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(54) FITNESS SCORE ASSESSMENT BASED ON HEART RATE VARIABILITY ANALYSIS DURING ORTHOSTATIC INTERVENTION

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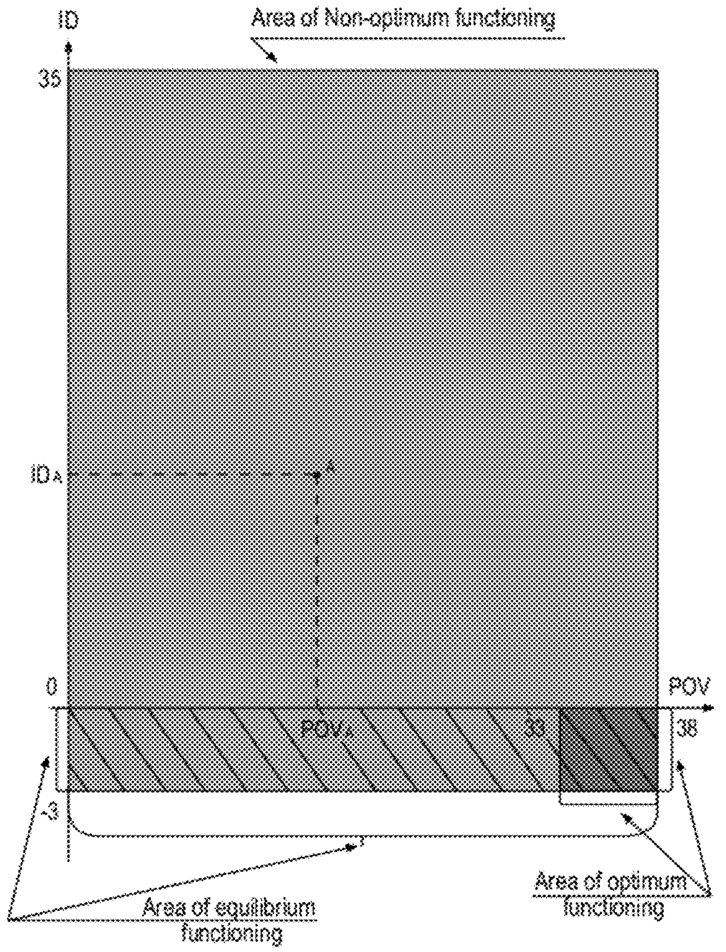
(57) ABSTRACT

This invention relates to fitness monitors and the like. This invention is more particularly directed to a device and a method for facilitating quantitative evaluation of level of physical fitness (fitness score) including a PC or handheld, or watch type electronic device having input and output means based on formulas for calculating level of physical fitness through heart rate variability analysis during orthostatic intervention by assessing two main parameters, such as level of adaptation reserve and wellness level.

Illustration of Optimum and Non- Optimum function of Heart Rate Variability regulation mechanisms during some physical or physiological intervention.



Sample of a handheld device with R-wave generating and transmitting device

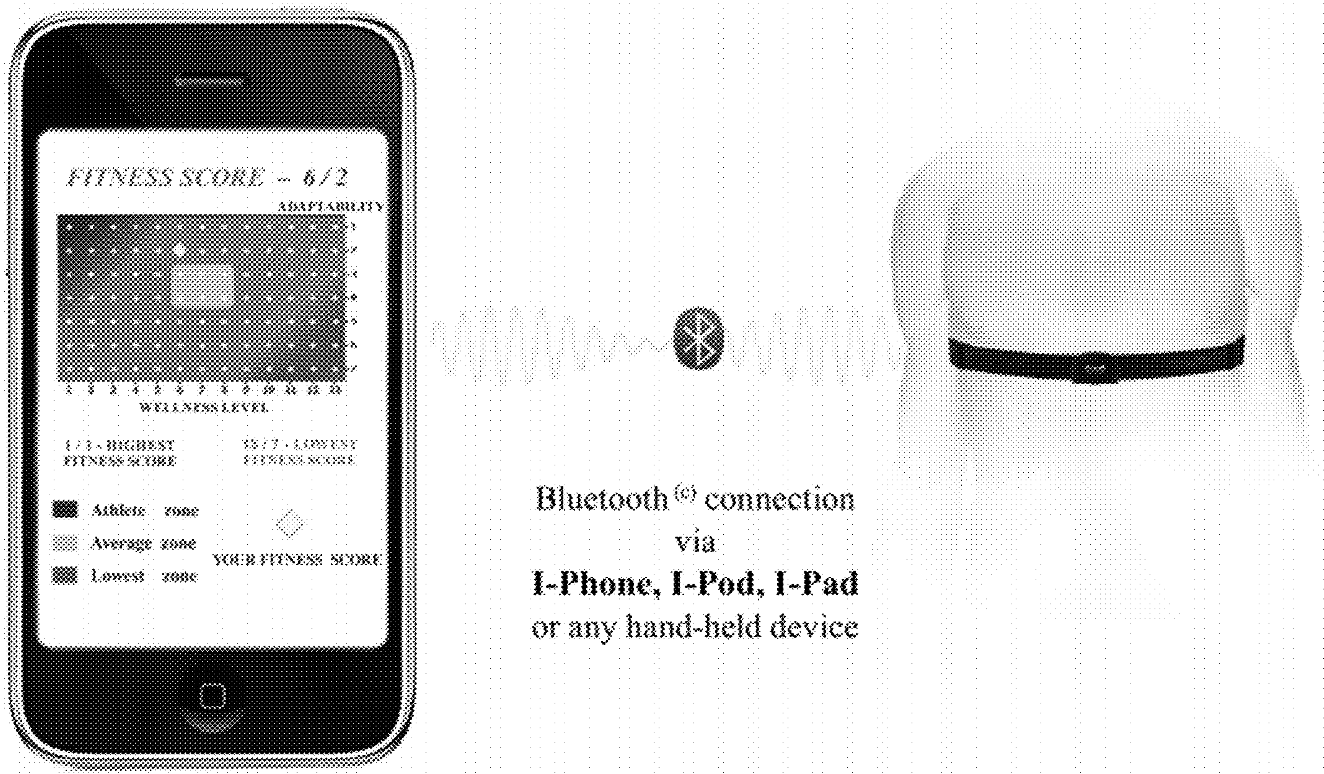


FIGURE 1

Illustration of Optimum and Non- Optimum function of Heart Rate Variability regulation mechanisms during some physical or physiological intervention.

