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Device und method for detecting and reporting of a stress condition of a person

Technical field

The invention relates to a device and a method for detecting and reporting of a  
5 stress condition of a person.

Prior art

Using the pulse rate or the heart rate variability for the detection of stress condi-  
tions has been known for a long time. Thereby, the interval between two heart  
10 beats is defined - in the sense of the present invention - as the time between the  
onsets of two contractions of the cardiac chambers. This onset of the chamber  
contraction shows up in the electrocardiogram (ECG) as the R wave. The distance  
between two R waves is usually denoted as RR interval. After averaging over a  
defined number of RR intervals, the heart rate can be determined by calculation.  
15 The individual values of the RR intervals vary around the mean value thus ob-  
tained. Thereby the variations can change from beat to beat. The variation is usu-  
ally denoted as heart rate variability (HRV). In principle, the heart rate can also be  
determined by a pressure measurement carried out on an artery.

20 Physiologically, the heart rate variability (HRV) is related to the ability of the hu-  
man organism to adapt the rate of the cardiac rhythm. Variations of the heart  
rate, i.e. variations of the temporal interval between two heart beats, can occur in  
a resting state, in which case they are mostly spontaneous, but also upon spe-  
cific variations of the surrounding conditions, e.g. under stress. A healthy organ-  
25 ism continuously adapts the heart beat rate to the current conditions via physio-  
logical regulation pathways of the vegetative nervous system. Therefore, physi-  
cal or psychological stress usually results in an increase of the heart frequency  
which ordinarily decreases again upon relief and relaxation. Thereby, a good  
adaptability to stress results in a higher variability of the heart rate. Under chronic  
30 stress burden, the adaptability is reduced. In this respect, it is known that the  
heart rate variability taken by itself already provides a certain - albeit still very

unreliable - indicator for the current stress burden and the ability of a person to cope with stress.

5 Several methods for determining the stress condition of a person have been proposed in the prior art, including the proposal to use further measurement parameters in addition to the pulse rate. Thus, DE 103 19 361 A1 proposes to use the pulse wave latency in addition to the heart rate variability.

10 Regarding the analysis of the heart rate variability, reference is made to DE 100 06 154 A1, DE 10 2006 039 957 A1, and also to DE 10 2008 030 956 A1 and EP 1 156 851 B1, in which the person skilled in the art can find various determination methods.

15 From EP-2 316 333 A1 there is known a device and a method in which a state quantity is calculated which is a function of the current heart rate and of the current heart rate variability, preferably a linear combination of the current heart rate  $P$  and of the current heart rate variability. Moreover, in the mentioned publication, it is proposed to provide the state function with at least one correcting value that includes the history of the person within at least the past 0.5 hours.

20

This approach appears quite suitable here. However, there results a further optimization problem which can be described by the fact that, on the one hand – particularly for comparing different persons – it is necessary to introduce normalizations, but that on the other hand it is also necessary to take into account individual differences.

25

#### Description of the invention

The object of the invention is to provide a device and a corresponding method for detecting and reporting of a stress condition of a person with an increased reliability as compared to the state of the art, and in which, on the one hand –

30

particularly for comparing different persons – normalizations can be introduced, but in which, on the other hand, individual differences are also taken into account.

The object of the invention is achieved - according to a first aspect - by a method  
5 according to claim 1. At the outset, the features of the invention have the result that, to a first approximation, namely in the first processing window, i.e. in a first time interval  $T_1$  or across a predetermined number of pulse beats, a first approximation result is obtained that can already be processed. For this purpose, one may consider, in particular, age related values that provide – preferably for the  
10 respective age groups – typical tabulated values of the minimum and the maximum values of the pulse rate and the HRV value. The subsequent processing windows then can – according to experimental studies – provide results that are improved, particularly if the person has characteristics that deviate from the tabulated values of the minimum and the maximum values of the pulse rate and the HRV value,  
15 regardless of whether this is due to reasons of e.g. a particularly good or particularly bad training condition or whether it is also due to high or low stress values in the near or medium term history. It should be noted that recording of the pulse is possible anywhere on the body and that the pulse can in principle be measured optically, acoustically or kinesthetically, and converted to electrical signals. Also,  
20 a direct measurement of electrical signals for the purpose of pulse measurement is possible according to the invention.

