light sources are Light Emitting Diodes, LEDs, and the light receivers are Photodiodes, PDs. The LEDs and PDs can be mounted on the carrier, wherein the carrier can be a flexprint. Optionally, the carrier can be bent with the LED's and/or PDs on the convex side. Such bent carrier can be included in a cylindrical or dome shaped plastic enclosure. Such enclosure can e.g. be moulded with the carrier included in the mould. Such plastic enclosure can also partly or wholly be compressible, enabling and allowing a static pressing force on the skin with high comfort for the user.

It is possible that the PDs are positioned on a semi cylindrical or dome shaped surface and that the LEDs are positioned on the same position or lower than the PDs, e.g. moulded inside the semi cylindrical or dome shaped part.

According to an aspect, the light emitting surface(s) and the light receiving surface(s) is(are) separated by a non-transparent light blocker. Each light emitting surface may be circumscribed by a light blocker, each light receiving surface may be circumscribed by a light blocker. The light blocker may e.g. be a black or grey plastic material. This helps in preventing direct radiation from a light emitting surface entering a light receiving surface, without travelling through the skin of the user first.

According to an aspect, the light emitting surface(s) and the light receiving surface(s) is(are) received in one or more elastic frames, preferably of light blocking material.

According to an aspect, the light emitting surface(s) and the light receiving surface(s) is(are) separated by a deformable non-transparent light blocker. Each light emitting surface may be circumscribed by a deformable light blocking element made from a compressible material, each light receiving surface may be circumscribed by a light blocking element made from a compressible material. The light blocker may e.g. be a black or grey plastic

material. This helps in preventing direct radiation from a light emitting surface entering a light receiving surface, without travelling through the skin of the user first. The compressible light blocking material will allow an appropriate pressing force on the skin, which is not too high to cause discomfort and is still high enough to enable a good signal without interference of ambient, circumferential, surrounding light, which can be blocked extra and initially by the partly compressed light blocker touching the skin around the area where light is being emitted in the skin and reflected light is being collected and measured by the light receiving surface or sensor.

According to an aspect, the light emitting surface(s) and the light receiving surface(s) can be covered by a transparent or semi-transparent or slightly coloured cover enabling light to be emitted and received. These transparent covers can be separated from each other by non-transparent light blocking materials, and are all arranged on a domed or cylindrical shape to enable sufficient light coupling in the skin of the wrist of the user. This dome can be made of a partly compressible and partly more ridged material or of a compressible material solely.

According to another aspect of the invention a method of eliminating the influences of the environmental, surrounding or ambient light in the measurements is realized using a modulation scheme. The light emitting sources are alternately driven in a maximal and minimal light intensity. A light source i.e. LED, is driven by a current (or voltage) source, and the light of the illuminated tissue is measured by a light receiving surface, the sensor i.e. photodiode or PD as mentioned before. The induced current of the sensor is amplified and digitized using an Analog to Digital Convertor (ADC) in the hardware of the wrist worn device.

The light source is driven to a maximal or a certain high intensity resulting in a maximal or a certain high ADC output. The light emitting source

(LED) is driven to a minimal or a certain low intensity resulting in a minimal or a certain low ADC output. Those two readings are subtracted from each other in the firmware or embedded software resulting in the final measurement reading. In this way the environmental light which is present as well in the high intensity as in the low intensity measurement is being eliminated. The alternating driving electrical current for the light emitting sources is in this method a square block signal with a certain offset and amplitude. The maximal and minimal value of the current is automatically calibrating before starting a measurement. A light source electrical current position or stand is adjusted in such a way that if the sensor reading exceeds for instance 10% of the ADC range, that electrical current stand is then used as the minimal value of the light source current. A light source electrical current stand is then adjusted in such a way that if the sensor reading exceeds for instance 90% of the ADC range, that electrical current stand is then used as the maximal value of the light source current.

A comparable modulation-demodulation scheme can be employed with a light source driven by a periodic electrical current signal like a sinusoidal signal. The demodulation scheme at the sensor side can then be realized by a simple multiplication of the measured signal by the same sinus signal used for the modulation followed by a low pass filtering. The maximal value of the sinusoidal current signal to the light source has to be adjusted to induce a maximal reading at the sensor side, and the minimal value of the sinusoidal current signal to the light source has to be adjusted to induce a minimal reading at the sensor side.

According to an aspect, the device further includes a wireless communication unit arranged for communicating with a communications device, such as smart phone with a display or a smart watch with a display.

According to an aspect, the securing band is provided with woven, knitted and/or embroidered electrical connection threads connecting the at least one light source and at least one light receiver with the control unit.

According to an aspect, the securing band is provided with at least one light source and at least one light receiver directly connected to the control unit on the same side of the band.

According to an aspect, the securing band is provided with at least one light source and at least one light receiver on the inner side of the wrist connected via wiring or a conductive flexfoil to the control unit which is on another point on the wrist or e.g. on the opposite, upper side of the wrist.

According to an aspect, the at least one light source includes an optical fiber for guiding light towards the skin of the user and/or wherein the at least one light receiver includes an optical fiber for guiding light from the skin of the user. The optical fiber can be woven in, knitted in and/or embroidered on the securing band. At least a section of the optical fiber positioned to mechanically touch the skin of the user has optionally been treated to allow light to couple out and/or in.

According to an aspect, the processing unit is arranged to detect whether the device is properly worn at the wrist on the basis of the quality of the received light signal, the received ambient light or combinations of both.

According to an aspect, the device further includes an accelerometer arranged for detecting the amount of movement of the wrist of the user.

According to an aspect, the processing unit is arranged for determining the blood composition of the user (hemoglobine, hematocrite, albumin value) for medical purposes such as blood deficiencies after chemo treatment and/or radiation therapy, blood loss after birth or accidents, infections with tropical diseases such as Denque, dehydration etc.

The invention also relates to a method for measuring a health status of a user is provided comprising the steps of: providing a device worn on an

arm, e.g. a wrist, of the user, wherein the device includes, a securing band or strap, at least one light source having a light emitting surface and at least one light receiver having a light receiving surface. The at least one light source and the at least one light receiver are arranged on the securing band of the device such that when worn, the at least one light emitting surface and the at least one light receiving surface substantially abut against the palmar side of the wrist of the user, e.g. on top of one or both of the main arteries (radial and ulnar artery) within the wrist, or on a higher position on the underarm or upper arm or on the upper side of the wrist. The method can include performing a measurement session including; emitting light in a wavelength range by the at least one light source for a predetermined amount of time; producing a received light signal by the at least one light receiver corresponding to a received intensity of light received at the at least one light receiver; defining an amplitude of the received light signal (pulsating due to the blood pulsation) to be maximised by using a static force pressing the at least one light emitting surface and/or at least one light receiving surface in a direction substantially perpendicular to the palmar side of the user's wrist, e.g. positioned on top of at least one of main arteries, being the ulnar and radial arteries. This static force pressing is achieved via the application of a raised part or a part which can enlarge the static force pressing at the light emitting and light receiving surfaces via a rotation and or translation in the direction of the wrist, to the centre of the wrist or directed at the arteries in the wrist. This rotational and or translational movement of this raised part can be in pre-defined steps via a screw-thread, bayonet closure, or a press lock system or can be continuous without predetermined pressing positions resulting in customized positions.

The raised part can optionally be a deformable part, such as a deformable foam and/or plastic part, or an element with at least one raised area. The raised part can optionally be a deformable spring combined with a non-deformable or a deformable part or both, such as a deformable foam and/or

plastic part, or an element with at least one raised area. This raised area on the deformable element will ensure that the light emitting and light receiving surface will be pressed into the skin directly on top of one or both of the main arteries in the wrist (ulnar or radial artery). These areas of the wrist are deformable and not rigid due to absence of tendons in these areas, and can be compressed with the raised area(s). The light emitting and receiving surfaces are positioned on top of the areas where most light reflection of the arteries can be expected. In this way the radiative flux into the palmar side of the wrist and/or the radiative flux out of the palmar side of the wrist is controlled in a static way. The position of the static pressing element can be varied in the securing band in the longitudinal and circumferential direction of the arm/wrist to adjust the measurement position to the personal physical dimensions of the arm and/or wrist and also if necessary in the radial direction towards the centre of the wrist from the inner side or the upper side of the wrist or directed toward the arteries to achieve a better signal. The adjustment of the static force pressing element in the band can be automatically, in a self seeking manner, as explained below, or can be done via manual adjustment and shifting in one or two or three directions by the user himself. When the user puts on the band a first heart rate measurement can be being carried out via the light emitting and light receiving surfaces. The results of the measurement, e.g. the physiological heart rate or other vital signs signal, can be visualized at a screen on the band, on a separate smartphone app, or via an audio and or light signal. Optionally, an indication is presented to the user to instruct the user to adjust the position and or shape of the static pressing element in a certain direction or to(wards) a certain position, so as to achieve a better signal, e.g. higher amplitude or better signal to noise ratio, for the next measurements. Optionally the device itself adjusts the vertical position of the static pressing force system, radially oriented at the centre of the wrist or directed towards the arteries.

Optionally, the wrist worn device includes one or more light sources and light receivers which can be pressed on the skin more tightly or loosely via a passive spring system which is tightened, compressed or loosened when the band is fastened to the skin. This system can be made into a controllable actuator when it's coupled to a mechanism, which tightens the band more or less based upon received light and possibly other sensor signals. The improving of the signal can also be achieved via the use of a static force pressing mechanism which has an adjustable pressing force in a direction perpendicular to the centre of the wrist, e.g. via a screw thread or piston system or an inflatable air balloon system pressing on the light emitter and light receiver. The improving of the signal can also be achieved via a clamp beam or beam lever system which presses the light sources, the light sensor packed in the polymer or non-polymer materials more or less into the skin.

The improvement of the signal can also be achieved via the use of at least two sets of light emitting surfaces and light receiving surfaces, one set positioned and pressed into the skin area directly on top of the radial artery on the thumb side and one set near the ulnar artery on the little finger side.

The improvement of the signal can also be achieved via the use of at least two sets of light emitting surfaces and light receiving surfaces, one set positioned and pressed into the skin area directly on top of the radial artery and or ulnar artery and one set on the upper side of the wrist.

The improvement of the signal can also be achieved via the use of at least one set of light emitting surfaces and light receiving surfaces, positioned on the upper side of the wrist and which can be pressed with a larger or smaller force into the skin.

The improving of the signal can also be achieved via the use of a static force pressing mechanism which is adjustable in force perpendicular to the centre of the wrist, automatically in a self seeking manner, when the user puts on the strap or band with the light emitting and light receiving elements

on his arm, more specifically on the inner side of his wrist. A static pressing element, which is fitted in the strap/band, can be arranged to be able to slide along the inner circumference of the band/strap during fastening. The element can be equipped with at least one raised area containing the at least one light emitter and light receiver, which will be pushed into the tendonless area of the skin on the left side or right side of the inner wrist area, almost directly on top of one of the two main arteries. The heart rate, oxygen saturation and/or other biometric or physiologic parameters can thus be measured. The static pressing on the light emitting and light receiving surfaces of the measurement system will ensure that the transport of light into the skin and arm is enhanced as well as the reception of the non-absorbed, reflected light by the light receiving surface. Secondly, the light emitting and light-receiving surfaces will by this also be closer positioned to the radial and/or ulnar artery or the centre of the wrist, without interference from tendons, ligaments and wrist-bones.

The improving of the signal can also be achieved via the use of at least two sets of light emitting and light receiving surfaces, one positioned and pressed into the skin area directly on top of the radial artery on the thumb side and one near the ulnar artery on the little finger side.

The improving of the signal can also be achieved via the use of at least two or three sets of light emitting surfaces and light receiving surfaces, one set positioned and pressed into the skin area directly on top of the radial artery and or ulnar artery and one set on the upper side of the wrist where also smaller blood vessels are present and can be measured with light emitting and light reflection measurement techniques as described before.

The improving of the signal can also be achieved via the use of at least four or more sets of light emitting and light receiving surfaces, two or more sets being positioned and pressed into the skin area directly on top of the radial artery on the thumb side and two or more sets near the ulnar artery on the little finger side.

The improving of the signal can also be achieved via the use of a set with at least three or more light emitting surfaces per light receiving surface/sensor, positioned and pressed into the skin area directly on top of the radial artery on the thumb side and the ulnar artery on the little finger side.

The improving of the signal can also be achieved via the use of a set with at least two or three or more light emitting surfaces per light receiving surface/sensor, positioned and pressed into the skin area directly on top of the radial artery on the thumb side and the ulnar artery on the little finger side, integrated in a plastic moulded part together with the light receiving surface(s). The moulded part can be spherically or cylindrical shaped on the skin side, realizing here the previously mentioned raised area. The moulded part can have a flatter and flange shaped contour on the side facing the band, to allow easy sliding and repositioning in the band to achieve a better measurement signal.

The improving of the signal can also be achieved via the use of the compressible light blocking shielding around the set or sets of light emitting and light receiving surfaces.