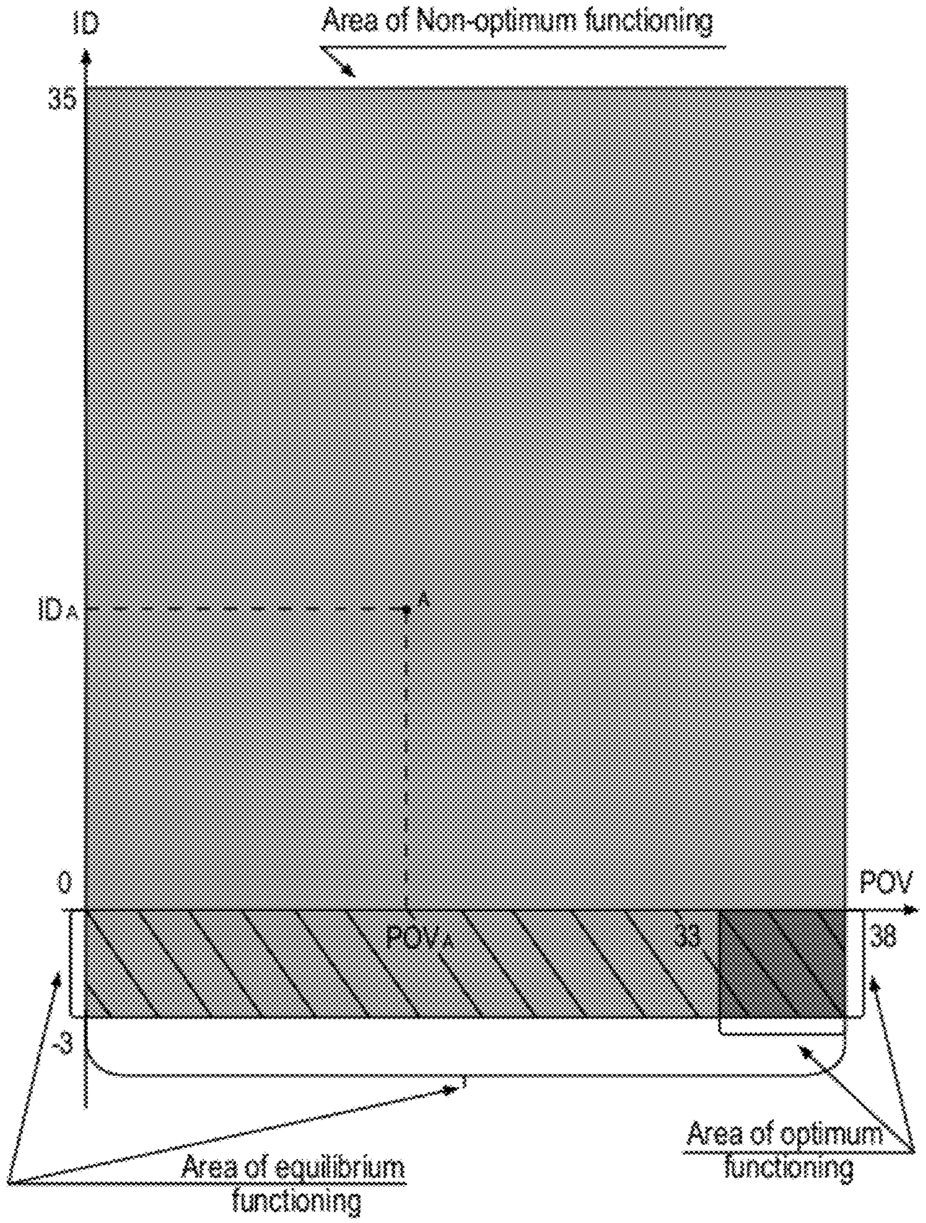


FIGURE 2

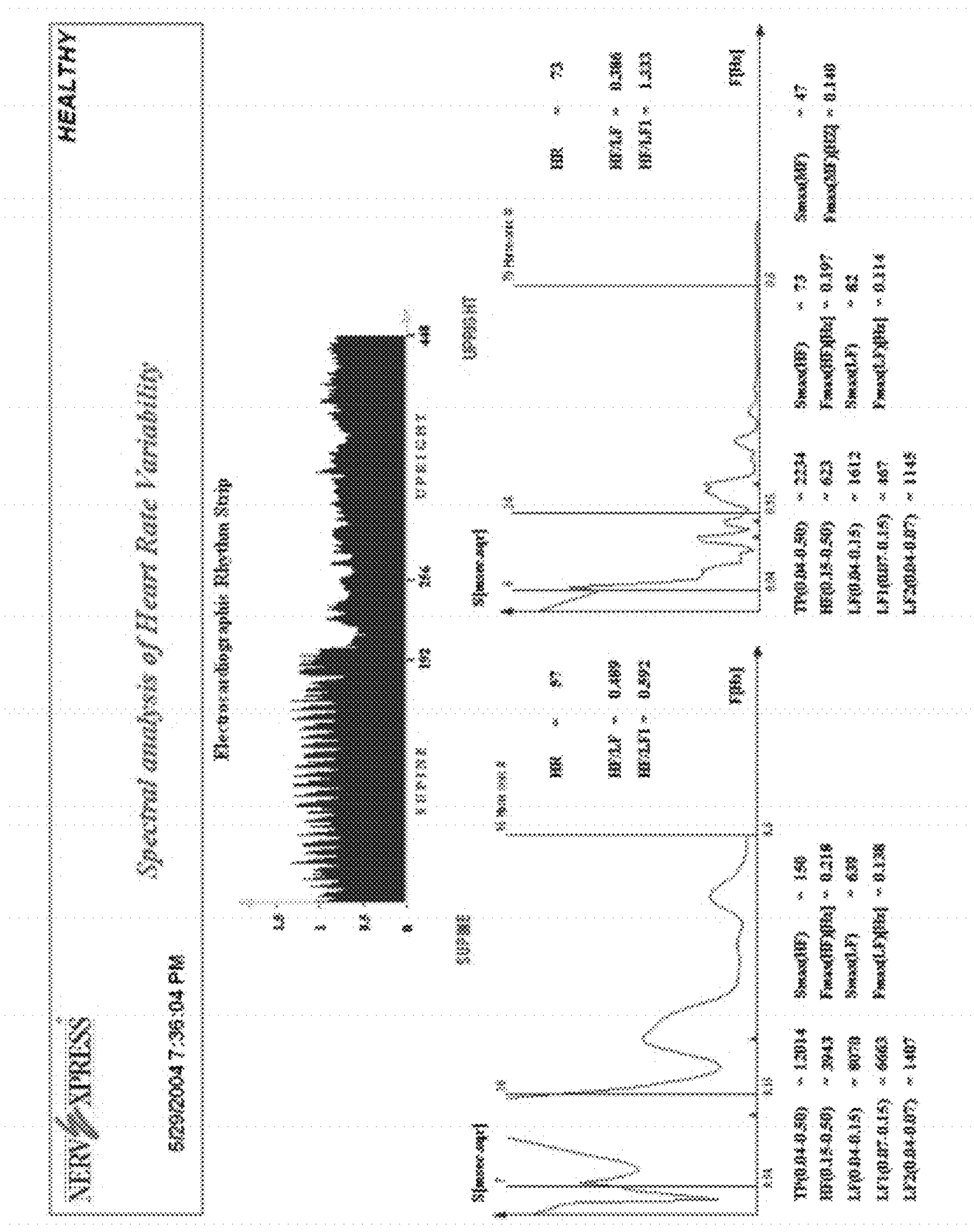

HEALTHY
Spectral analysis of Heart Rate Variability
5/29/2004 7:36:04 PM
Electrocardiographic Rhythm Strip
SUPINE
UPRIGHT