According to the method for detecting and reporting of a stress condition of a person according to the present invention, the following steps are carried out:

25

Within the time interval, or for a predetermined number of pulse beats, the data of the current pulse frequency  $P$  and of the current heart rate variability HRV are continuously acquired and processed. Thereby, a value for the stress index is separately calculated for the pulse rate and for the heart rate variability, and subsequently the two values are added – using weighting factors. In this step the  
30 values of the pulse rate and of the heart rate variability are normalized with

respect to tabulated extremal values  $P_{\max}$ ,  $P_{\min}$ ,  $HRV_{\max}$  and  $HRV_{\min}$ , which extremal values have preferably been sorted according to age. In this manner a first – potentially already useful – value for the stress index is determined.

5 Subsequently, however, one determines for said time interval, or for said predetermined number of pulse beats, whether the individual extremal values  $P_{\max}$ ,  $P_{\min}$ ,  $HRV_{\max}$  and  $HRV_{\min}$  are different from the previously adopted values. For the subsequent time interval or for the subsequent measurement of predetermined pulse beats, for which neither the length of the time interval nor the number of the pulse beats necessarily needs to be identical to that of the first measurement, and which can also be significantly later, i.e. after a temporal delay of  
 10 up to several hours, either the earlier extremal values or the newly determined extremal values are used, depending on which values are more extremal. The calculation of the new values for the stress index then occurs basically in an  
 15 analogous manner as the above described first measurement, i.e. a value of the stress index is calculated by continuously and separately determining the stress index values for the pulse rate and for the heart rate variability and subsequently adding the two values with weighting factors. The time interval lies typically in the range of 100s to 1000s – preferably of 300s to 500s – but it can also be about  
 20 one order of magnitude (factor 10) smaller or larger. The predetermined number of pulse beats lies between 50 and 500, preferably 100, but it can be larger, in particular, by about one to two orders of magnitude. It should be emphasized that the subsequent measurements may temporally overlap, in which case at the onset of the new series of measurements clearly only those extremal values can  
 25 be used that have previously occurred. This „moving-window“ method can be appropriate if massive computing power is available and a very rapid result shall be achieved.

Advantageously, the method can be carried out if the normalizations are each  
 30 carried out by means of a normalization value at the first, table-related

$$P_z = P_{\min} + a \cdot (P_{\max} - P_{\min})$$

$$HRV_z = HRV_{min} + b * (HRV_{max} - HRV_{min})$$

and the calculations of the summands of the stress value SI are each carried out according to

$$SI_P = (P_{d1} - P_z) / (P_{max} - P_z) \text{ if } P_{d1} > P_z$$

5  $SI_P = (P_{d1} - P_z) / (P_z - P_{min}) \text{ if } P_{d1} < P_z$

$$SI_{HRV} = -(HRV_{d1} - HRV_z) / (HRV_{max} - HRV_z) \text{ if } HRV_{d1} > HRV_z$$

$$SI_{HRV} = -(HRV_{d1} - HRV_z) / (HRV_z - HRV_{min}) \text{ if } HRV_{d1} < HRV_z.$$

The further windows are then advantageously calculated according to

$$SI_P = (P_{dx} - P_z) / (P_{max} - P_z) \text{ if } P_{dx} > P_z$$

10  $SI_P = (P_{dx} - P_z) / (P_z - P_{min}) \text{ if } P_{dx} < P_z$

$$SI_{HRV} = -(HRV_{dx} - HRV_z) / (HRV_{max} - HRV_z) \text{ if } HRV_{dx} > HRV_z$$

$$SI_{HRV} = -(HRV_{dx} - HRV_z) / (HRV_z - HRV_{min}) \text{ if } HRV_{dx} < HRV_z.$$

It has been proven advantageous if the values a for the processing of the pulse  
 15 rate are selected in the range between 0.2 and 0.3, advantageously as 0.25 and  
 the values b for the processing of the heart rate variability between 0.33 to 0.66,  
 advantageously as 0.5.