The improving of the signal can also be achieved via the use of modulation scheme for the LEDs and PDs as described on the end of page 9 and on the first half of page 10.

Additionally, it will be appreciated that a health status can include a general fitness, heart rate measurement and derivates thereof such as heart rate variability value which is directly related to levels of stress, heart rate recovery rate value which is related to a general fitness or physical health condition, the oxygen saturation rate within the blood which can be measured by using two light sources with different wavelengths, the respiration rate on basis of the periodic fluctuation of the heart rate signal, the CO2 saturation rate in veins, arteries and in other blood vessels which is a valuable factor for premature born babies to determine the function and quality of the respiratory

system and for other applications such as acidification of muscles during sports exercises, the blood pressure and/or a compliance to an exercise schedule of a user.

Optionally, the improving of the signal includes the increasing and or decreasing of the force manually via adjustment of the position and/or shape of the static pressing element or via a manual or automatic adjustment of the force pressing on the light emitting and light receiving surfaces, to achieve an optimum in the amplitude of the pulsating signal. It has been found that when the pressure increases, from zero, between skin and the light emitting and light receiving surfaces, that the amplitude of the received light signal, the radiative flux out of the palmar side of the wrist, increases up to a certain maximum of the amplitude, and then starts decreasing again. The optimum of the pressure level can be found by increasing and decreasing the force pressing on the at least one light emitting surface and/or the at least one light receiving surface. Also has been found that the effect from the ambient or surrounding light can be eliminated when the pressure increases. To guarantee the comfort of the user this pressure force can be limited via the application of a compressible and deformable light blocking shield around the light emitter and receivers and via the use of a compressible light blocking and light emitting casing directly around the LEDs and PDs, which can move also towards or away from the arteries or centre of the wrist via a spring mechanism, a piston mechanism, a clamp or beam lever mechanism or combinations of any of the above. The modulation system for the light emitters and light receivers will also limit the influence of the environmental, ambient surrounding day and or artificial light. The amount of pressing, the tightness of the contact of the light emitting and receiving unit on the skin, the comfort and the desired quality of the signal can so be brought into balance to achieve an optimal product.

Optionally, the method further includes controlling the amplitude of the received light signal to maximise the amplitude of the pulsating component of the light signal by controlling an emitted intensity of light

emitted by the at least one light source. It is conceivable that in order to better control the amplitude of the received light signal, that in addition to the static pressing force, the emitted intensity of light emitted by the at least one light source is controlled. The emitted intensity of light emitted by the at least one light source can be measured as radiant emittance or radiant excitance measured as power per unit area radiated by a surface.

Optionally, the method includes determining the amplitude of the pulsating light signal by measuring the received light signal during a predetermined period, and determining the amplitude value on the basis of the measured received light signal during the predetermined period.

Optionally, the step of determining the amplitude of the pulsating signal is performed at the start of the measurement session. In this way the amplitude of the pulsating signal corresponds to the conditions present at the beginning of the measurement session.

Optionally the method further includes determining whether the controlling mechanism should be manually adjusted based upon the received light signal, based upon the amplitude of the received light signal more in particular, and based upon one or more received additional sensor signals (pressure sensor, accelerometer sensors, additional light signals from a different wavelength received by the light receiver etc.) or based on a received light signal from an addition light source with a wavelength which is different from the wavelength or wavelengths which is or which are being used to measure the desired physiological parameters. This extra wavelength is also not able to penetrate the skin deeply and or has a high water absorption and which will more clearly show movement of the light source and the light receiver on the skin (e.g. blue and/or green LED-light, e.g. a wavelength with a high water absorption capacity of e.g. 1100-1400 nm and the corresponding sensors), measures the motion artefacts and the influence of circumferential light. The blue or green LED-lights or light emitters with a wavelength

between 400 and 550 nm, or any other light emitter and receiver such as a 1100 nm system or with a higher wavelength till 1400 nm is primarily being used for the detection of movement and motion artefacts, but can if necessary also be used to perform additional heart rate or pulsation measurement in smaller blood vessels (capillaries, arterioles) directly under the skin on the upper side, inner side of left or right side of the wrist, This also applies to light emitters of other wavelengths.

Another embodiment or facility, increasing the sensitivity to the movement of the wearable device in reference to the skin, is formed by using appropriate polarisation filters at the light source(s) and the optical sensor(s). The movement sensor consisting of a light source and an optical sensor is preferable measuring only the movement of the wearable device in reference to the skin, via the reflection of light. Therefore the movement sensor has to be predominantly sensitive to the reflection of the light on the skin and less sensitive to the scattering of light through the tissue. The light scattered through the tissue shows a pulsating element related to the pulsing of blood. This pulsating element has to be minimised in the movement sensor reading to separate the movement from the blood pulsating in the analysis of the measurements in an algorithm and software. Therefore a polarisation filter is placed on the light source resulting in a light beam polarised in one direction. The light reflected on the skin rotates the polarisation direction of the light by ninety degrees. By placing a polarisation filter on the optical sensor turned by ninety degrees in reference to the polarisation filter at the light source, the sensor is more sensitive to the reflected light and less to the scattered light through the tissue. This embodiment will enable detection of heart rates under medium and more severe movement of body, arm en device on arm, due to the ability to distinguish in the signals between movement or motion artefacts and heart rate values.

Optionally, the method further includes determining the amount of manual adjustment of position and shape and or adjustment of pressing force of the static control mechanism based upon the received light signal, based upon the received light signal and one or more additional sensor signals (pressure sensor, accelerometer sensors, additional light signals from a different wavelength received by the light receiver etc.), or based on a received light signal from an addition light source with a wavelength which is not able to penetrate the skin deeply and which will show more clearly movement of light source and light receiver on the skin (e.g. a blue and/or green LED-light of 400-550 nm or a 1100-1400 nm LED light).

Optionally, the method further includes a separate set of light emitter and light receiving surfaces on the outside of the band of the wrist worn device, on which the user can place one of it's finger to perform a separate measurement of heart rate and oxygen saturation in a defined tissue volume with a known and limited optical path. This additional measurement method with the same device requires a separate action of the user but can be applied to validate, compare and or calibrate the heart rate and/or oxygen saturation measurements which have been determined with the light emitting and receiving surfaces on the inside of the wrist. The user can get an instruction to perform this separate measurement via the display of the wrist worn device and/or the smart phone with application software.

Optionally, the method further includes determining the user's heart rate and/or related health parameters such as heart rate variability (is a measure for stress) and heart rate recovery (an indication of physical condition) and oxygen saturation on the basis of the received light signal based on time and/or frequency domain analysis. The high frequency component of the received light signal may also be used.

Optionally, the method further includes performing a first measurement session wherein the light emitted by the at least one light source is in a first wavelength range and performing a second measurement session

wherein the light emitted by the at least one light source is in a second wavelength range. Using light in a first wavelength range followed by light in a second wavelength range allows for additional health indicators to be determined and to determine the heart rate parameter via two measurements. The amount of different wavelengths to be used can be one, two, three or more depending on the desired accuracy, artefact compensation measures, redundancy and additional health indicators to be measured.

Optionally, the step of performing a measurement session further includes a step of calculating a perfusion index value on the basis of the received light signals of two light sources or two light wavelengths of e.g. 600-660 nm and 880-940 nm. Optionally, the method further includes determining the user's saturation of peripheral oxygen level, SpO2, on the basis of a ratio of the perfusion index value calculated in the first measurement session and the perfusion index value calculated in the second measurement session, and optionally on the basis of a value of a control signal of the control unit for controlling the force and/or emitted intensity. Here the oxygen saturation of the user's blood and changes in the blood volume in the skin are monitored. The changing absorbance at each of the wavelengths is measured allowing the absorbance due to the pulsing of the blood to be determined. The wrist worn device can act as a plethysmograph, and a photoplethysmogram may be produced and displayed.

The perfusion index valve can be calculated on the basis of a ratio of a high frequency component and a low frequency component of the received light signals.

Optionally, the at least one light source includes a plurality of light sources and at least one light receiver includes a plurality of light receivers, arranged around the circumference of the arm, e.g. wrist, or around part of the circumference of the arm, e.g. wrist, perpendicular to the arm or parallel to the arm or in both or more directions.

Providing a plurality of light sources and a plurality of light receivers allows for different possibilities of emitting light. Furthermore, with a plurality of receivers the received light signal can be produced in different ways.

Optionally, the step of producing the received light signal at the at least one light receiver includes averaging the received light signals produced at a subset of the plurality of light receivers. Through averaging a more reliable received light signal can be produced.

Optionally, the step of producing the received light signal at the at least one light receiver includes selecting an optimum received light signal produced at one of the light receivers. In this way a received light signal is produced at more than one of the light receivers, and the optimum received light signal is selected. Optionally, the optimum received light signal is selected on the basis of an alternating signal (AC) to static signal (DC) ratio, determining the best AC/DC ratio to be able to distinguish the heart rate as first primary parameter for health measurement and derivatives thereof (Heart Rate Variability and Heart Rate Recovery) and e.g. using the received AC/DC signal to determine oxygen saturation, dehydration or other parameters.

Optionally, the step of producing the received light signal at the at least one light receiver includes selecting the best and second best received signal produced at two of the light receivers. Additionally, the best and second best received signal may be combined for example by averaging.

Optionally, the method further includes detecting a movement of the user, and or the presence of skin against the measurement device on the basis of the received light signals, which can be the light signals being used to measure physiological parameters or other light signals which penetrate not so deeply in the skin. Detecting a movement of the user and/or presence of skin against the measurement device can be used to determine the amount or level of artefacts influencing the received signal, can be used to determine if a user

is following a prescribed exercise regime, and/or if a user is moving enough to achieve a given health status. Optionally the method further includes detection of the effect or presence of surrounding artificial or natural light via the received light signals, so that the user can tighten the system more or less.

Optionally, the method further comprises a step of selecting the at least one light source from the plurality of light sources and selecting the at least one light receiver from the plurality of light receivers, wherein the step of selecting comprises; for each light source of the plurality of light sources emitting light in a wavelength range for a predetermined amount of time; producing at each light receiver a received light signal corresponding to the light received at that light receiver individually from each light source; separating each received light signal into a high frequency component and a low frequency component; calculating for each received light signal a perfusion index value on the basis of a ratio of the high frequency component and the low frequency component, and selecting a light source and light receiver combination having the highest perfusion index value as the at least one light source and the at least one light receiver.

It has been shown that selecting the light source and light receiver combination having the highest perfusion index (or AC/DC ratio) value provides an improved received light signal. Different filtering possibilities exist for separating each received light signal into a high frequency component and a low frequency component. The cut-off values frequencies may be based on the lowest expected heart rate and/or the highest expected heart rate.

Optionally, the method includes selecting a subset of light sources of the plurality of light sources and a subset of light receivers of the plurality of light receivers having the highest perfusion index values as the at least one light source and the at least one light receiver. In this way methods of producing the received light signal on the basis of more than one light source and light receiver combination can also be performed.

Optionally, the step of selecting is performed for a first wavelength range and a second wavelength range and optionally a third and optionally fourth wavelength range. It is conceivable that different light source and light receiver combinations are ideal for the first wavelength range and the second wavelength range. It can be advantageous to determine the light source and light receiver combination independently.

Optionally and preferably, (only) light emitting surfaces and light receiving surfaces that are in close proximity to one another are used for determining the oxygen saturation, e.g. neighbouring light emitting surfaces and light receiving surfaces. When multiple light emitting surfaces and multiple light receiving surfaces are used in the device, it may be preferred to not activate all light emitting surfaces at the same time, but to activate the light emitting surfaces in groups around in close proximity to a light receiving surface or one at a time, to limit and diminish the optical path and illuminated tissue volume, and by this to minimise the effect of light receiving surfaces receiving light emitted by far away light emitting surfaces. This will enhance the accuracy and reproducibility of the oxygen saturation measurement.

Optionally, the method further comprises a way of determining the amount of physical movement or exercise of the user by a combined use and analysis of heart rate values and the detected movement via the light reflection measurement with the additional light emitter and receiver of a different wavelength such as 400-550 nm or 1100-1400 nm, so that only a higher heart rate combined with a higher motion artefact detection indicates physical exercise. The analysis of these two measurement can be combined with data of an integrated 3-axis accelerometers in the device, a GPS receiver in the device or in a wirelessly connected communication device (smart watch, smart phone, navigation device etc.), a tri-angulation GSM positioning method in the device itself or in the wirelessly connected device, an electrical or optical temperature sensor measuring the increasing temperature of the skin during exercise.

Optionally, the method further comprises a step of displaying on a display associated with the wrist worn device an instruction instructing and advising the user to perform a predetermined exercise; performing a measurement session while the user performs the predetermined exercise; and storing a result of the measurement session, wherein the result preferably includes the user's heart rate and/or saturation of peripheral oxygen level and/or ability to recover the user's heart rate at a normal, non-exercising level, for example heart rate recovery.