FIGURE 2-A

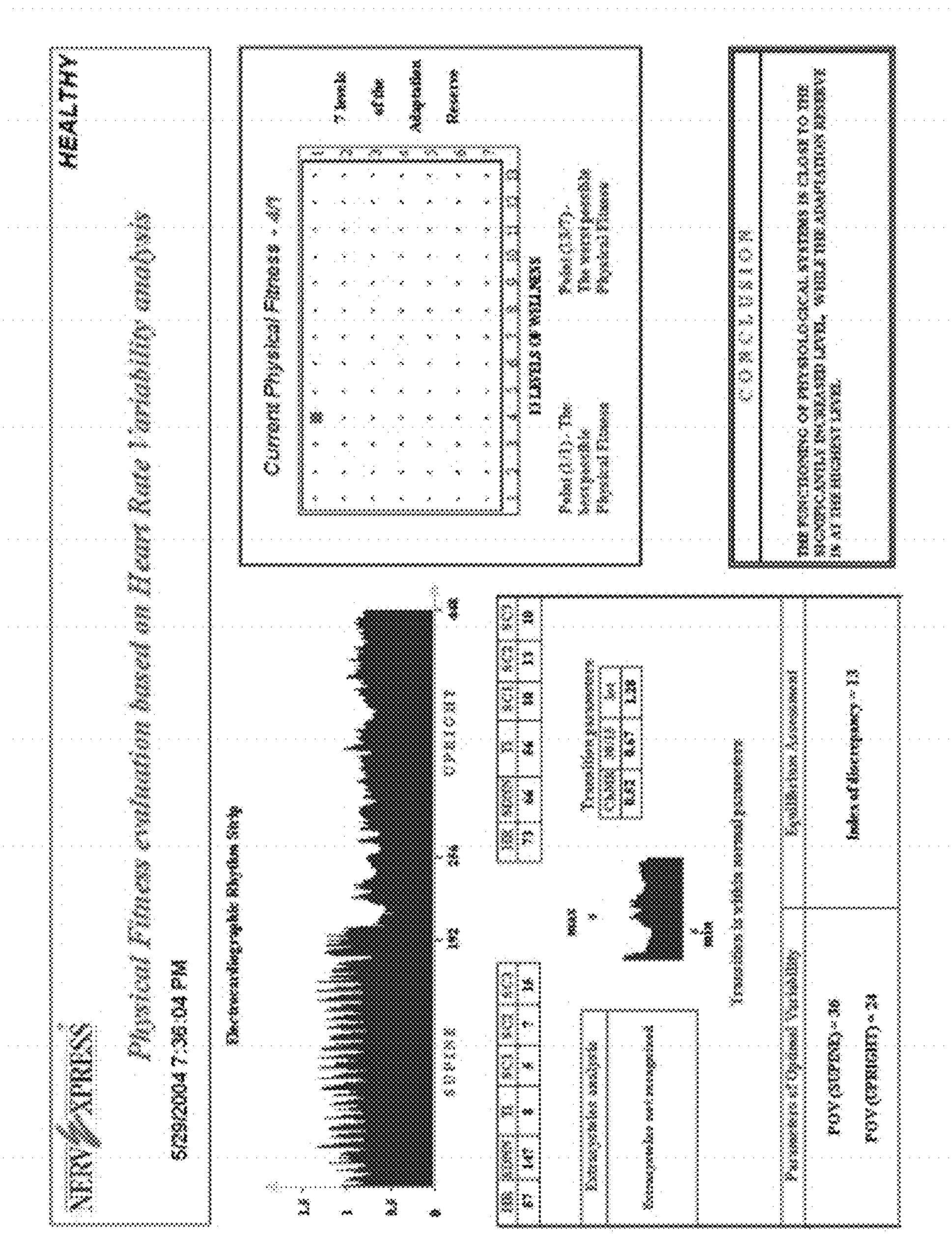


FIGURE 2-B

Areas of Discrepancy from Optimum and Equilibrium functioning of Heart Rate Variability regulation mechanisms.
(Samples of orthostatic intervention)

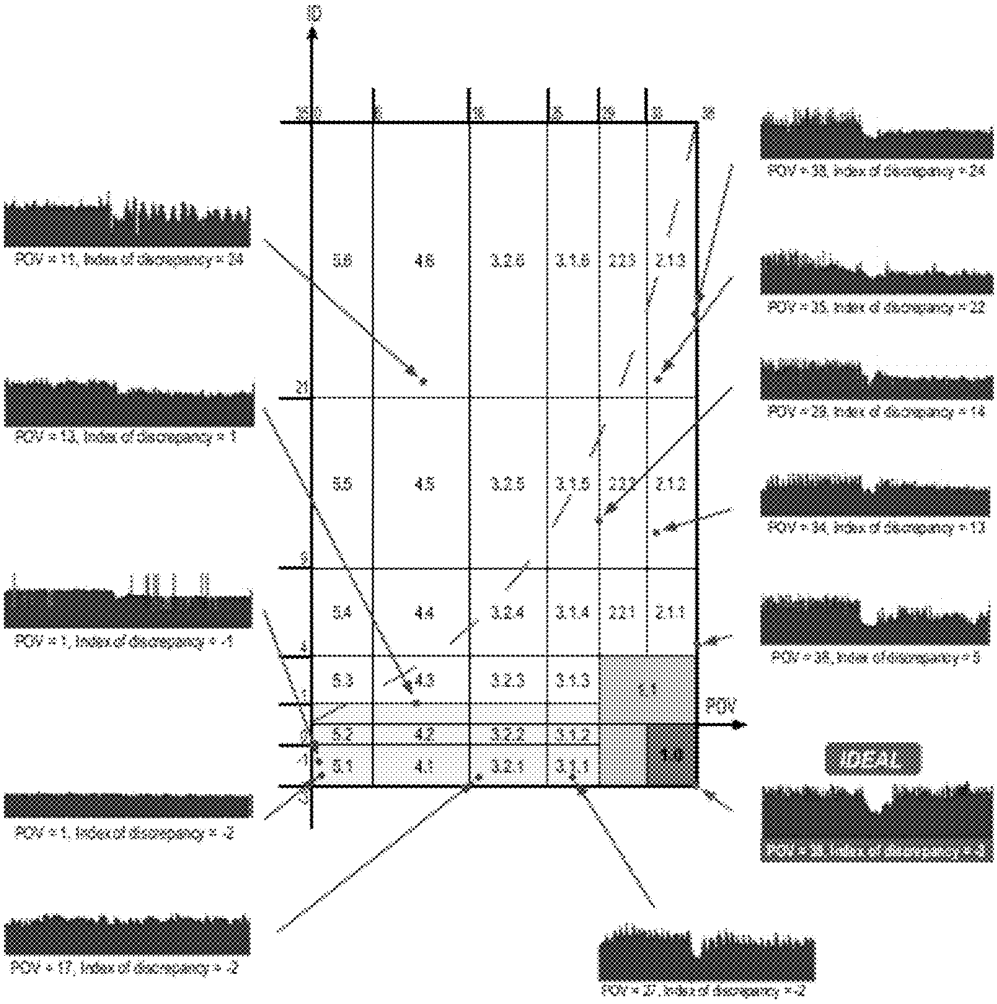


FIGURE 3

TRANSLATION OF SUBREGIONS ON THE WELLNESS GRAPH (FROM FIGURE 3) INTO THE X-AXIS VALUES ON THE FITNESS SCORE GRAPH (FIGURE 6)