Depending on the application the method can be calibrated in the sense that the  
 20 weighting of the partial value of the stress index, which is determined from the  
 pulse rate, and of the partial value of the stress index, which is determined from  
 the heart rate variability, are optimized by trials. If there are no reasons to do so,  
 the values c and d will be selected as 1.

25 It is particularly advantageous if the respectively determined stress values are  
 not only output directly, which of course is not ruled out, but rather the current  
 stress index SI is fed to a filter, typically to a digital low-pass filter, after the time  
 interval  $T_x$  or after the predetermined number of pulse beats, in order to average  
 over individual outliers, e.g.  $SI = f * SI_x + (1-f) * SI_{x-1}$ , with f between 0.05 and 0.5, ad-  
 30 vantageously of 0.1.

According to a second aspect of the present invention there is proposed a device that is suitable for carrying out the method of the present invention, optionally including the above-mentioned advantageous embodiments.

5 Such a device for detecting and reporting of a stress condition of a person typically comprises an acquisition device for continuously acquiring data of the current pulse frequency and of the current heart rate variability, a processing device for continuously processing the data of the current pulse frequency and of the current heart rate variability, and a comparator device for comparing the current  
10 state function of the person thus obtained with an alert criterion.

The aforementioned elements as well as those claimed and described in the following exemplary embodiments, to be used according to the invention, are not subject to any particular conditions by way of exclusion in terms of their size,  
15 shape, use of material and technical design, with the result that the selection criteria known in the respective field of application can be used without restrictions. For carrying out the method of the present invention, the calculation of the heart rate variability can be carried out by means of conventional methods (e.g. in the time domain: RMSSD, RRinter, SDNN, or in the frequency domain  $LF_{tot}/HF_{tot}$ ),  
20 wherein the method RMSSD („Root mean square of successive differences“) is suitable for the method and device mentioned here. It should be pointed out that the method of the present invention is not intended for determining the health status or pathological status of the person, whereas the device of the present invention is not restricted in this regard.

25

#### Modes for carrying out the invention

The device of the present invention comprises, according to a preferred exemplary embodiment of the invention, a measuring device for detecting the pulse rate and the values that are necessary for calculating heart rate variability. In the present  
30 case this is a pulse measuring sensor, but alternatively it can also be an electrical sensor for measuring electrical cardiographic measurement values, as well as a

display device. Moreover, the device comprises an interface for the input of person-related parameters, which are particularly needed for determining the history to be used according to the invention. A key component of the device is a computing device that controls the necessary acquisition of the measurement data, processes the measurement data in the digital form needed, executes the data processing and controls the display.

In the present exemplary embodiment the heart rate variability HRV is determined by means of the RMSSD method („Root mean square of successive differences“), but also by other methods, such as e.g. the method „SIR“ based on standard deviations, the method pRR50, in which the number of consecutive RR intervals that are larger than 50ms is determined and the value thus obtained is divided by the total number of consecutive RR intervals, or frequency-oriented methods such as, for example, the calculation via the quotient  $LF_{tot}/HF_{tot}$  of the low-frequency frequency components divided by the higher-frequency frequency components. The HRV value obtained by means of RMSSD is calculated as the square root of the sum of the squared differences between neighboring RR intervals. In this context it should be noted that for the selection of the calculation method one may use, on the one hand, pertinent recent findings of the respective technical field and of the respective application range of the method according to the present invention or of the device according to the present invention, but on the other hand it is conceivable to simply take into account practical aspects of the respective selection. In the case where the HRV values are determined by means of the RMSSD method, in the present exemplary embodiment 0 is used as tabulated value for HRV<sub>min</sub> for all ages. The other minimum values used in the exemplary embodiment shown here, which refer to the pulse and to the HRV, are selected according to the following table:

Age dependent resting heart rate values

Youths: 14...18	Resting heart rate: 85 beats/minute
Adults: 19...65	Resting heart rate: 70 beats/minute
Seniors: 65+	Resting heart rate: 90 beats/minute

Age dependent HRV<sub>max</sub> values (RMSSD)

15...20	47ms
21...30	46ms
31...40	40ms
41...50	35ms
51...60	30ms
61...70	24ms

according to Angelink et al: Innovationstagung FH Rapperswil 4.5.2011

- 5 In this context it should be noted that – without departing from the sense of the method of the present invention – rather different parameters of the subjects such as e.g. the gender etc. can be incorporated into the table.