In this way, an indication of the user's health can be determined while performing a predetermined exercise. The display may be included in or on the wrist worn device. Additionally, or alternatively, the display may be included in an external device, such as a smart phone device, that is communicatively connected with the wrist worn device, wired or wirelessly.

Optionally, the method further comprises, measuring the general fitness of the user on the basis of the measurement session and/or previous measurement sessions; displaying an indication of the general fitness and/or health of the user. In this way, the user and/or a health advisor can quickly determine an indication of the user's general fitness.

Preferably a graphical representation of a person having a general fitness corresponding to the general fitness of the user is displayed. For example if it is determined that the general fitness of the user is poor, the displayed graphical representation of the person may have his hands on his knees and he breathes heavily. On the other hand if the general fitness of the user is good, the displayed graphical representation of the person may be performing jumping jacks, or be jogging in place. Or, on the other hand if the oxygen saturation value and or heart rate recovery rate of the user is good, the displayed graphical presentation of the person may be moving faster than if the oxygen saturation value and or heart rate recovery rate of the user is less good, giving an indication of a lower general fitness or deteriorating health

condition resulting in a slower movement of the graphical presentation of the person.

Optionally, the graphical representation moves and is coloured corresponding to the general fitness of the user and/or compliance to the exercise schedule and/or measurement of movement with higher heart rate values. For example, if the general fitness of the user and exercise compliance is determined to be poor, the displayed graphical representation may be coloured orange to red and or moving slowly in the display. Similarly, if the general fitness of the user and/or exercise compliance is determined to be improving, the displayed graphical representation may be coloured orange green and/or moving a bit faster in the display than the displayed graphical presentation in red, representing a status of low exercise compliance, low oxygen saturation values or not improving heart rate parameters.

Similarly, if the general fitness of the user and/or exercise compliance is determined to be good, the displayed graphical representation may be coloured green and or moving even faster in the display.

Optionally, the graphical representation moves and or is coloured and shaped corresponding to the Body Mass Index of the user and/or his/her compliance to the exercise schedule.

Optionally, the wrist worn device further including a wireless communication unit arranged for communicating with a communications device, such as a smart phone, with display. In this way, the wrist worn device can take advantage of the smart phone's processing power, display capabilities, and user interface, e.g. via combined use with a smart phone application (app).

Optionally, the securing band is provided with woven, knitted and/or embroidered electrical connection threads connecting the at least one light source and at least one light receiver with the control unit. Retaining the electrical connection threads in the securing band allows the control unit to be placed remotely from the at least one light emitting surface and at least one light receiving surface and can be adjusted more easily to the dimensions and

different wrist circumferences of various users. This is advantageous as the at least one light receiving surface substantially abut against the palmar side of the wrist of a user.

Optionally, the at least one light source includes an optical fiber for guiding light towards the skin of the user and/or wherein the at least one light receiver includes an optical fiber for guiding light from the skin of the user. Advantageously, the at least one light source and/or the at least one light receiver may be remote from the skin of the user on palmar side of the wrist.

Optionally, the optical fiber is woven in, knitted in and/or embroidered on the securing band. Optionally, the optical fiber is included in the securing band such that the ends of the fibers are mechanically touching the skin of the user. In this way the band holds the end of the fibers in position for guiding light towards and/or away from the skin of the user.

Optionally, at least a section of the optical is fiber positioned to mechanically touch the skin of the user has been treated mechanically or chemically to allow light to couple out and/or in.

Optionally, the wrist worn device includes a plurality of static force pressing elements and a plurality of light sources having a plurality of light emitting surfaces and a plurality of light receivers having a plurality of light receiving surfaces wherein each static force pressing element is arranged for exerting a force on one light emitting surface and/or one light receiving surface pushing these surfaces more on and/or into the skin of wrist preferably positioned in the areas of the skin on top or above the position of the radial and or ulnar artery.

Optionally, the light emitting surface of the at least one light source and/or the light receiving surface of the at least one light receiver is covered with a transparent soft polymer cover, preferably spherically shaped or thicker and protruding above the light emitter and receiver surfaces and surrounded

with an elastic frame, of light blocking non transparent polymer material, separating the light emitting surfaces from the light receiving surfaces.

In this way the light emitted from the light emitting surface is directed substantially towards the skin of the user. Stray light emitted from the light emitting surface is prevented from interfering with other emitting surfaces and from entering the light receiving surface without traveling through the user. Therefore, crosstalk between light sources and light receivers is reduced substantially. Also ambient light can be blocked by this method, combined with the mechanical force applied by the fastened securing band and the static force pressing element integrated or being part of the securing band.

Optionally, the cover is cylindrical or spherically shaped and is arranged to be pressed inwardly of the palmar part of the wrist by adjusting the securing band and/or the static force pressing element, preferably on top of the radial and or ulnar artery. A spherically or cylindrically shaped cover improves the coupling of light emitted from the light emitting surface into the user, and improves the capture of light traveling out of the user and into the light receiving surface.

Optionally, the processing unit is arranged to detect whether the device is properly worn, or even worn at all, at the wrist on the basis of the received light signal. When the device is worn properly, an expected received light signal can be determined. On the basis of this signal, it can be determined if the received light signal corresponds to a properly worn device.

Optionally, the wrist worn device further includes an accelerometer arranged for detecting the amount of movement of the wrist of the user and or the device on the wrist of the user and gives an indication of physical activity of the body of the user. This may provide an indication of the amount of everyday movement of the user. Additionally, or alternatively, this may provide an indication of a user's compliance to an exercise program or schedule. Furthermore, the output signal of the accelerometer may be provided

to the processing unit and/or the control unit for taking the amount of movement of the wrist of the user into account when determining the amplitude envelope control band and/or controlling the force.

Optionally, the processing unit is arranged for determining the blood composition of the user (haemoglobin, haematocrit, water, plasma value) for medical purposes such as blood deficiencies after chemo treatment and/or radiation therapy, blood losses after birth or accidents, infections with tropical diseases such as Denque.

Further, according to the invention a system including a wrist worn device according to the invention including a communication unit for wired or wireless communication and a communications device such as a display on the wrist worn device and or a smart phone with a display.

It will be appreciated that features described with regard to one of the method according to the invention, the device according to the invention and the system according to the invention are considered to be disclosed for the remaining categories.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be further elucidated by means of non-limiting examples referring to the drawings, in which

Fig. 1 shows a schematic top view of a wrist worn device according to the invention;

Figs. 2a, 2b, and 2c show a schematic side view of a part of a wrist worn device according to the invention with an exemplary static force pressing element;

Fig. 2d shows an example of a tunnel shaped element on the inside of the securing band.

Fig. 3 shows a schematic representation of a system according to the invention including a wrist worn device and a communications device;

Fig. 4 shows the system according to the invention displaying an indication of the general fitness and/or health of a user; and

Fig. 5 shows the system according to the invention displaying an indication of the general fitness and/or health of a user;

Fig. 6 shows an alternative shape and mounting method for a static force pressing element with moulded spring parts.

Fig. 7 shows an alternative version of the static force pressing system with a piston system.

Fig. 8 shows a clamp and beam lever system.

Fig. 9 shows a compressible shield around the light emitting and light receivers which blocks ambient light and allows a high comfort during wearing.

DETAILED DESCRIPTION

Fig. 1 shows a schematic top view of a wrist worn device 1 according to the invention, and Figs. 2a-2c show a schematic side view, in cross section, in the part of the band strap in which the sensor system (light emitting and receiving surfaces is positioned during use).

The wrist worn device includes a securing band 2, a processing unit 4, an integrated or separate wireless communications unit 6, a light emitting and light receiving unit or sensor element 8 positioned on top of one or both of the main arteries, A_R, A_U, in the wrist W and a static pressing element 9. In this example, the device 1 includes three light sources each having a light emitting surface 12. In this example, the device 1 also includes three light receivers having each a light receiving surface 16. One or two of the light emitting and receiving surfaces are being used to perform physiological measurement, whereas at least one set of light emitter and receiver is being used for detection of motion artefacts via measurement of all light reflected on the skin. The light emitting surfaces 12 and the light receiving surfaces 16 are arranged on the inside of the securing band 2 of the wrist worn device 1 such

that when worn the at least one light emitting surface 12 and the at least one light receiving surface 16 substantially abut against the palmar side of the wrist of a user, preferably at the side of the wrist where the ulnar artery A_U and/or radial artery A_R are located. Additionally in this embodiment the light emitting surfaces 12 and the light receiving surfaces 16 are separated by a non-transparent light blocker 13, which can be made from a flexible, compressible material. Furthermore, in this example the light emitting surfaces 12 and the light receiving surfaces 16 are received in an elastic frame 10 and 14, respectively, of light blocking material. Finally a spherically shaped partly transparent polymer cover 26 can be provided, which enhance the pressing into the skin and the light coupling and which can have non-transparent light blocking segments between the LEDs and PDs.

In this example, the static pressing element 9 is made from a deformable, compressible material. The static pressing element 9 is mounted in a tunnel shaped pocket 11 (see fig 2d) of the securing band 2, which can either be in the longitudinal direction of the securing band or in the width direction or both.

The static pressing element 9, can be made of foam, a deformable plastic moulded part, a spring element, a spacer fabric or 3D-textile element or the like. The pressing element 9 has a raised area 9A which presses underneath the sensor element 8 with the light emitter 12 and light receiver 16 so that these are pushed into the skin on top of the ulnar artery A_U and/or radial artery A_R. The position of this static pressing element 9 and thus also it's raised area 9A can be varied by shifting/sliding the pressing element 9 inside the tunnel shaped part 11 of the securing band 2. The sliding can be done manually after having performed the first signal amplitude measurement, either via sliding the static pressing element 9 from the inside of the band 2 via pulling and or pushing, via the outside via an integrated sliding handle 13 (see fig 2c) or automatically in a self-seeking manner. For

this last embodiment the static force pressing element 9 can have a low friction smooth surface that enables easy automatic sliding inside the tunnel 11.

In this example, the tunnel is made of a polymer and/or textile material and has a larger elasticity and elongation capacity on the inside, skin side, than on the outside, in order to force the static pressing element 9 with it's raised area 9A to press the light emitting surface 12 and light receiving surface 16 into the skin. The static pressing element 9 is arranged for exerting a force on the light emitting surfaces and light receiving surfaces in a direction substantially perpendicular to the palmar side of the user's wrist. In this tunnel also the rigid beam lever 71 can be mounted (see fig. 8), which applies more pressure on the light emitting an light receiving surfaces at the skin area above the main wrist arteries.

The static force pressing element 9 can also have the shape of a rectangular, square or oval shaped part (24) with flanges (22) which can be mounted in a deformable stretchable pocket (11) on the inside of the securing band 2 (see fig 6). This part 24 has one or two or more raised areas which can be lowered in height via compression enabling by this a higher pressing force to the skin when the light emitting and light receiving surfaces 12, 16 are mounted above this part on the inside of the securing band.

The securing band or strap can include one or more sections of stretchable textile materials and or polymer materials enabling a tight securing and delivering an initial pressing force for the actuators and light emitting and light receiving surfaces. The entire circumference of the securing band or strap can also be made of such material.

The securing band or strap can include a stretchable foam material which is permeable to water vapour, sweat and gasses, allowing ventilation of the skin. Such foam material can on the side abutting the arm or wrist be covered with a textile material allowing absorption and uptake of sweat,

regulating the microclimate and preventing allergic reactions. The entire circumference of the securing band or strap can also be made of such foam material. This foam material can be coated with a stretchable textile material enabling a high comfort and easy moisture uptake from the skin

The securing band or strap further can comprise one or more sections, or be completely made, of stretchable material textile and or polymer materials enabling a tight securing and delivering an initial pressing force for the static force pressing element and light emitting and light receiving surfaces.

The securing band or strap further can comprise a stretchable foam material which is permeable to water vapour and gasses, allowing ventilation of the skin. The foam material can on the arm or wrist side be covered with a fine textile material allowing absorption and uptake of sweat, regulating the microclimate and allergic reactions.

The light receivers 16 are arranged for producing a received light signal corresponding to a received intensity of the light received at the at least one light receiving surface 16. The processing unit 4 is arranged for determining an amplitude of the received light signal.

During a measurement session the amplitude of the received light signal can be increased by varying the position of the static force pressing element and or the selection of the most appropriate light emitting surface and light receiving surface. Measurements derived from a received light signal where the amplitude of the received light signal has a distinctive value in which the AC part of the heart pulsating can be clearly discriminated from the DC part including the motion artefacts in this DC-part of the signal. By this the signals during a measurement session are more reliable. Also the effect of motion artefact and movement which is measured by the light reflection on the

skin can be used in the dataprocessing in the unit 4 to be able to clearly discriminate the heart beat signal. In this example, a user's heart rate and heart rate variability are determined on the basis of the received light signal.