X-AXIS VALUES ON THE FITNESS SCORE GRAPH	SUBREGIONS ON THE WELLNESS GRAPH
1	1.0
2	1.1
3	3.1.1, 3.1.2, 2.1.1
4	3.2.1, 3.1.3, 2.2.1
5	3.2.2, 3.1.4, 2.1.2
6	3.2.3, 2.2.2, 2.1.3, 3.1.6
7	3.2.4, 3.1.5, 2.2.3, 3.2.6, 4.6
8	3.2.5, 4.1, 4.5
9	4.2, 4.3, 4.4, 5.6
10	5.4, 5.5
11	5.3
12	5.2
13	5.1

FIGURE 4

Schematic representation of how we break down the transition period into two phases

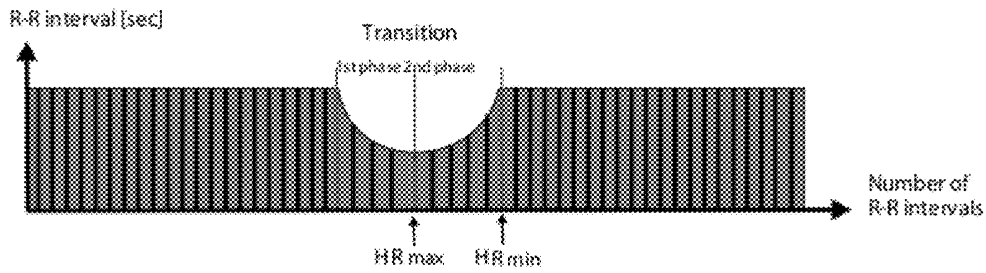


FIGURE 5

Standard presentation on a hand-held device

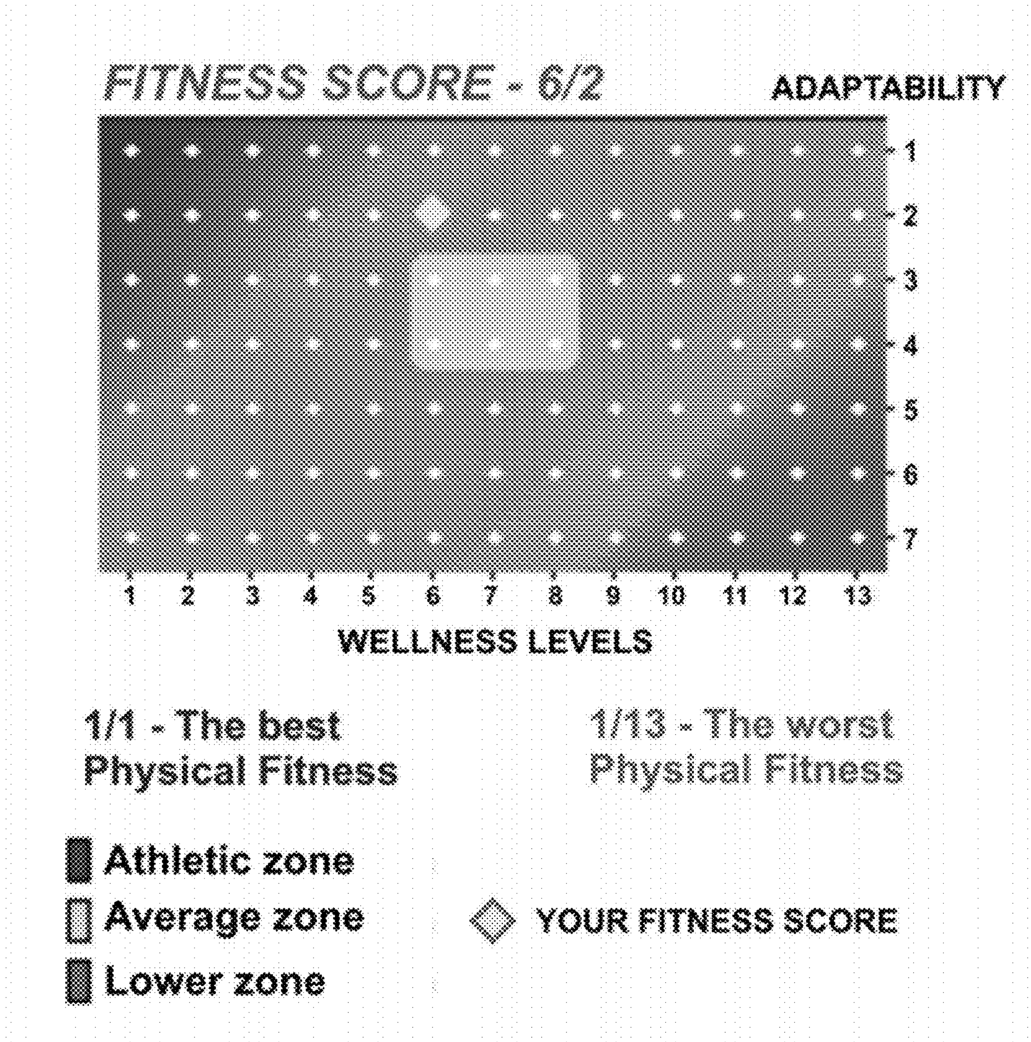


FIGURE 6

Standard presentation on a typical computer

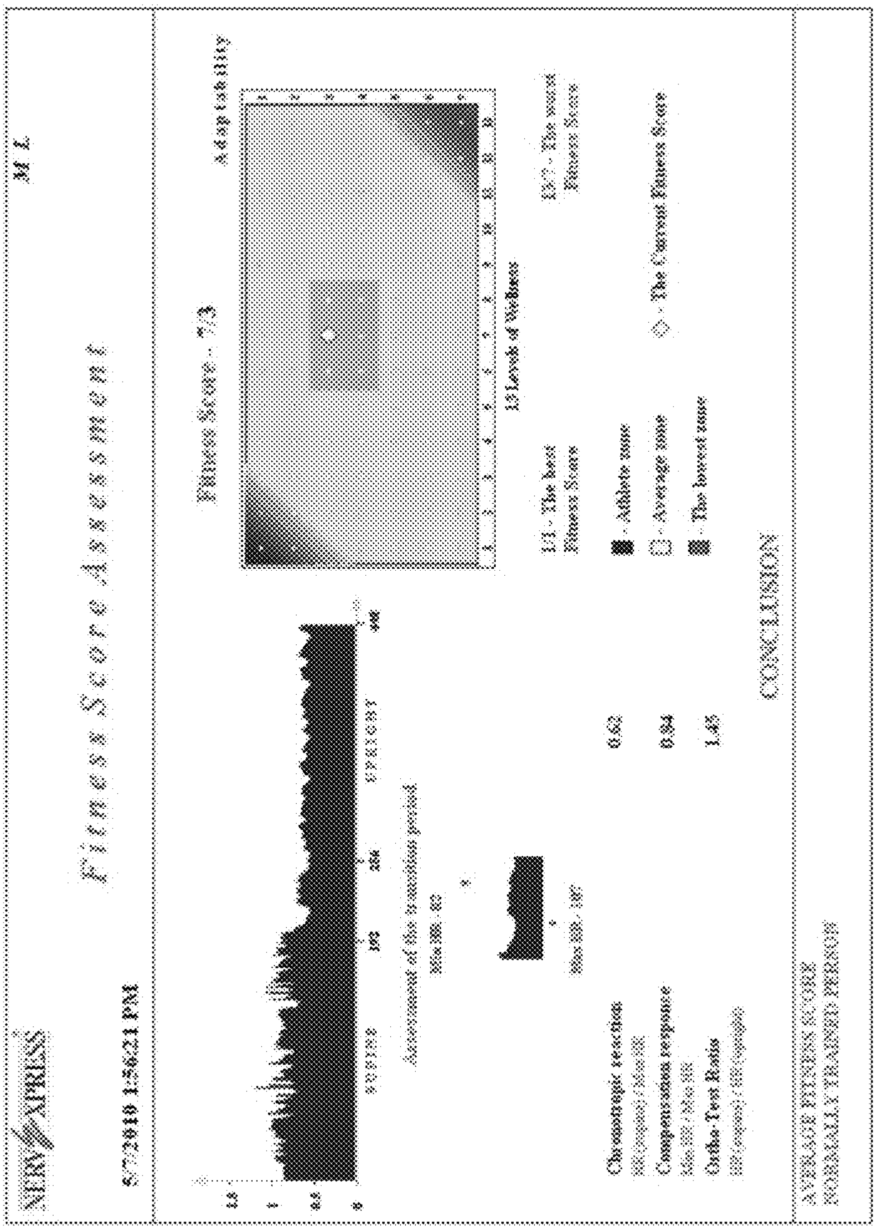


FIGURE 7

FITNESS SCORE ASSESSMENT BASED ON HEART RATE VARIABILITY ANALYSIS DURING ORTHOSTATIC INTERVENTION

DESCRIPTION OF THE INVENTION

[0001] This invention relates to fitness monitors and the like. This invention is more particularly directed to a device and a method for facilitating quantitative evaluation of level of physical fitness (fitness score) including a PC or handheld, or watch type electronic device having input and output means based on formulas for calculating level of physical fitness through heart rate variability analysis during orthostatic intervention by assessing two main parameters, such as level of adaptation reserve and wellness level.

[0002] Please refer to the FIG. **1** that demonstrates a sample of a handheld device with R-wave generating and transmitting device (any heart rate monitor produced by Polar or any other company) with the results of our method and software calculations displayed on the screen.

I. BACKGROUND OF THE INVENTION

[0003] 1. Field of the Invention

[0004] The field of present invention relates to fitness application and more particularly to a system and a method for facilitating personal physical fitness diagnostic evaluation based on heart rate variability analysis during orthostatic intervention.

[0005] 2. Description of the Prior Art

[0006] The ability of the human organism to withstand physical strain is one of the most important characteristics of health. We can easily distinguish a person who is able to run 10 miles from an individual that cannot even walk 100 yards without a break. The difference between them is in their physical fitness. What is "physical fitness"? According to physiology, it is the ability of the cardio vascular system to provide the function of the organism in the state of heightened strain. Therefore, in assessing the state of the cardio vascular system we are also assessing the state of physical fitness. In recent times, for this purpose, the method of analyzing heart rate variability during the orthostatic challenge test became widely used.

[0007] It is well known that orthostatic challenge test is one of the most informative methods used to detect subtle changes in cardiovascular function and specifically its regulatory mechanisms. When body's position is changed from supine to standing, specific changes in heart rate and blood pressure happen as a compensatory reaction of the body. This standup maneuver does not cause any significant physical exertion to a healthy individual. However, if body's regulatory mechanisms do not have adequate functional capacity or there is subtle cardiovascular deficiency then this maneuver can show regulation mechanism dysfunction.