According to the exemplary embodiment the normalizations are each carried out  
10 by means of a normalization value

$$P_z = P_{\min} + a \cdot (P_{\max} - P_{\min})$$

$$\text{HRV}_z = \text{HRV}_{\min} + b \cdot (\text{HRV}_{\max} - \text{HRV}_{\min})$$

and the calculation of the summands of the stress value SI is each carried out according to

15  $\text{SI}_P = (P_{d1} - P_z) / (P_{\max} - P_z)$  if  $P_{d1} > P_z$

$$\text{SI}_P = (P_{d1} - P_z) / (P_z - P_{\min})$$
 if  $P_{d1} < P_z$

$$\text{SI}_{\text{HRV}} = -(\text{HRV}_{d1} - \text{HRV}_z) / (\text{HRV}_{\max} - \text{HRV}_z)$$
 if  $\text{HRV}_{d1} > \text{HRV}_z$

$$\text{SI}_{\text{HRV}} = -(\text{HRV}_{d1} - \text{HRV}_z) / (\text{HRV}_z - \text{HRV}_{\min})$$
 if  $\text{HRV}_{d1} < \text{HRV}_z$

and

20  $\text{SI}_P = (P_{dx} - P_z) / (P_{\max} - P_z)$  if  $P_{dx} > P_z$

$$\text{SI}_P = (P_{dx} - P_z) / (P_z - P_{\min})$$
 if  $P_{dx} < P_z$

$$\text{SI}_{\text{HRV}} = -(\text{HRV}_{dx} - \text{HRV}_z) / (\text{HRV}_{\max} - \text{HRV}_z)$$
 if  $\text{HRV}_{dx} > \text{HRV}_z$

$$\text{SI}_{\text{HRV}} = -(\text{HRV}_{dx} - \text{HRV}_z) / (\text{HRV}_z - \text{HRV}_{\min})$$
 if  $\text{HRV}_{dx} < \text{HRV}_z$  ,

wherein a was selected as 0.25 and b as 0.5 and c and d were selected as 1. In

- 25 the exemplary embodiment the current values of the stress index SI are selected after the predetermined number of pulse beats by means of a digital low-pass filter  $\text{SI} = f \cdot \text{SI}_x + (1-f) \cdot \text{SI}_{x-1}$  calculated with f of 0.1. The device has been set up accordingly.

It should be still noted that the individual windows in which the stress index values are determined advantageously include various states of the subjects, such as e.g. lying, standing, moving – in the sense of the Conconi test – etc.

- 5 Moreover, it should be noted that even if test intervals are very widely separated in time, the adoption of the last test interval leads to a better result or more quickly to a good result than starting out with tabulated values. On the other hand, it may of course be appropriate to revert using tabulated values if the status of the subject has significantly changed in a fundamental manner.

## Patentkrav

1. En fremgangsmåde til detektion og rapportering af en persons stresstilstand, hvori fremgangsmåden omfatter følgende trin:

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- kontinuerlig indsamling af data om den aktuelle pulsfrekvens P og den aktuelle hjertefrekvensvariabilitet (HRV) ved hjælp af en pulssensor eller en elektrokardiografisk sensor.