Additionally, in this example the three light emitting sources are each capable of emitting light in a first wavelength range and a second wavelength range. In this example, each light source comprises a first LED capable of emitting light in a first wavelength range of 600-660 nm and a second LED capable of emitting light in a second wavelength range of 880-940 nm and a third LED capable of emitting light in a second wavelength range of 1100-1400 nm or 400-500 nm.

By performing a first measurement session wherein the light emitted by the three light sources in the first wavelength range and performing a second measurement session wherein the light emitted by the three light sources is in the second wavelength range additional health indicators such as the user's saturation of peripheral oxygen level, SpO2, can be determined. This is determined on the basis of a ratio of the perfusion index value (AC/DC value) calculated in the first measurement session and the perfusion index value calculated in the second measurement session.

In this example, prior to performing a measurement session a selection step is performed. In the selection step a light source and light receiver combination is selected. For each light source of the three light sources, light is emitted in a wavelength range for a predetermined amount of time. A received light signal is produced at each of the light receivers. The processing unit 4 separates each received light signal into a high frequency component and a low frequency component using filters with cut-off frequency values that are based on the lowest expected heart rate and the highest expected heart rate. A perfusion index value is calculated for each received light signal by the processing unit 4 on the basis of a ratio of the high frequency component and the low frequency component. The steps are repeated for each light source, and the light source and light receiver

combination having the highest perfusion index value is selected. It is possible that after this selection the non-selected light sources are switched off to reduce power consumption.

A system 100 including a wrist worn device 1 and a communications device 50 is shown in Fig. 3. The communications device 50 includes a display 52, e.g. a touch screen display, which gives information, feedback and instructions to the user. A software application running on the processing unit 4 or the communications device 50 can also be used to define, start and install measurement sessions. In this example the display 52 is associated with the wrist worn device. Additionally both the communications device 50 and the wrist worn device 1 include a communication unit, not pictured, through which the devices are able to communicate with each other. In this example the communications device 50 can for instance be a smart phone device with a touch screen display.

With the system 100, a user can monitor his general fitness. In addition, a user and/or a health advisor can monitor a user's compliance to a selected exercise schedule, can measure his/her daily exercise, his heart rate and oxygen saturation values during exercise, before and after exercise etc. For example, in Fig. 4, an exercise instruction 54 appears on the display 52 of the communications device 50. For example, the instruction 54 instructs the user to perform e.g. twenty knee bendings (so called squats). During the exercise a measurement session is performed. Preferably, a measurement session is performed prior to starting the exercise and, e.g. at predefined intervals, after the exercise is completed. It is possible that the wrist worn device 1 concludes that the exercise is completed on the basis of at least one of an amount of movement determined on the basis of the received light signal, an amount of movement determined by an accelerometer of the wrist worn device, and a measured elapsed time interval.

In this case during each measurement session the user's heart rate, heart rate variability, heart rate recovery and oxygen saturation, SpO2, is

measured. On the basis of these measurements recorded during different measurement sessions, an indication of a user's general fitness indication of the user's health is determined.

On the display 52 of communications device 50 associated with the wrist worn device 1, an indication 56 of the general fitness of the user is displayed. The indication 56 may relate to the general fitness just measured during the exercise. Additionally, or alternatively, the indication 56 may relate to a general fitness measured on the basis of the measurement session and one or more previous measurement sessions, for example measurement sessions taken over the previous week or month.

In this example, the indication 56 is a graphical representation of a person having a general fitness corresponding to the general fitness of the user or an activity pattern or movement achievement during a certain amount of time. In Fig. 4, the measured general fitness of the user is poor. Therefore a graphical representation 56 of a person having a poor general fitness is shown. In this example, the graphical representation 56 is of an overweight person. Additionally, in the case that the graphical representation 56 of the person is animated, the animation can represent the general fitness of the user, e.g. graphical representation 56 of the person can be animated to be breathing heavily.

In Fig. 5, the measured general fitness of the user is good. Therefore a graphical representation 56 of a person having a good general fitness is shown. The graphical representation 56 is of healthy person of normal build. Additionally, in the case that the graphical representation 56 of the person is animated, the graphical representation 56 of the person can e.g. be running in place.

The indication 56 of a general fitness of the user can also be measured on the basis of measurement session initiated in response to an amount of movement being detected by the integrated optical motion artefact and movement detection system, and if necessary with additional sensors such

as provided accelerometers provided, not pictured, in the wrist worn device, or GPS positioning data and or GSM tri-angulation data. The amount of movement and the measured health status are recorded in the wrist worn device 1 and/or the communications device 50. In this way a measure of compliance to an exercise schedule is measured. For example, the schedule might require that the user performs 30 minutes of exercise a day at or above the users target heart rate. In the case of Fig. 5, the user has achieved a 90 % compliance. In the example of Fig. 5 this is displayed as a text 58, including an encouraging comment, on display 52 of the communications device 50.

In the foregoing specification, the invention has been described with reference to specific examples of embodiments of the invention. It will, however, be evident that various modifications and changes may be made therein without departing from the broader spirit and scope of the invention as set forth in the appended claims. For the purpose of clarity and a concise description features are described herein as part of the same or separate embodiments, however, alternative embodiments having combinations of all or some of the features described in these separate embodiments are also envisaged.

Fig. 7 shows an alternative version of the static force pressing system with a piston system. In this embodiment the pressing force on the skin 74 with the spherical or otherwise shaped dome with transparent cover 26 with sensor 16 and LEDs 12 can be applied via an adjustable piston system 62 which glides and locks its rim 63 in predetermined positions 61. This piston system 62 with its corresponding cylinder 60 has a contact surface 64 on the outside of the securing band or strap 59 which can be pressed with a finger 65 to adjusting the pressing force dome with the light emitting surfaces 12 and light receiving surfaces 16 more or less on the skin 74 to achieve a better heart rate signal from the main arteries in the wrist Ar and or Av. The polymer material 13 between the light emitters 12 and light receivers 16 can be opaque and non transparent to block cross transfer of light directly to the sensor. The

polymer material can be elastic and compressible. The transparent polymer cover material 26 can also be elastic and compressible. The piston system 62, 60 can have an in built spring or lever to release the part 63 via pushing to a higher position. The piston system can have predetermined positions 61 or can have unlimited variable positions not predetermined.

Fig. 8 shows a stiff clamp and beam lever system 71 with a cylindrical, round, spherical, or otherwise shaped end 67 which can exert a force on the back side of the dome shaped sensor unit containing the light emitting surfaces 12 and light receiving surfaces 16 to push this more or less into the skin 74. The light and sensor unit is either mounted in a partly flexible strap 59 or can be slidingly moved upward and downward like in a piston system of fig 7 or in an axis and corresponding cylinder system, The beam lever 71 rotates or moves with a cylindrical or dome shaped end 69 in a corresponding casing 70 depending on the amount of fastening of the securing band or strap 59 in one of the positions 73 with the corresponding elements 72. This clamp or beam lever system can have various shapes, sizes or different constructions, but always will be able to push the lighting and sensing unit harder or less harder into the skin 74 above one or two of main arteries Ar or Av of the wrist to detect the heart rate better and other physiological parameters. An alternative version of this embodiment comprises a half circular stiff polymer or metal element, which rests on upper part of the wrist and near the artery and is half circular or covering the outer and inner side of the wrist. This beam lever or clamp 71 is integrated in the partly or wholly flexible strap 59 and will push the lighting and sensor unit more or less in the skin 74 to achieve a better measurement. The stiff beam lever 71 has a slight larger curve or radius then the side of the wrist and due to its stiffness will push itself inwardly in the direction of the arteries Ar and or Av pushing the light emitting and receiving surfaces closer to one or two of these arteries. Also other beam lever or clamp versions are possible, with the basic principle that a

stiff or stiffer element of the strap pushes the lighting and sensing unit deeper or less deeper in the skin.

Fig. 9. shows a compressible non-transparent shield 73 around the light emitting and light receivers 12 and 16 which blocks ambient light and allow a high comfort during wearing. The shield is deformable due to its shape and or use of flexible, compressible material. The shield 73 has ends 72 which can rest upon the skin and block all ambient light from the environment. The shield can have a bellows shape or another deformable shape allowing compression after applying force on the fastening strap, or clamp, beam lever system of fig. 8 or piston system of fig. 7 or via another method.

However, other modifications, variations, and alternatives are also possible. The specifications, drawings and examples are, accordingly, to be regarded in an illustrative rather than in a restrictive sense.

For the purpose of clarity and a concise description features are described herein as part of the same or separate embodiments, however, it will be appreciated that the scope of the invention may include embodiments having combinations of all or some of the features described.

In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. The word 'comprising' does not exclude the presence of other features or steps than those listed in a claim. Furthermore, the words 'a' and 'an' shall not be construed as limited to 'only one', but instead are used to mean 'at least one', and do not exclude a plurality. The mere fact that certain measures are recited in mutually different claims does not indicate that a combination of these measures cannot be used to advantage.

Conclusies

1. Apparaat voor het meten van een gezondheidstoestand van een gebruiker, dat gedragen wordt rond de pols van een statische of bewegende gebruiker, het instrument bevattende een vastmaak band, ten minste één lichtbron met een licht emitterend oppervlak en tenminste één licht ontvanger met een licht ontvangend oppervlak; waarin ten minste één lichtbron en ten minste één licht ontvanger zijn gepositioneerd op een zodanige wijze op de vastmaak band dat wanneer het apparaat gedragen wordt, ten minste één licht emitterend oppervlak en tenminste één licht ontvangend oppervlak grenzen aan en tegen de binnenkant, palmaire zijde van de pols van de gebruiker geplaatst zijn.

Het apparaat bevat verder een drukelement geprojecteerd op de zijde van de vastmaak band en zodanig gericht naar de pols toe dat één licht emitterend oppervlak en tenminste één licht ontvangend oppervlak in de huid van de pols gedrukt worden.

Het apparaat bevat verder tenminste een tweede lichtbron en ten minste een tweede lichtontvanger, die verschillen van de eerste set en waarvan het licht niet diep penetreren kan in de huid en de corresponderende sensor daardoor in staat is bewegingsartefacten en beweging van het instrument vast te stellen.

2. Apparaat volgens conclusie 1, waarin het drukelement, zoals een vast onderdeel of een indruk baar onderdeel, zoals een schuimdeel of een veersysteem, dat handmatig ingesteld kan worden om de drukkracht in te stellen.

3. Apparaat volgens conclusie 1 of 2, waarin het drukelement een koepelvorm heeft, zoals b.v. een afgeronde vorm, een piramide vorm,

halfbolvormig deel; een half ovaal deel; een afgerond ruitvormig deel en bestaat uit een beweegbaar binnenste kerndeel en buitenste geleidende deel.

4. Apparaat volgens conclusie 1 of 2, waarin het drukelement bestaat uit een vast en niet comprimeer baar deel dat een koepelvorm heeft, zoals b.v. een afgeronde vorm, een piramide vorm, halfbolvormig deel; een half ovaal deel; een afgerond ruitvormig deel en bestaat uit een beweegbaar binnenste kerndeel en buitenste geleidende deel.

5. Apparaat volgens conclusie 1 of 2 of 3 of 4, waarin het drukelement is verbonden rechtstreeks of indirect met een klem of hefboom system welke het licht emitterende oppervlak en het licht ontvangende oppervlak in de huid van de pols kan drukken.

6. Apparaat volgens een van de conclusies 1-5, waarin de licht bron en licht ontvanger beiden bedekt zijn met een polariseer system, b.v. een polarisatiefilter, om de penetratie van licht te beperken en de reflectie van licht te maximaliseren om in staat te zijn bewegingsartefacten en beweging te detecteren.

7. Apparaat volgens conclusive 6, waarin het polariseer system, polarisatiefilter, voor de optische sensor of de licht ontvanger 90 graden gedraaid is ten opzichte van het polarisatiefilter voor de lichtbron of licht emitters om in staat te zijn bewegingsartefacten en beweging te detecteren.

8. Apparaat volgens een van de conclusies 1-7, waarin de licht emitterende en de licht ontvangende oppervlakken afgeschermd zijn van omgevingslicht door een niet transparant, licht blokkerende scherm dat de huid raakt.

9. Apparaat volgens conclusies 8, waarin de licht emitterende en de licht ontvangende oppervlakken afgeschermd zijn van omgevingslicht door een comprimeer baar en vervormbaar, niet transparant, licht blokkerende scherm dat de huid raakt.

10. Apparaat volgens een van conclusies 1-9, waarin een modulatieschema wordt gebruikt voor het uitgezonden, geëmitteerde licht op een zodanige wijze dat het omgevingslicht dat aanwezig is in zowel de hoge lichtintensiteit meting als in de lage lichtintensiteit meting daardoor wordt geëlimineerd uit het licht dat gerelateerd is aan de fysiologische parameters. in de software of firmware van het apparaat.