[0008] With the help of heart rate variability analysis, it is possible to assess these regulatory mechanism dysfunction. Multiple research studies have shown that reaction of the cardiovascular system on changing body posture and speed of its compensation depends on fitness level. The most indicative parameter of this Heart Rate Variability test is a pattern of heart rate changes caused by a standup maneuver. The weaker and slower this reaction is the less an organism is fit and susceptible to physical exertions, which means lower level of fitness.

[0009] Modern techniques of HRV (Heart Rate Variability) analysis allow us to determine an almost exact cardiovascular function condition during the orthostatic challenge test. For example, the Heart Rhythm Scanner program, developed by Biocom Technologies, includes Cardiovascular Health Test. It makes an assessment of the cardiovascular function condition based on two variables:

[0010] Cardiovascular Tolerance—indicates dynamic regulatory reserve of the cardiovascular system responsible for a quick reaction to rapid changes in the body's condition.

[0011] Cardiovascular Adaptation—indicates the ability of the cardiovascular system to adapt to physiological changes in the body and establish a new stable regulatory state.

[0012] The higher the variables of these results the better the ability of the organism to withstand physical strain and as a result a higher level of fitness.

[0013] Heart Rate Variability (HRV) is a powerful, very accurate, reliable, reproducible, yet simple method of fitness assessment. Regardless of the vast amount of research in this field, its use by fitness specialists has not yet spread to reach full potential. However, the use of this method will give an individual the ability to customize his physical strain according to cardiovascular function. This will help to avoid overstrain of the organism during workout.

[0014] It has been previously proposed to construct fitness monitors to count the number of strides when individual is running. From this, the fitness monitor calculates the distance run by multiplying the number of steps times the individual's stride length. The number of calories consumed by the individual is automatically estimated using the elapsed exercise time and individual is average speed.

[0015] Recently, the capacity of the individual's cardiovascular system to bring oxygen to the body tissues has been determined to be the most meaningful index of fitness level. This fitness index is usually expressed in terms of the volume of oxygen taken up by the cardiovascular system, per kilogram of body weight, per minute, this fitness index is commonly referred to as the maximum oxygen intake, or VO_{2max}. Generally, this fitness index is higher, the greater the level of fitness is for a given individual. The application of maximal oxygen uptake VO_{2max} as an index of fitness is discussed, e.g., in Astrand and others, for example, in the Journal of Physiology, November 1963. Portable heart rate monitors based on measurement of this index came into existence back in 1982 when Polar launched the first wireless wearable heart rate monitor.