10

- kontinuerlig behandling af dataene for den aktuelle pulsfrekvens P og den aktuelle hjertefrekvensvariabilitet (HRV),
- bestemmelse af et stressindeks og sammenligning af samme med et alarmkriterium,

**kendetegnet ved, at bestemmelse af stresstilstanden omfatter:**

15

inden for et første tidsinterval T1 eller på tværs af et forudbestemt antal pulsslæg bestemmes en første værdi SI1 for stressindekset ved at tilføje en værdi SIP for det stressindeks, der opnås fra en normaliseret gennemsnitsværdi Pd1 for pulsfrekvensen i det nævnte første tidsinterval T1 eller på tværs af det

20 forudbestemte antal pulsslæg, plus en værdi SIHRV, der opnås fra en normaliseret gennemsnitsværdi HRVd1 for hjertefrekvensvariabiliteten HRV inden for det nævnte første tidsinterval T1 eller på tværs af det forudbestemte antal af pulsslæg i henhold til:

$$SI_1 = c * SI_P + d * SI_{HRV}$$

25

hvor c og d er henholdsvis vægtningsfaktorer for den stressindeksdelværdi, der er bestemt ud fra pulsfrekvensen, og for den stressindeksdelværdi, der er bestemt ud fra hjertefrekvensvariabiliteten, hvori normalisering udføres ved hjælp af tabulerede værdier Pmax, Pmin, HRVmax og HRVmin, som er opnået ud fra aldersafhængige minimums- og maksimumpulsfrekvensværdier og HRV-

30 værdier, og, desuden, de maksimale og minimale værdier af de målte pulsfrekvensværdier og HRV-værdier inden for tidsintervallet T1 eller på tværs

af det forudbestemte antal pulsslæg bestemmes, hvori T1 ligger mellem 100 s og 1000 s, og fortrinsvis 300 s, eller det forudbestemte antal pulsslæg ligger mellem 50 og 500, og fortrinsvis 100, i mindst ét yderligere tidsinterval  $T_x$  ( $x=2\dots n$ ), eller på tværs af et yderligere forudbestemt antal pulsslæg en yderligere værdi  $Sl_x$  for stressindekset bestemmes ved at tilføje en værdi  $SIP$  for det stressindeks, der opnås fra en normaliseret gennemsnitsværdi  $Pd1$  for pulsfrekvensen i det nævnte tidsinterval  $T_x$  eller på tværs af det forudbestemte antal pulsslæg, plus en værdi  $SI_{HRV}$ , der er opnået fra en normaliseret gennemsnitsværdi  $HRVd1$  for hjertefrekvensvariabiliteten  $HRV$  inden for det nævnte tidsinterval  $T_x$  eller på tværs af det forudbestemte antal pulsslæg:

$$Sl_x = c * SIP + d * SI_{HRV}$$

fortrinsvis med samme længde som T1 eller med samme antal pulsslæg, hvori  $c$  og  $d$  henholdsvis igen er vægtningsfaktorer for den stressindeksdelværdi, der bestemmes ud fra pulsfrekvens og for den stressindeksdelværdi, der bestemmes ud fra hjertefrekvensvariabiliteten, hvori normalisering udføres ved hjælp af værdierne  $P_{max}$ ,  $P_{min}$ ,  $HRV_{max}$  og  $HRV_{min}$ , hvori  $P_{max}$  og  $HRV_{max}$  er udvalgt fra den større værdi af  $P_{max}$  og  $HRV_{max}$ , som blev bestemt i det forrige tidsinterval  $T_{x-1}$  eller på tværs af det forudbestemte antal pulsslæg og værdierne af  $P_{max}$  og  $HRV_{max}$ , som blev brugt i det forrige tidsinterval  $T_{x-1}$  eller på tværs af det forudbestemte antal pulsslæg, og hvori  $P_{min}$  og  $HRV_{min}$  er valgt ud fra den mindre værdi af  $P_{min}$  og  $HRV_{min}$ , som blev bestemt i det forrige tidsinterval  $T_{x-1}$  eller på tværs af det forudbestemte antal pulsslæg og værdierne for  $P_{min}$  og  $HRV_{min}$ , som blev brugt i det forrige tidsinterval  $T_{x-1}$  eller på tværs af det forudbestemte antal af pulsslæg, hvori den yderligere værdi  $Sl_x$  for stressindekset, som dermed blev opnået, svarer til det stressindeks, der skal bestemmes.