11. Apparaat volgens een van de conclusies 1-10 waarin een indrukbaar materiaal of element is aanwezig rond of achter de licht emitterende en licht ontvangende oppervlakken om het kruisend licht direct tussen licht emitter en licht ontvanger te blokkeren en om een hoger comfort voor de gebruiker te garanderen.

12. Apparaat volgens een van de conclusies 1-11 waarin het drukelement wordt gepositioneerd boven één of beide van de hoofdslagaders in de pols.

13. Apparaat volgens een van de conclusies 1-12 waarin het drukelement tenminste voor een gedeelte wordt geplaatst tussen de vastmaakband en/of de licht ontvangende oppervlakken.

14. Apparaat volgens een van de conclusies 1-12 waarin het drukelement tenminste voor een gedeelte wordt geplaatst tussen de vastmaakband en/of de licht ontvangende oppervlakken.

15. Apparaat volgens conclusies 13 of 14 waarin het drukelement is opgenomen in tunnelvormig deel van de vastmaak band of mechanisch wordt verbonden aan de vastmaakband.

16. Apparaat volgens een van conclusies 13-15 waarin het drukelement is opgenomen op zodanige wijze dat het beweegbaar is omtrek richting of axiale richting van de vastmaakband.

17. Apparaat volgens conclusie 16, waarin het drukelement is opgenomen op zodanige wijze dat het schuifbaar is.

18. Apparaat volgens conclusie 17, waarin het oppervlak van het drukelement en of een oppervlak van de vastmaak band, drager, tunnelvormig deel gericht naar het drukelement een lage wrijving heeft om gemakkelijk schuiven mogelijk te maken.

19. Apparaat volgens een van conclusies 16-18, waarin het drukelement een positioneringsmiddel heeft gericht naar de buitenkant van de vastmaakband, om positionering en verplaatsing van drukelement mogelijk te maken.

20. Apparaat volgens conclusie 19, waarin het positioneringsmiddel een hendel is die uitsteekt t.o.v. een zijde van de vastmaak band, en/of radiaal uitsteekt door de vastmaakband.

21. Apparaat volgens een elke van de voorgaande conclusies, waarin de vastmaak band deels of geheel bestaande uit rekbaar materiaal om door het strak vastmaken hiervan en het uitoefenen van een drukkracht, het drukelement in de huid te kunnen drukken.

22. Apparaat volgens conclusie 21, waarin de vastmaak band bestaat uit een uitrekbaar schuimmateriaal dat permeabel is voor waterdamp en gassen, hiermee ventilatie mogelijk maken van de huid, waarin optioneel het schuimmateriaal bedekt kan zijn aan de polszijde met een materiaal dat vloeistof en vocht kan absorberen.

23. Apparaat volgens een elke van de voorgaande conclusies, verder bevattende een control unit ingericht voor het bepalen van een gezondheidstoestand, zoals een fysiologische parameter, zoals hartritme, hart ritme variabiliteit, hart ritme herstel rate, ademhalingsfrequentie en/of zuurstofsaturatie, CO2 waarden, van een signaal representatief voor de hoeveelheid licht ontvangen door de licht ontvanger.

24. Apparaat volgens een elke van de voorgaande conclusies, waarin de licht emitterende oppervlak(ken) en de licht ontvangende oppervlak(ken) zijn gescheiden van elkaar door een niet-transparante licht blokkeerder.

25. Apparaat volgens een elke van de voorgaande conclusies, waarin de licht emitterende oppervlak(ken) en de licht ontvangende oppervlak(ken) zijn opgenomen in een of meer elastische, comprimeerbare houders, bij voorkeur gemaakt van licht blokkerend materiaal.

26. Apparaat volgens een elke van de voorgaande conclusies, waarin de licht emitterende oppervlak(ken) en de licht ontvangende oppervlak(ken) zijn bedekt met een transparante laag of deksel, bij voorkeur een koepelvormige, gedeeltelijk bolvormige bedekking.

27. Apparaat volgens een elke van de voorgaande conclusies, verder bevattende een draadloze communicatie module voor communicatie met een

communicatie device, zoals een smart phone met een display, een tablet of een smart watch.

28. Apparaat volgens een elke van de voorgaande conclusies voor zover afhankelijk van conclusie 23, waarin de vastmaak band is voorzien van geweven, gebreide en of geborduurde elektrisch geleidende verbindingsdraden die ten minste één lichtbron en tenminste één lichtontvanger verbinden met de control unit.

29. Apparaat volgens een elke van de voorgaande conclusies, waarin ten minste één lichtbron een optische fiber bevat voor het geleiden van licht naar de huid van de gebruiker en/of waarin tenminste één lichtontvanger een optische fiber bevat voor geleiding van het licht van de huid van de gebruiker.

30. Apparaat volgens conclusie 29, waarin de optische fiber is geweven, gebreid en/of geborduurd in de vastmaakband.

31. Apparaat volgens conclusie 29 of 30, waarin tenminste een deel of sectie van de optische fiber die gepositioneerd is om de huid te raken van de gebruiker, is behandeld om licht gemakkelijker te laten inkoppelen.

32. Apparaat volgens een elke van de voorgaande conclusies, voor zover afhankelijk van conclusie 1, waarin de verwerkingsmodule is ingericht om te detecteren of the apparaat op de juiste wijze rond de pols is gedragen op basis van de ontvangen licht signalen van een array van lichtbronnen die gebruikt worden voor fysiologische meten, bewegingsartefacten metingen en metingen van het niveau van omgevingslicht.

33. Apparaat volgens een elke van de voorgaande conclusies, verder bevattende een versnellingsopnemer ingericht voor het detecteren van de hoeveelheid beweging van de pols van de gebruiker.

34. Apparaat volgens een elke van de voorgaande conclusies, voor zover afhankelijk van conclusie 23, waarin de verwekingsmodule is ingericht voor het bepalen van een bloedsamenstelling van de gebruiker (hemoglobine, hematocriet, albumine waarden) voor medische doeleinden, zoals bloed afwijkingen na chemotherapie en/of bestralingstherapie, bloedverlies na geboorte of bij ongelukken, infecties met tropische ziektes zoals Denque (kokkelkoorts).

35. Methode voor het meten en bepalen van een gezondheidstoestand van een gebruiker, een algemene fitheid, en/of het naleven en opvolgen van een oefenschema van een gebruiker, bestaande uit de volgende stappen:
Voorzien van de gebruiker van een apparaat rond de pols van de gebruiker, bestaande uit een vastmaak band, ten minste één lichtbron hebbende een licht emitterend oppervlak en ten minste één lichtontvanger hebbende een licht ontvangend oppervlak; waarin het apparaat tenminste één lichtbron en tenminste één lichtontvanger bevat die geplaatst zijn op de vastmaakband van het apparaat op zodanige wijze dat wanneer het gedragen wordt tenminste één licht emitterend oppervlak en tenminste één licht ontvangend oppervlak rusten tegen de binnenzijde, de palmaire zijde van de pols van de gebruiker en

uitvoering van een meetsessie bestaande uit:

emitteren van licht in een golflengtegebied door tenminste één lichtbron voor een vooraf bepaalde tijdsduur;

een lichtsignaal voortbrengend door tenminste één van licht ontvanger corresponderend met de ontvangen intensiteit van licht op een tenminste één van de lichtontvanger;

regelen van het ontvangen licht signaal door aanbrengen van een drukkracht op tenminste één licht emitterend oppervlak en/of tenminste een licht ontvangend oppervlak in een richting die substantieel loodrecht staat op de palmaire zijde van de pols van de gebruiker;

bepalen van de invloed van beweging en motion artefacten door analyse van het ontvangen lichtsignaal van een andere licht emitterende bron die niet in staat is om diep te penetreren in de huid en of een hoge water absorptiegraad heeft (400-550 nm or 1100-1400 nm)

36. Methode volgens conclusie 35, bevattende een mogelijkheid om de grootte van de toegepaste kracht aan te passen.

37. Methode volgens conclusie 35 of 36, bevattende een mogelijkheid om de positie van de toegepaste kracht op de palmaire zijde van de pols aan te passen.

38. Methode volgens conclusie 35, 36 of 37 verder bevattende een regeling van de amplitude van een alternerende signaal component van het ontvangen lichtsignaal als gevolg van het pulserende bloed, aan te passen door de juiste kracht toe te passen.

39. Methode volgens een van de conclusies 35-38, verder bevattende een regeling van het ontvangen lichtsignaal door handmatige aanpassing en instelling van de drukkracht.

40. Methode volgens een van de conclusies 35-39, verder bevattende een regeling van het ontvangen lichtsignaal door de regeling van het geëmitteerde licht van tenminste één lichtbron.

41. Methode volgens een van de conclusies 35-40, voor zover afhankelijk van claim 38, verder bevattende het bepalen van de amplitude van de alternerende signaal component, door
het gemeten ontvangen lichtsignaal gedurende een vooraf bepaalde tijdsperiode en het bepalen van de amplitude van de alternerende signaal component van het gemeten ontvangen lichtsignaal gedurende de vooraf bepaalde periode

42. Methode volgens een van de conclusies 35-41, verder bevattende het bepalen van het hartritme van de gebruiker op basis van het ontvangen lichtsignaal gebaseerd op tijd en/of frequentie domein analyse, en optioneel op basis van een amplitude waarde van een controle signaal van de regelunit voor het regelen van de uitgezonden intensiteit en optioneel op basis van een wiskundige correctie van de invloed van bewegingsartefacten en beweging gemeten met de aparte lichtbron en sensor combinatie.

43. Methode volgens een van de conclusies 35-42, verder bevattende het uitvoeren van een eerste meetsessie waarin het geëmitteerde licht van ten minste één lichtbron is in een eerste golflengte gebied, het uitvoeren van een eerste meetsessie waarin het geëmitteerde licht van ten minste één lichtbron is in een tweede golflengte gebied en waarin het geëmitteerde licht van ten minste één lichtbron is in een derde golflengte gebied.

44. Methode volgens conclusie 43, waarin de stap voor het uitvoeren van een meetsessies verder bevat een stap waarin de perfusie index waarde berekend wordt op basis van het ontvangen lichtsignaal; en waarin de methode verder bevat het bepalen van de saturatie van het perifere zuurstofniveau op basis van de verhouding van de perfusie index waarde zoals berekend in de eerste meetsessie en de perfusie index waarde zoals berekend in de tweede

meetsessie en optioneel of basis van de waarde van een regelsignaal van de regelunit voor het regelen van de geëmitteerde lichtintensiteit.

45. Methode volgens een van de conclusies 35-45, waarin tenminste één lichtbron een meervoud van lichtbronnen bevat en ten minste één licht ontvanger een meervoud van lichtontvangers bevat.

46. Methode volgens 45, waarin de stap van het voortbrengen en creëren van het ontvangen lichtsignaal van tenminste één licht ontvanger een middeling bevat van de ontvangen licht signalen die zijn voortgebracht door een subset van de meervoudige lichtontvangers bevat.

47. Methode volgens conclusie 46, waarin de stap van het voortbrengen en creëren van het ontvangen lichtsignaal van tenminste één licht ontvanger een keuze en selectie bevat van het meest optimale signaal voortgebracht door één van de lichtontvangers.

48. Methode volgens conclusie 47, waarin de stap van het voortbrengen en creëren van het ontvangen lichtsignaal van tenminste één licht ontvanger een keuze en selectie bevat van het beste en op een na beste signaal voortgebracht door één van de lichtontvangers.

49. Method volgens claim 48, verder bevattende een selectiestap van tenminste één lichtbron van het meervoud van lichtbronnen en het selecteren van tenminste één lichtontvanger van de meervoud van lichtontvangers, waarin de selectiestap bevat:

voor elke lichtbron van het meervoud van lichtbronnen die licht emitteren in een golflengte range voor een vooraf bepaalde tijdsperiode;

voortbrengen bij elke lichtontvanger van een ontvangen lichtsignaal corresponderend met het ontvangen licht op deze lichtontvanger apart van elke lichtbron

scheiden van elk ontvangen lichtsignaal in een hoge frequentie en een lage frequentie component;

berekenen van de perfusie index waarde voor elk ontvangen lichtsignaal op basis van de verhouding tussen de hoge frequentie component en de lage frequentie component en het selecteren van een lichtbron en lichtontvanger combinatie die de hoogste perfusie index waarde heeft van tenminste één lichtbron en tenminste één lichtontvanger.

50. Methode volgens een van de conclusies 45-49, verder bevattende het selecteren van een subset van lichtbronnen van het meervoud van lichtbronnen en een subset van lichtontvangers van het meervoud van lichtontvangers die de hoogste perfusie index warden hebben van tenminste één lichtbron en tenminste één lichtontvanger.

51. Methode volgens conclusie 49 of 50, waarin de selectiestap wordt uitgevoerd voor een eerste golflengte range en een tweede golflengte range.