[0016] All the fitness evaluation inventions that are based on approximate assessment VO_{2max} have multiple drawbacks. First, all these methods are based on only one fitness parameter (maximal oxygen uptake level) and they require the individual to go through a strict training protocol in order to provide the assessment. Second, these methods require special skills for performing assessment and therefore, usually performed with assistance of the exercise physiologist. In addition, such methods take substantial time to complete, not very precise, difficult to quantify, require to input multiple parameters. Thus, despite the existing methods for fitness evaluation based on Heart Rate Variability Analysis, there is a need for a quick, quantifiable and comprehensive method of fitness assessment, which can be easy performed without supervision and other complications.

* Based on our previous study's result, invented method of Fitness Score assessment well correlated with VO_{2max} approach.

II. SUMMARY OF THE INVENTION

[0017] The present invention is directed to a system and a method for facilitating personal physical fitness diagnostic evaluation based on heart rate variability analysis during orthostatic intervention by assessing level of adaptation reserve and wellness level. This evaluation is evolving around method and device in which fitness score is a point on a two-coordinate system presented on a device monitor. X-axis reflects wellness level and y-axis reflects level of adaptation reserve, where:

[0018] Wellness level is determined by the effectiveness of the reaction of the regulatory mechanisms, primarily parasympathetic and sympathetic mechanism, to the orthostatic intervention;

[0019] * by regulatory mechanisms, we mean parasympathetic regulation, sympathetic regulation, baroreceptors regulation, neuro-humoral regulation, thermo regulation, hormonal and other types of regulations.

[0020] Adaptation reserve means the level of adaptability of the myocardium and compensatory ability of the peripheral vascular system during orthostatic intervention.

[0021] Calculation of the wellness level is based on the ability of all regulatory mechanisms to function at the optimal, self-maintaining and equilibrium mode during orthostatic intervention. There is a need to note that the best regulatory mechanism is present under condition of Parasympathetic dominancy.

[0022] Calculation of the adaptation reserve level is based on the analysis of the transition period between supine and upright position. During the standup maneuver, there is a two-phase transition process between supine and upright position: 1^{st} phase is characterized by chronotropic myocardial reaction or adaptability of the myocardium, 2^{nd} phase is related to the vascular compensation response from peripheral vascular system.

[0023] Our method identifies 13 levels of wellness and 7 levels of the adaptation reserve, all presented as coordinates on a point coordinate system. Each point on a coordinate system is represented simultaneously by two parameters, one being the level of wellness, and another being the level of adaptation reserve.

[0024] In the preferred embodiment, the present invention provides automatic calculation of two predetermined factors relevant to an individual's fitness evaluation and produces results in a printable color format by providing hard copy to the individual.

[0025] Input of data related to two parameter is performed by the ECG based or Pulse-wave measuring device, which wirelessly transmits R-R intervals or beat-to-beat data during fitness evaluation and testing to the PC, hand-held, or watch type microcomputer device. Such microcomputer device is used to store and analyze collected data.

[0026] To summarize, the purpose of the present invention is to provide a method for automatic calculation of two predetermined related to fitness evaluation parameters. Testing is performed with the help of a PC, handheld or watch type device having a software program with relevant for individual evaluation of fitness level and testing; ECG device or Pulse-wave device collecting relevant data to be evaluated; the microcomputer automatically calculating two select parameters; and the microcomputer outputting the result of calculation in a readable and understandable for user format.

III. BRIEF DESCRIPTION OF THE FIGURES

[0027] FIG. **1**. Sample of a handheld device with illustration on a graph of the fitness score test results demonstrated along with R-wave generating and transmitting device with Bluetooth connection.

[0028] FIG. **2**. Illustration of method of optimum and non-optimum function of heart rate variability regulation mechanisms during some physical or physiological intervention

[0029] FIG. **2**(A). Showing an example of rhythmografic strip and spectral function during orthostatic intervention corresponding with high level of Optimum variability and middle level of discrepancy from Equilibrium.

[0030] FIG. **2**(B). Showing the final test result from FIG. **2**(A) with calculation of optimum and equilibrium numbers.

[0031] FIG. **3**. Graph showing areas of discrepancy from optimum and equilibrium functioning of heart rate variability regulation mechanisms (samples of orthostatic interventions).

[0032] FIG. **4**. Translation of subregions on the wellness graph (FIG. **3**) into the x-axis values on the fitness score graph (FIG. **6**).

[0033] FIG. **5**. Schematic representation of how our method breaks down transition period into two phases: 1^{st} phase—chronotropic reaction of the myocardium and 2^{nd} phase—compensation response from peripheral vascular system.

[0034] FIG. **6**. Standard presentation of the fitness score test result on a hand held device.

[0035] FIG. **7**. Standard presentation of the fitness score test result on a typical computer featuring additional information describing analysis of the transition period with appropriate parameters.

IV. DETAILED DESCRIPTION OF THE INVENTION

Method for Assessment of Fitness Score by Determining Wellness Level and Level of Adaptation Reserve

[0036] Our method comprises of two distinctly separate stages: first, we assess the wellness level, which in essence is assessment of the effectiveness of the body's regulatory mechanisms; second, we assess the level of adaptation reserve. Then we combine these two parameters in order to determine the fitness score result. Let us start with the description of the first stage.

1. Assessment of Wellness Level or Effectiveness of the Body's Regulatory Mechanisms During Orthostatic Intervention

[0037] In the present method, we propose to use spectral analysis of the heart rate variability and specifically three ranges of spectral function as follow:

Ranges of Spectral function		Frequency Range
*High frequency range-IA		HF (0.15-0.50 Hz)
**Low frequency range	Subdiapason 1-I_{C1}	LF1 (0.07-0.15 Hz)
	Subdiapason 2-I_{C2}	LF2 (0.04-0.07 Hz)

*High frequency range corresponds with parasympathetic regulatory mechanism only.
**Low frequency range related to mixed regulatory mechanisms: sympathetic, parasympathetic, baroreceptors, neuro-humoral, thermo, hormonal and others.
IA-index of activity of the High frequency range,
I_{C1}-index of activity of Subdiapason 1 of Low frequency range
I_{C2}-is the index of activity of Subdiapason 2 of Low frequency range

[0038] Based on the experimental analysis of 7,000 volunteers, we identified the maximum power of the spectral function of each frequency range. Such power (measured in msec square) was broken down into 15 levels where is 1 being the highest power and 15 the lowest. Such approach allows to assess the levels of Heart Rate Variability (HRV) control quantitatively by calculating 3 values of indices I_A, I_{C1}, and I_{C2}, and, in addition, to perform qualitative assessment of the status of HRV control by assessing different combinations of activity of HRV regulatory mechanisms. On a stationary stage, HRV regulatory mechanism can be described through these three parameters. Since every index has 15 values, the total number of states of the HRV control is equal to the number of combinations of 3 parameters each multiplied by 15, i.e. 3375 distinct statuses of HRV regulatory mechanisms.