**2. Fremgangsmåden til detektion og rapportering af en persons stresstilstand i henhold til krav 1, hvori normalisering udføres ved hjælp af en normaliseringsværdi,**

$$P_z = P_{\min} + a*(P_{\max} - P_{\min})$$

$$HRV_z = HRV_{\min} + b*(HRV_{\max} - HRV_{\min})$$

og beregningen af addender for stressværdien SI hver udføres i henhold til

$$SI_P = (P_{d1} - P_z) / (P_{\max} - P_z) \text{ if } P_{d1} > P_z$$

5 
$$SI_P = (P_{d1} - P_z) / (P_z - P_{\min}) \text{ if } P_{d1} < P_z$$

$$SI_{HRV} = -(HRV_{d1} - HRV_z) / (HRV_{\max} - HRV_z) \text{ if } HRV_{d1} > HRV_z$$

$$SI_{HRV} = -(HRV_{d1} - HRV_z) / (HRV_z - HRV_{\min}) \text{ if } HRV_{d1} < HRV_z$$

og

$$SI_P = (P_{dx} - P_z) / (P_{\max} - P_z) \text{ if } P_{dx} > P_z$$

10 
$$SI_P = (P_{dx} - P_z) / (P_z - P_{\min}) \text{ if } P_{dx} < P_z$$

$$SI_{HRV} = -(HRV_{dx} - HRV_z) / (HRV_{\max} - HRV_z) \text{ if } HRV_{dx} > HRV_z$$

$$SI_{HRV} = -(HRV_{dx} - HRV_z) / (HRV_z - HRV_{\min}) \text{ if } HRV_{dx} < HRV_z.$$

3. Fremgangsmåden i henhold til krav 2, hvori a er valgt som 0,25 og b som 0,5.

15 4. Fremgangsmåden i henhold til ethvert af kravene 1 til 3, hvori c og d er valgt som 1.

5. Fremgangsmåden i henhold til ét af kravene 1 til 4, hvori det aktuelle stressindeks SI er valgt efter tidsintervallet  $T_x$  eller efter det forudbestemte antal pulsslæg ved hjælp af et digitalt lavpasfilter  $SI = f*SI_x + (1-f)*SI_{x-1}$  med f mellem  
20 0,05 og 0,5, fortrinsvis lig med 0,1.

6. Fremgangsmåden i henhold til ét af kravene 1 til 5, hvori tidsintervallerne eller tiderne, hvorunder et forudbestemt antal pulsslæg måles, overlapper.

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7. Fremgangsmåden i henhold til ét af kravene 1 til 5, hvori tidsintervallerne eller tiderne, hvorunder et forudbestemt antal pulsslæg måles, har en fast eller variabel afstand mellem hinanden.

5 **8.** En anordning til detektion og rapportering af en persons stresstilstand, som omfatter:

- en registreringsanordning til kontinuerlig indsamling af data om den aktuelle puls-frekvens og den aktuelle hjertefrekvensvariabilitet, hvori nævnte
- 10 registreringsanordning er en pulssensor eller en elektrokardiografisk sensor,
- en behandlingsanordning til kontinuerlig behandling af dataene for den aktuelle puls-frekvens og den aktuelle hjertefrekvensvariabilitet, og
- en sammenligningsanordning til bestemmelse af et stressindeks og til sammenligning af samme med et alarmkriterium

15

**kendetegnet ved, at**

behandlingsanordningen er konfigureret på en sådan måde, at der inden for et første tidsinterval T1 eller på tværs af et forudbestemt antal pulsslæg

20 bestemmes en første værdi SI1 for stressindekset ved at tilføje en værdi SIP for det stressindeks, der opnås fra en normaliseret gennemsnitsværdi Pd1 for puls-frekvensen i det nævnte første tidsinterval T1 eller på tværs af det forudbestemte antal pulsslæg, plus en værdi SIHRV, der opnås fra en normaliseret gennemsnitsværdi HRVd1 for hjertefrekvensvariabiliteten HRV