52. Methode volgens een van de conclusies 36-51, verder bevattende een stap waarin een instructie wordt afgebeeld op een display die verbonden is met het om de pols gedragen apparaat en die de gebruiker instrueert om een vooraf vastgestelde oefening uit te voeren; verder bevattend het uitvoeren van een meetsessie terwijl de gebruiker de vooraf vastgestelde oefening uitvoert; en het opslaan van het resultaat van de meetsessie, dat bij voorkeur bevat het hartritme van de gebruiker en/of zuurstofsaturatieniveau en/of het vermogen van de gebruiker om het hartritme snel terug te brengen op een normaal, niet inspanningsniveau.

53. Methode volgens conclusie 52, verder bevattende: het meten van de algemene fitheid en conditie van de gebruiker op basis van de meetsessie en/of vorige meetsessies;
Het afbeelden van een indicatie van de algemene fitheid en conditie van de gebruiker, bij voorkeur bevattende een grafische weergave van een person die een algemene fitheid heeft corresponderend met de algemene fitheid van de gebruiker.

54. Methode volgens conclusie 53, waarin de grafische weergave beweegt en is gekleurd corresponderend met de algemene fitheid van de gebruiker en/of het opvolgen van het oefenschema.

55. Methode volgens een van de conclusies 1-54, om beweging te meten, activiteit van de gebruiker op basis van het hartritme meten, de meting van mate van bewegingsartefacten en beweging met behulp van een separate lichtbron en sensor.

56. Methode volgens conclusie 55, om beweging te meten, activiteit van de gebruiker op basis van de hartritme meting, de meting van mate van bewegingsartefacten en beweging met behulp van een separate lichtbron en sensor, en de meting van de lokale positie en beweging met de GPS ontvanger in het apparaat zelf of in een ander hulp device.

57. Methode volgens conclusie 55 of 56, om beweging te meten, activiteit van de gebruiker op basis van de hartritme meting, de meting van mate van bewegingsartefacten en beweging met behulp van een separate lichtbron en sensor, en de meting van de lokale positie en beweging met een triangulatie GSM meting.

58. Methode volgens conclusie 55 of 56 of 57, om beweging te meten, activiteit van de gebruiker op basis van de hartritme meting, de meting van mate van bewegingsartefacten en beweging met behulp van een separate lichtbron en sensor, en de meting van de lokale positie en beweging met een triangulatie GSM meting en een huidtemperatuur sensor.