[0039] Our goal is to evaluate how HRV regulatory mechanisms function in case of intervention that triggers a specific response of the body's physiological system. Hereinafter, we use intervention as a general term that includes any kind of physical activity, psycho-emotional stress, change of environment (e.g. exposure to heat), medications, and other kinds of impact. For evaluation of functioning of HRV regulatory systems during orthostatic intervention, it is necessary to analyze how they function before and after the intervention. For this analysis, we recommend applying principle of the optimum and the equilibrium status.

The Principles of OPTIMUM and EQUILIBRIUM Status as a Universal Approach to Assessment of Effectiveness of Regulatory Mechanisms During any Intervention

[0040] The principle of the optimum and equilibrium status are introduced in order to quantitatively evaluate body response to intervention, and, ultimately, to assess the functional status of HRV regulatory mechanisms. The functioning of HRV regulatory mechanisms during intervention is determined by comparing HRV control before and after the impact. For assessment of HRV control before and after the intervention it is necessary to collect some data while the individual is not changing activities and no intervention is performed—such periods are further referred to stationary periods. Thus, the typical simplified testing model includes three stages:

[0041] 1. Stationary period of rest before intervention;

[0042] 2. Intervention;

[0043] 3. Stationary period of rest after intervention.

Substage 1—Determining the Optimum Condition on a Stationary Stage

[0044] By analyzing 7,000 cases, we selected 74 clinically healthy individuals with the best possible test results, and found that their three parameters of HRV spectral function satisfy the following conditions:

$$\begin{cases} I_A < I_{C1} < I_{C2} \\ I_A \le 6 \\ I_{C1} \le 8 \\ I_{C1} - I_A = \{2, 3\} \\ I_{C2} = \{9/12\} \end{cases}$$

We identified such condition to be the optimum status of regulatory mechanisms on a stationary stage.

Substage 2—Determining the Equilibrium Condition after any Intervention

[0045] Equilibrium status of the HRV regulatory mechanisms after intervention is the state when the values of activity indices of I_A, I_{C1} and I_{C2} of the stationary stage before the impact are equal to or differ by no more than 3 values from the values on activity indices of the stationary period after the impact.

[0046] Thus, the parameters for equilibrium status of HRV control after impact is as follows:

$$\begin{cases} I_{A\ before\ int} - I_{A\ after\ int} \mid \le 1 \\ I_{C1\ before\ int} - I_{C1\ after\ int} \mid \le 1 \\ I_{C2\ before\ int} - I_{C2\ after\ int} \mid \le 1 \end{cases}$$

[0047] $I_{A\ before\ int}$ is the value of the index of HRV control by the High frequency range on the stationary period before intervention:

[0048] Intervention is any kind of impact including physical activity, such as orthostatic test described below or controlled exercise, medications, psycho-emotional stress and other activities or effects that trigger a reaction of the Autonomic Nervous system and all other regulation mechanisms and can affect HRV;

[0049] $I_{A\ after\ int}$ is the value of the index of HRV control by the High frequency range on the stationary period after intervention;

[0050] I_{C1} before int and $I_{C1\ after\ int}$ are the values of the index of HRV control by the Subdiapason 1 of the Low Frequency range on spectral function on the stationary period before and after intervention;

[0051] $I_{C2\ before\ int}$ and $I_{C2\ after\ int}$ are the values of the index of HRV control by the Subdiapason 2 of the Low Frequency range on spectral function on the stationary period before and after intervention.

[0052] FIG. **2**(A) showing an example of rhythmografic strip and spectral function during orthostatic intervention corresponding with high level of Optimum variability and middle level of discrepancy from Equilibrium.

Substage 3—Calculating Discrepancy Between Actual Condition and the Optimum and Equilibrium (Ideal) Condition.

[0053] For quantitative assessment of the degree of discrepancy of the actual status to the optimum and equilibrium condition of the regulatory mechanisms, we introduce biparametric index of correlation (B).

The index of correlation is composed of two components:

[0054] B**1** component evaluates deviation of HRV regulatory mechanisms during impact from the equilibrium state, while B**2** component evaluates deviation of HRV regulatory mechanisms from the optimal status on a stationary stage before intervention.

[0055] Formulas for calculation of these B components can be written as follows:

$$B1=(|I_{A\ before\ int}-I_{A\ after\ int}|+|I_{C1\ before\ int}-I_{C1\ after\ int}|+|I_{C2\ before\ int}-I_{C2\ after\ int}|)-3$$

* The domain of values of B**1** will be equal to (−3, 35). B**1** is ≦0 when the functioning of HR regulation is at equilibrium.

$$B2=K_A-Kc_{1.1}-Kc_{1.2}-Kc_2, \text{ where}$$

$$K_A = \begin{cases} 40 - I_{A\ before\ int} & \text{if } I_{C1} - I_A \ne (0 \text{ to } 3) \text{ and } I_A \ge 7 \\ 36 - I_{A\ before\ int} & \text{if } I_{C1} - I_A = (0 \text{ to } 3) \text{ and } I_A = 7 \text{ to } 9 \\ 33 - I_{A\ before\ int} & \text{if } I_{C1} - I_A = (0 \text{ to } 3) \text{ and } I_A > 9 \end{cases}$$

$$K_{C1.1} = \begin{cases} I_{C1} - (I_A + 3) & \text{if } (I_{C1} - I_A) > 3 \\ 2 - (I_{C1} - I_A) & \text{if } (I_{C1} - I_A) \le 1 \\ 0 & \text{if } (I_{C1} - I_A) = 2, 3 \end{cases}$$

-continued

$$C_{C1.2}=\begin{cases}0 & \text{if } I_{C1}\le 8\\ I_{C1}-8 & \text{if } I_{C1}>8\end{cases}$$

$$K_{C2}=\begin{cases}2\times(9-I_{C2}) & \text{if } I_{C2}<9\\ I_{C2}-12 & \text{if } I_{C2}>1\\ 0 & \text{if } I_{C2}=9 \text{ to } 12\end{cases}$$

* The range of values when status of HR V regulatory mechanism is optimal is B**2**=(33-38).

* The full range of values of B**2** is (0-38).

[0056] As result of such of calculation we can observe different conditions of the regulatory mechanisms during intervention and distinguish between the areas of optimum and equilibrium as shown on FIG. **3**. FIG. **2**(B) showing the final test result related to FIG. **2**(A) with calculation of optimum and equilibrium numbers.

[0057] The position of a point with coordinates B**1** and B**2** on this graph (FIG. **3**) will fall in a certain region and will reflect the degree of discrepancy of the analyzed case of the HRV regulatory mechanism with the optimal and equilibrium condition.

[0058] Our method distinguishes **32** subregions for orthostatic intervention as shown on FIG. **3**.

[0059] In addition, FIG. **3** contains examples of the rhythmographic strips of the most typical statuses of the HRV regulatory mechanisms during orthostatic intervention.