25 inden for det nævnte første tidsinterval T1 eller på tværs af det forudbestemte antal af pulsslæg:

$$SI_1 = c * SI_P + d * SI_{HRV}$$

hvor c og d er henholdsvis vægtningsfaktorer for den stressindeksdelværdi, der er bestemt ud fra puls-frekvensen, og for den stressindeksdelværdi, der er

30 bestemt ud fra hjertefrekvensvariabiliteten, hvori normalisering udføres ved hjælp af tabulerede værdier Pmax, Pmin, HRVmax og HRVmin, som er opnået

ud fra aldersafhængige minimums- og maksimumspulsfrekvensværdier og HRV-værdier, og, desuden, de maksimale og minimale værdier af de målte pulsfrekvensværdier og HRV-værdier inden for tidsintervallet T1 eller på tværs af det forudbestemte antal pulsslæg bestemmes, hvori T1 ligger mellem 100 s og 1000 s, og fortrinsvis 300 s, eller det forudbestemte antal pulsslæg ligger mellem 50 og 500, og fortrinsvis 100, i mindst ét yderligere tidsinterval  $T_x$  ( $x=2\dots n$ ), eller på tværs af et yderligere forudbestemt antal pulsslæg en yderligere værdi  $Sl_x$  for stressindekset bestemmes ved at tilføje en værdi  $SIP$  for det stressindeks, der opnås fra en normaliseret gennemsnitsværdi  $Pd1$  for pulsfrekvensen i det nævnte tidsinterval  $T_x$  eller på tværs af det forudbestemte antal pulsslæg, plus en værdi  $SI_{HRV}$ , der er opnået fra en normaliseret gennemsnitsværdi  $HRVd1$  for hjertefrekvensvariabiliteten HRV inden for det nævnte tidsinterval  $T_x$  eller på tværs af det forudbestemte antal pulsslæg:

$$Sl_x = c^* SIP + d^* SI_{HRV}$$

fortrinsvis med samme længde som T1 eller med samme antal pulsslæg, hvori c og de henholdsvis igen er vægtningsfaktorer for den stressindeksdelværdi, der bestemmes ud fra pulsfrekvens og for den stressindeksdelværdi, der bestemmes ud fra hjertefrekvensvariabiliteten, hvori normalisering udføres ved hjælp af værdierne  $P_{max}$ ,  $P_{min}$ ,  $HRV_{max}$  og  $HRV_{min}$ , hvori  $P_{max}$  og  $HRV_{max}$  er udvalgt fra den større værdi af  $P_{max}$  og  $HRV_{max}$ , som blev bestemt i det forrige tidsinterval  $T_{x-1}$  eller på tværs af det forudbestemte antal pulsslæg og værdierne af  $P_{max}$  og  $HRV_{max}$ , som blev brugt i det forrige tidsinterval  $T_{x-1}$  eller på tværs af det forudbestemte antal pulsslæg, og hvori  $P_{min}$  og  $HRV_{min}$  er valgt ud fra den mindre værdi af  $P_{min}$  og  $HRV_{min}$ , som blev bestemt i det forrige tidsinterval  $T_{x-1}$  eller på tværs af det forudbestemte antal pulsslæg og værdierne for  $P_{min}$  og  $HRV_{min}$ , som blev brugt i det forrige tidsinterval  $T_{x-1}$  eller på tværs af det forudbestemte antal af pulsslæg, hvori den yderligere værdi  $Sl_x$  for stressindekset, som dermed blev opnået, svarer til det stressindeks, der skal bestemmes.

**9.** Anordningen i henhold til krav 8, hvori anordningen er konfigureret på en sådan måde, at fremgangsmåden kan udføres i henhold til krav 2.

**10.** Anordningen i henhold til krav 8 eller 9, hvori a er valgt som 0,25 og b som 0,5 og/eller hvori c og d er valgt som 1, og/eller hvori det aktuelle stressindeks SI er valgt efter tidsintervallet  $T_x$  eller efter det forudbestemte antal pulsslæg ved hjælp af et digitalt lavpasfilter  $SI = f * SI_x + (1-f) * SI_{x-1}$  med f mellem 0,05 og 0,5, fortrinsvis 0,1.