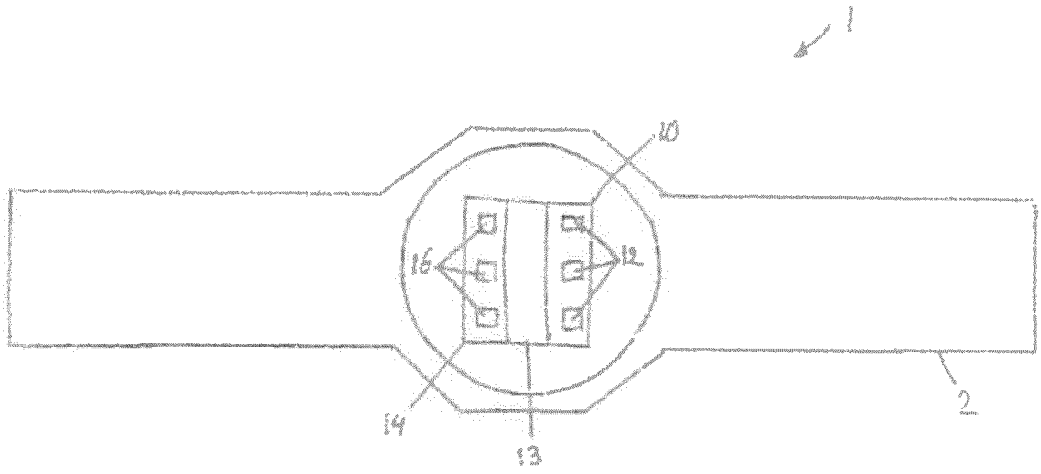

Fig 1

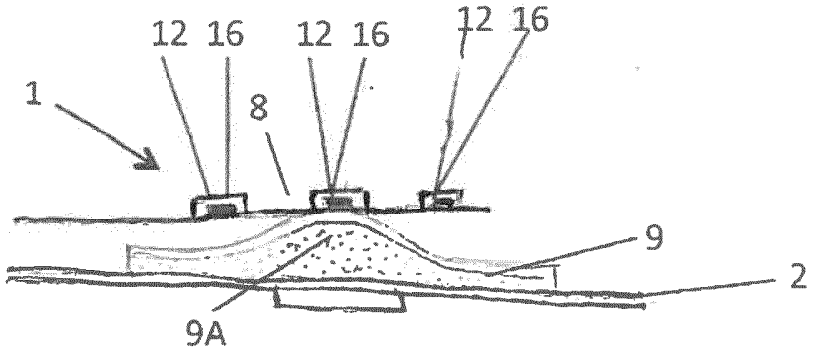

Fig. 2a

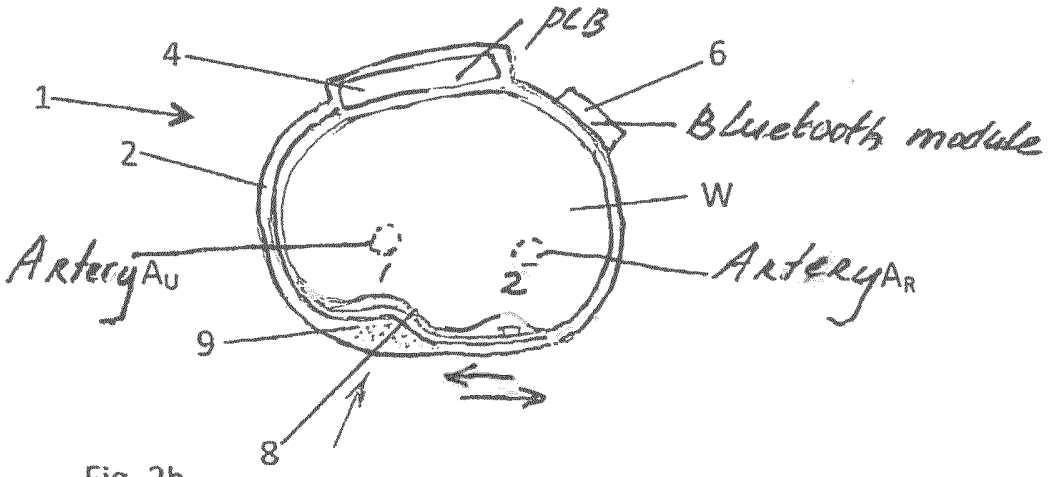

Fig. 2b

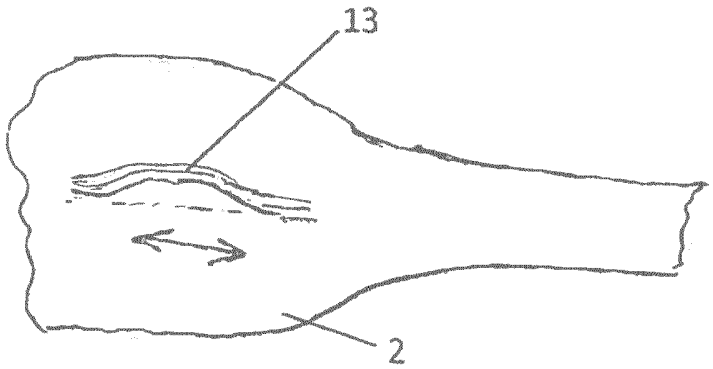

Fig. 2c

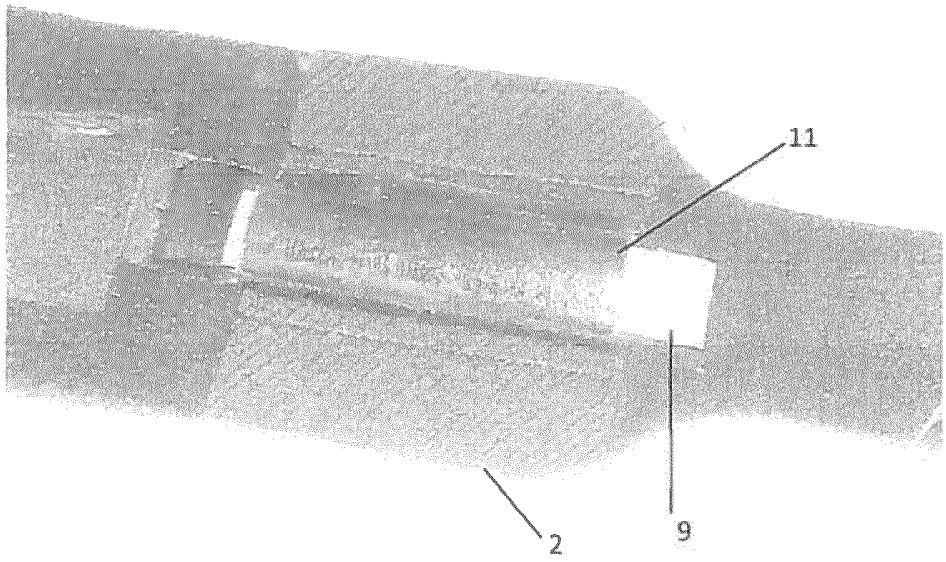

Fig. 2d

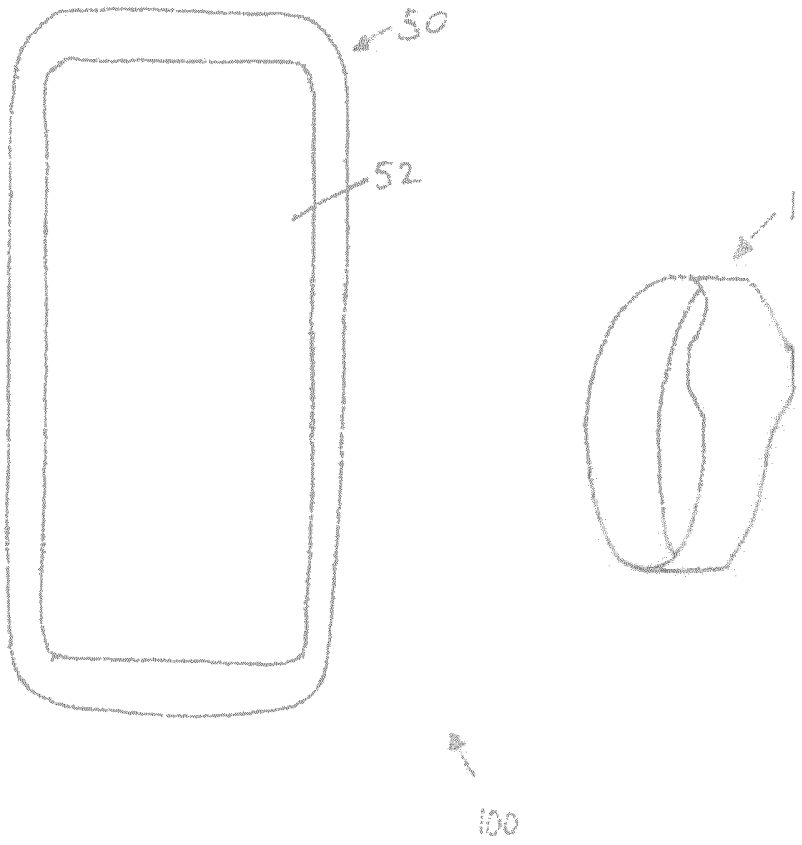

Fig. 3

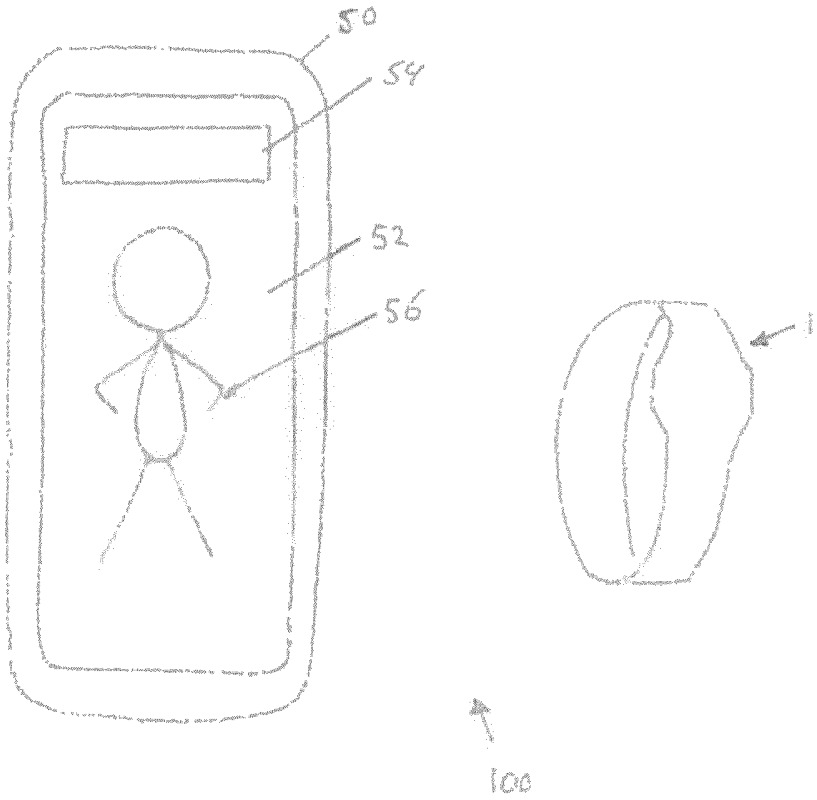

Fig. 4

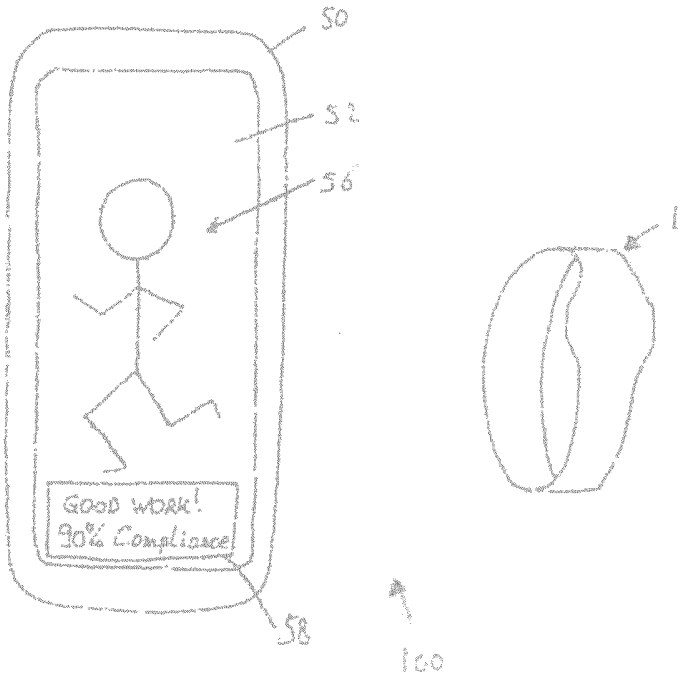

Fig. 5

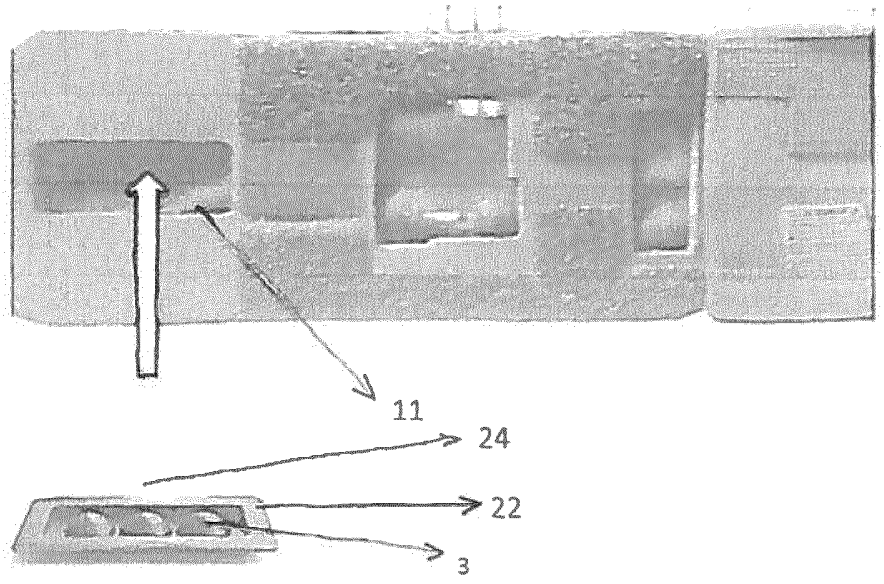

Fig. 6

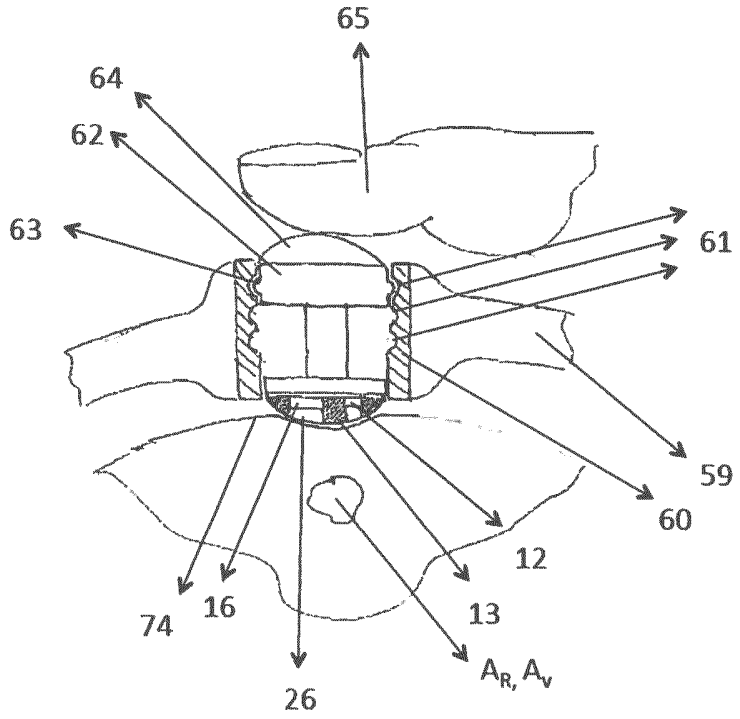
65
64
62
63
61
59
60
12
13
74
16
26
A_R, A_V

Fig 7

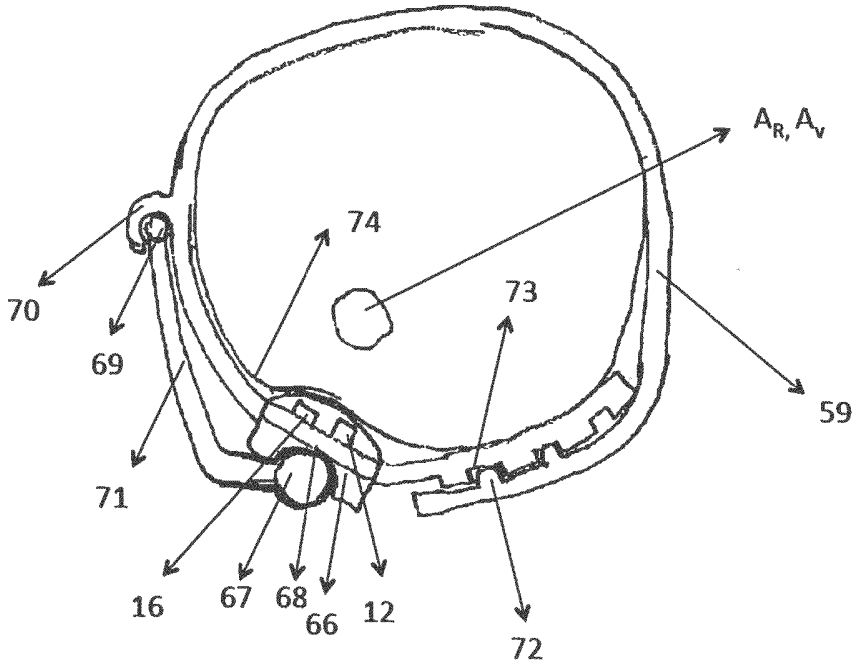
A_R, A_V
74
70
73
69
59
71
16
67
68
66
12
72

Fig 8

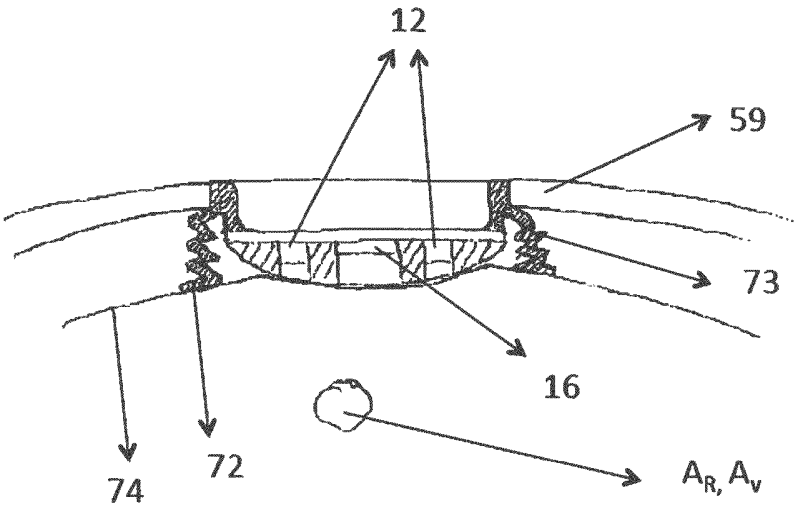

Fig 9

Title: Method and device for measuring a health status and physiological parameters of an user at rest and under movement

Abstract

Method and device for measuring a health status and physiological parameters of and user at rest and under movement, to be worn on a wrist of a user. The device includes a securing band, at least one light source having a light emitting surface and at least one light receiver having a light receiving surface. The at least one light source and the at least one light receiver are arranged on the securing band of the device such that when worn, the at least one light emitting surface and the at least one light receiving surface substantially abut against the palmar side of the wrist of the user. The device further includes a pressing element projecting towards the side of the securing band facing the wrist such that the light emitting surface and/or the light receiving surface is pressed into the skin of the wrist, a second light source which is used for detection of movement and motion artefacts.

Rijksdienst voor Ondernemend Nederland

OCTROOIAANVRAAG NR.
NO 139364
NL 1041276

ONDERZOEKSRAPPORT

BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK

RELEVANTE LITERATUUR

Categorie[1]	Literatuur met, voor zover nodig, aanduiding van speciaal van belang zijnde tekstgedeelten of figuren	Van belang voor conclusie(s) nr.	Classificatie (IPC)
	ONVOLLEDIG ONDERZOEK zie aanvullingsblad C -----		INV. A61B5/022 A61B5/1455 A61B5/00 A61B5/024
X	US 2002/095092 A1 (KONDO SHINJI [JP] ET AL) 18 juli 2002 (2002-07-18)	1,35	
Y	* alineas [0047], [0049]; figuren 1,3,7,8 *	1,35	

Y	US 2013/190576 A1 (MATSUMURA NAOMI [JP] ET AL) 25 juli 2013 (2013-07-25) * figuur 2 *	1,35	

Y	JP 2008 237453 A (CASIO COMPUTER CO LTD) 9 oktober 2008 (2008-10-09) * figuren 1-8 *	1,35	

Y	EP 1 820 443 A1 (SEIKO INSTR INC [JP]) 22 augustus 2007 (2007-08-22) * figuren 3,4 *	1,35	
	-----		Onderzochte gebieden van de techniek
Y	US 2014/275852 A1 (HONG JUNG OOK [US] ET AL) 18 september 2014 (2014-09-18) * alinea [0162]; figuren 2-5 *	1,35	A61B

Indien gewijzigde conclusies zijn ingediend, heeft dit rapport betrekking op de conclusies ingediend op:

Plaats van onderzoek	Datum waarop het onderzoek werd voltooid	Bevoegd ambtenaar
's-Gravenhage	6 januari 2016	Lommel, André

[1] CATEGORIE VAN DE VERMELDE LITERATUUR

X: de conclusie wordt als niet nieuw of niet inventief beschouwd ten opzichte van deze literatuur
Y: de conclusie wordt als niet inventief beschouwd ten opzichte van de combinatie van deze literatuur met andere gepubliceerde literatuur van dezelfde categorie, waarbij de combinatie voor de vakman voor de hand liggend wordt geacht
A: niet tot de categorie X of Y behorende literatuur die de stand van de techniek beschrijft
O: niet-schriftelijke stand van de techniek
P: tussen de voorrangsdatum en de indieningsdatum gepubliceerde literatuur
T: na de indieningsdatum of de voorrangsdatum gepubliceerde literatuur die niet bezwarend is voor de octrooiaanvraag, maar wordt vermeld ter verheldering van de theorie of het principe dat ten grondslag ligt aan de uitvinding
E: eerdere octrooiaanvraag), gepubliceerd op of na de indieningsdatum, waarin dezelfde uitvinding wordt beschreven
D: in de octrooiaanvraag vermeld
L: om andere redenen vermelde literatuur
&: lid van dezelfde octrooifamilie of overeenkomstige octrooipublicatie

ONVOLLEDIG ONDERZOEK
AANVULLINGSBLAD C

Octrooiaanvraag Nr.:
NO 139364
NL 1041276

Dit verslag van het onderzoek heeft geen betrekking op bepaalde conclusies omdat deze betrekking hebben op delen van de nationale aanvrage die niet voldoen aan de voorgeschreven vereisten, en wel in die mate dat geen zinvol nieuwheidsonderzoek verricht kan worden, in het bijzonder:

Volledig onderzoekbare conclusie(s):
1, 35

Niet onderzochte conclusie(s):
2-34, 36-58

Reden voor de beperking van het onderzoek:

The dependent claims relate to various alternatives and details of the described embodiments, without being clear which of these alternatives or details forms the invention. Consequently, the different combinations of features recited in the various dependent claims do not alow to correctly identify 'the claimed invention' on which an opinion should be based.

In addition, the dependent claims go into various directions relating to multiple general inventive concepts.

Therefore, a full opinion concerning the dependent claims is currently not possible and efficient.

AANHANGSEL BEHORENDE BIJ HET RAPPORT BETREFFENDE HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK, UITGEVOERD IN DE OCTROOIAANVRAGE NR.

NO 139364
NL 1041276

Het aanhangsel bevat een opgave van elders gepubliceerde octrooiaanvragen of octrooien (zogenaamde leden van dezelfde octrooifamilie), die overeenkomen met octrooigeschriften genoemd in het rapport.
De opgave is samengesteld aan de hand van gegevens uit het computerbestand van het Europees Octrooibureau per
De juistheid en volledigheid van deze opgave wordt noch door het Europees Octrooibureau, noch door het Bureau voor de Industriële eigendom gegarandeerd; de gegevens worden verstrekt voor informatiedoeleinden.

06-01-2016

In het rapport genoemd octrooigeschrift	Datum van publicatie	Overeenkomend(e) geschrift(en)	Datum van publicatie
US 2002095092 A1	18-07-2002	EP 1212979 A2	12-06-2002
		JP 2002172095 A	18-06-2002
		US 2002095092 A1	18-07-2002
US 2013190576 A1	25-07-2013	CN 103222860 A	31-07-2013
		DE 102012223269 A1	25-07-2013
		JP 5821657 B2	24-11-2015
		JP 2013150691 A	08-08-2013
		US 2013190576 A1	25-07-2013
JP 2008237453 A	09-10-2008	GEEN	
EP 1820443 A1	22-08-2007	EP 1820443 A1	22-08-2007
		JP 4813919 B2	09-11-2011
		JP 2007215749 A	30-08-2007
		US 2007191718 A1	16-08-2007
US 20142758 52 A1	18-09-2014	US 2014275852 A1	18-09-2014
		US 2014288390 A1	25-09-2014
		US 2014288391 A1	25-09-2014
		US 2014288392 A1	25-09-2014
		US 2015025393 A1	22-01-2015
		US 2015025394 A1	22-01-2015
		US 2015201853 A1	23-07-2015
		US 2015201854 A1	23-07-2015

SCHRIFTELIJKE OPINIE

DOSSIER NUMMER	INDIENINGSDATUM	VOORRANGSDATUM	AANVRAAGNUMMER
NO139364	16.04.2015		NL1041276

CLASSIFICATIE
INV. A61B5/022 A61B5/1455 A61B5/00 A61B5/024

AANVRAGER
Scint B.V., et al

Deze schriftelijke opinie bevat een toelichting op de volgende onderdelen:

- ☒ Onderdeel I Basis van de schriftelijke opinie
- ☐ Onderdeel II Voorrang
- ☒ Onderdeel III Vaststelling nieuwheid, inventiviteit en industriële toepasbaarheid niet mogelijk
- ☐ Onderdeel IV De aanvraag heeft betrekking op meer dan één uitvinding
- ☒ Onderdeel V Gemotiveerde verklaring ten aanzien van nieuwheid, inventiviteit en industriële toepasbaarheid
- ☐ Onderdeel VI Andere geciteerde documenten
- ☐ Onderdeel VII Overige gebreken
- ☐ Onderdeel VIII Overige opmerkingen

DE BEVOEGDE AMBTENAAR
Lommel, André

Aanvraag nr.
NL1041276

SCHRIFTELIJKE OPINIE

Onderdeel I Basis van de Schriftelijke Opinie

1. Deze schriftelijke opinie is opgesteld op basis van de meest recente conclusies ingediend voor aanvang van het onderzoek.

2. Met betrekking tot **nucleotide en/of aminozuur sequenties** die genoemd worden in de aanvraag en relevant zijn voor de uitvinding zoals beschreven in de conclusies, is dit onderzoek gedaan op basis van:

   a. type materiaal:

   ☐ sequentie opsomming

   ☐ tabel met betrekking tot de sequentie lijst

   b. vorm van het materiaal:

   ☐ op papier

   ☐ in elektronische vorm

   c. moment van indiening/aanlevering:

   ☐ opgenomen in de aanvraag zoals ingediend

   ☐ samen met de aanvraag elektronisch ingediend

   ☐ later aangeleverd voor het onderzoek

3. ☐ In geval er meer dan één versie of kopie van een sequentie opsomming of tabel met betrekking op een sequentie is ingediend of aangeleverd, zijn de benodigde verklaringen ingediend dat de informatie in de latere of additionele kopieën identiek is aan de aanvraag zoals ingediend of niet meer informatie bevatten dan de aanvraag zoals oorspronkelijk werd ingediend.

4. Overige opmerkingen:

Aanvraag nr.
NL1041276

SCHRIFTELIJKE OPINIE

Onderdeel III Vaststelling nieuwheid, inventiviteit en industriële toepasbaarheid niet mogelijk

De vraag of de uitvinding in de aanvraag nieuw, inventief en industrieel toepasbaar is, wordt niet behandeld in deze schriftelijke opinie met betrekking tot:

☐ de gehele aanvraag

☒ conclusies 2-34, 36-58

omdat:

☐ deze aanvraag of deze conclusies , betrekking hebben op materie waarvoor het niet zinvol is een schriftelijke opinie op te stellen.

☒ de beschrijving, figuren of deze conclusies 2-34, 36-58, , zo onduidelijk zijn dat het niet zinvol is een schriftelijke opinie op te stellen.

Zie aparte bladzijde

☐ deze conclusies , onvoldoende steun vinden in de beschrijving waardoor het niet zinvol is een schriftelijke opinie op te stellen.

☒ geen onderzoek naar de stand van de techniek is uitgevoerd voor deze conclusies 2-34, 36-58.

☐ een zinvolle schriftelijke opinie niet opgesteld kon worden omdat de sequentie opsomming niet beschikbaar was in het juiste formaat, of in het geheel niet beschikbaar was (WIPO ST25).

☐ een zinvolle schriftelijke opinie niet opgesteld kon worden zonder de tabellen met betrekking tot de sequentie opsommingen; of deze tabellen waren niet beschikbaar in elektronische vorm.

☒ Zie aparte bladzijde

Onderdeel V Gemotiveerde verklaring ten aanzien van nieuwheid, inventiviteit en industriële toepasbaarheid

1. Verklaring

Nieuwheid	Ja:	Conclusies 1, 35
	Nee:	Conclusies
Inventiviteit	Ja:	Conclusies
	Nee:	Conclusies 1, 35
Industriële toepasbaarheid	Ja:	Conclusies 1, 35
	Nee:	Conclusies

2. Citaties en toelichting:

Zie aparte bladzijde

Re Item III

Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

The dependent claims relate to various alternatives and details of the described embodiments, without being clear which of these alternatives or details forms the invention. Consequently, the different combinations of features recited in the various dependent claims do not alow to correctly identify 'the claimed invention' on which an opinion should be based.

In addition, the dependent claims go into various directions relating to multiple general inventive concepts. For instance, the following group of possible inventions can be determined in respect of claims 2-34:

claims 2-5, 12-22: features relating to the pressure element for applying a desired force

claims 7-11, 24-26, 29-31: features relating to light, e.g. blocking light, for minimising artefacts caused by interference or ambient light

claims 23, 27, 28, 32, 34: control unit, communication and accelerometer

For claims 36-58, again multiple groups are present:

claims 36-41: features relating to adjust the contact force

claims 42, 55-58: detection of heart rhythm

claims 43-51: features relating to details of light sources and light detectors, e.g. selection

claims 52-54: instructions and display

It is noted that neither the objective problems underlying the subjects of said claimed inventions, nor their solutions as defined by the further distinguishing technical features described above, allow for a link of a common inventive concept to be established between said inventions.

Therefore, a full opinion concerning the dependent claims is currently not possible and efficient. Nevertheless, the following references are made:

claims 2-5, 12-22: D1, figure 2; JP2008237453 A1, figures 1-7

claims 7-11, 24-26, 29-31: US2014/0275852 A1, figures 3-5

The features of claims 23, 27, 28, 32 and 34 are either already known from the available prior art or relate to standard configurations.

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

Reference is, amongst others, made to the following document:

D1: US2002095092 A1

1. The present application does not meet the criteria of patentability, because the **subject-matter of claim 1 does not involve an inventive step**.

1.1 Document D1 discloses (references applying to this document):

Apparaat voor het meten van een gezondheidstoestand van een gebruiker, dat gedragen wordt rond de pols van een statische of bewegende gebruiker (figure 1), het instrument bevattende een vastmaak band (10), ten minste één lichtbron met een licht emitterend oppervlak (17) en tenminste één licht ontvanger met een licht ontvangend oppervlak (18); waarin ten minste één lichtbron en ten minste één licht ontvanger zijn gepositioneerd op een zodanige wijze op de vastmaak band dat wanneer het apparaat gedragen wordt, ten minste één licht emitterend oppervlak en tenminste één licht ontvangend oppervlak grenzen aan en tegen de binnenkant, palmaire zijde van de pols van de gebruiker geplaatst zijn (figure 1).

Het apparaat bevat verder een drukelement geprojecteerd op de zijde van de vastmaak band en zodanig gericht naar de pols toe dat één licht emitterend oppervlak en tenminste één licht ontvangend oppervlak in de huid van de pols gedrukt worden (figure 2 and paragraph [0027].

Het apparaat bevat verder tenminste een tweede lichtbron en ten minste een tweede lichtontvanger (figure 2)

The subject-matter of claim 1 therefore differs from this known device in that the second light source and the second light receiver

verschillen van de eerste set en waarvan het licht niet diep penetreren kan in de huid en de corresponderende sensor daardoor in staat is bewegingsartefacten en beweging van het instrument vast te stellen.

It is noted that from the wording of the claim it is unclear in what respect the second light source and the second light receiver differ from the first set. In the light of the description, the wavelength of the light seems to differ.

The objective technical problem to be solved by the present invention may be regarded as providing means for detecting motion artefacts.

In the field of photoplethysmography, especially when integrated in wearable monitoring devices, the effects of motion on measurements is known to be a major aspect and a general consideration, especially when developing and designing monitoring devices. In fact, document D1 already deals with detection and removal of body motion components, see especially paragraphs [0047] and [0049]. As clearly described in paragraph [0047], a body motion sensor is formed by a blue light LED and a phototransistor. The output signal from said body motion sensor is used to obtain a more accurate signal, see paragraph [0049].

Consequently, starting from a device as presented in figures 1 and 2 in D1 and faced with the problem of providing means for obtaining a more accurate signal during motion, the skilled person would take the teaching of D1 as presented in paragraphs [0047] and [0049] and inevitably arrive at the device as claimed in current claim 1.

1.2 In the Search Report, various documents disclosing wrist watch-type devices comprising a protrusion and having a light source and a light detector are cited:

document US2014/0221854 A1: figure 1

document EP1820443 A1: figures 3 and 4

document JP2008237453 A1: figure 1

In fact, the use of protrusions in order to facilitate a good contact is common practice, see also US2014/0275852 A1, paragraph [0162].

Starting from such a disclosure, the subject-matter of claim 1 differs again in that the second light source and the second light receiver

verschillen van de eerste set en waarvan het licht niet diep penetreren kan in de huid en de corresponderende sensor daardoor in staat is bewegingsartefacten en beweging van het instrument vast te stellen.

A similar problem-solution attack as already described in point 1.1 above can be made.

2. The present application does not meet the criteria of patentability, because the **subject-matter of claim 35 does not involve an inventive step**.

Document JP2008237453 A1 discloses a wrist watch-type device comprising a protrusion and having a light source and a light detector. In addition, the contact pressure between the sensor and the arm can be adjusted.

Starting from this disclosure, the subject-matter of claim 35 differs in that a second light source and a second light receiver are provided to detect motion artefacts.

As already pointed out above, the use of a motion sensor based on light is known, see D1, paragraph [0047]. In D1, the motion signal is subtracted from the pulse wave signal, see D1, paragraph [0049]. Hence, the influence of motion is determined and taken into account when determining a final pulse wave signal.

Finally, it is noted that various steps in the claimed method do not have any technical character. For instance, a contact pressure may simply be applied by means of a human force and the determination of the effect of motion may be performed as a mental act, i.e. observing the output waveform. Features which have no technical character or do not contribute to the technical character of the claim cannot contribute to an inventive step

Consequently, the subject-matter of claim 35 does not involve an inventive step.