[0060] For analysis first, we look at the x-axis for evaluation of the optimum level of regulatory mechanisms on a stage before intervention. The bigger the value of the x-axis, the more optimum the level of regulatory mechanisms is. The smaller the value, the less optimum the level of the regulatory mechanisms. The best optimum level is usually identified in healthy people who regularly exercise and have a great genetic ability.

[0061] Then we look at the y-axis to identify the equilibrium level of regulatory mechanisms. The bigger the value, the less equilibrium level meaning that there is a high level of discrepancy of regulatory mechanism.

[0062] After this, we look at the two parameters in combination. Based on 7,000 evaluated cases, we have identified the common features characterizing each region on the graph. Cases with the most effective regulatory mechanism will fall under the lower right region on the graph.

[0063] Suggested approach based on method of Optimum and Equilibrium can be used for any type of intervention. With different types of intervention there will be assessment of different physiological parameters which depend on the type of utilized intervention. It is necessary to note that for different interventions there will be different subdivision of the regions on the FIG. **3** and correspondingly completely different translation of these subregions into new physiological parameter, for instance tolerance level or physical reserve level instead of wellness level. Such parameter will be chosen based on the type of intervention used in a particular method.

[0064] In this case we used this approach only for the assessment of the wellness level during orthostatic Intervention. This is physiological approach, but we find also that some of subregions related with specific pathology. For instance, we find high correlation of subregions **2.1.1**, **2.1.2**, **2.1.3**, **2.2.1**, **2.2.2**, **2.2.3**, **3.1.4**, **3.1.5**, and **3.1.6** with gastrointestinal system problems and brain deregulation. Subregions **3.2.5**, **3.2.6**, **4.4**, **4.5**, **4.6**, **5.4**, **5.5**, and **5.6** are highly correlated with individual psycho-emotional condition such as introversion.

[0065] Generally, from physiology point of view, we can translate numbers of subregions into the wellness level based on deviation of each subregions from Optimum and Equilibrium.

[0066] FIG. **4** explains translation of subregions from the FIG. **3** into 13 levels of wellness demonstrated on FIG. **6**, which shows the graphical result user obtains with the help of our method and software.

[0067] Let us now discuss the process of assessment of the level of adaptation reserve.

2. Method for Assessment of the Level of Adaptation Reserve

[0068] After we have described the first stage in our method, let us continue with the description of the assessment of the level of adaptation reserve.

[0069] Adaptation reserve means level of adaptability of the myocardium and compensatory ability of the peripheral vascular system during orthostatic intervention. Calculations of the adaptation reserve are based on the analysis of the transition period between supine and upright position.

[0070] During the standup maneuver, there is a two-phase transition process between supine and upright position:

[0071] 1^{st} phase characterized by chronotropic myocardial reaction or adaptability of the myocardium, which allows assessing heart functionality and its level of adaptability during intervention;

[0072] 2^{nd} phase related to the vascular compensation response from peripheral vascular system and allows assessing peripheral vascular tonus and its regulatory mechanisms.

[0073] FIG. **5** demonstrates schematic representation of how we break down transition period into two phases.

[0074] Quantitative assessment of the 1^{st} and 2^{nd} phases is conducted based on the rhythmographic analysis performed during orthostatic intervention. The following parameters are analyzed:

C **1**—coefficient of the 1^{st} phase, which can be calculated as follows:

$$C1=\frac{R\min}{R_{1average}}=\frac{\text{min value of } R\text{-}R \text{ interval during transition period}}{\text{average } R\text{-}R \text{ interval on a first stationary stage (before intervention)}}$$

C **2**—coefficient of the 2^{nd} phase, which can be calculated as follows:

$$C2=\frac{R\min}{R\max}=\frac{\text{min value of } R\text{-}R \text{ interval during transition period}}{\text{max value of } R\text{-}R \text{ interval during transition period}}$$

I_{ot}—index of the orthotest, which reflects overall reaction of the heart rate during orthotest, calculated as follows:

$$I_{ot} = \frac{R_{1average}}{R_{2average}} = \frac{\text{average } R\text{-}R \text{ interval on a first stationary stage (before intervention)}}{\text{average } R\text{-}R \text{ interval on a second stationary stage (after intervention)}}$$

[0075] Rhythmographic analysis performed during orthostatic intervention allowed us to distinguish five specific types of transition processes:

[0076] 1. Normal or conditionally normal transition process

[0077] 1.1 normal

[0078] 1.2 conditionally normal

[0079] 2. Generally weakened reaction of both phases of the transition period (by at least 4 values)

[0080] 2.1 slight decrease

[0081] 2.2 moderate decrease

[0082] 2.3 significant decrease

[0083] 2.4 sharp decrease

[0084] 3. Weakened 2^{nd} phase with normal or conditionally normal 1^{st} phase (by at least 4 values)

[0085] 3.1 moderate decrease

[0086] 3.2 significant decrease

[0087] 3.3 sharp decrease

[0088] 3.4 2^{nd} phase is absent

[0089] 4. Weakened 1^{st} phase with inexistence of the 2^{nd} phase (by at most 3 values)

[0090] 4.1 moderate decrease

[0091] 4.2 significant decrease

[0092] 4.3 sharp decrease

[0093] 5. Mixed reaction to orthostatic intervention—various mixes of weakened reactions on a 1^{st} And 2^{nd} phases (by at most 3 values)

[0094] 5.1 moderate decrease of the 1^{st} phase with the significant decrease of the 2^{nd} phase

[0095] 5.2 significant decrease of the 1^{st} phase with the sharp decrease of the 2^{nd} phase

[0096] 5.3 moderate decrease of the 1^{st} phase with the sharp decrease of the 2^{nd} phase

[0097] These 5 groups of transition processes are determined by 27 conditions of the next 4 parameters: C**1**, C**2**, Iot and C**1**-C**2** as shown below (please note that these values are decimal values, but for simplicity of presentation we have multiplied each value by 100):

CONDITION NUMBER	C1	C2	Iot	C1-C2	SUBGROUP NUMBER
1	(39, 58),	(39, 63),	(90, 129),	(−4, 23)	1.1
2	(39, 59),	(39, 59),	(90, 107),	(−4, 20)	1.1
3	(59, 63),	(56, 68),	(90, 125),	(−4, 10)	1.2
4	(59, 63),	(59, 72),	(90, 119),	(−4, 10)	1.2
5	(64, 68),	(65, 72),	(90, 119),	(−4, 6)	2.1
6	(69, 72),	(69, 73),	(90, 119),	(−4, 4)	2.1
7	(73, 75),	(71, 76),	(90, 119),	(−4, 4)	2.2
8	(73, 77),	(71, 77),	(90, 116),	(−4, 4)	2.2
9	(78, 85),	(78, 87),	(90, 112),	(−4, 10)	2.3
10	(86, 90),	(86, 90),	(90, 109),	(−4, 4)	2.4

-continued

CONDITION NUMBER	C1	C2	Iot	C1-C2	SUBGROUP NUMBER
11	(39, 59),	(63, 70),	(115, 124),	(−4, 34)	3.1
12	(60, 63),	(63, 70),	(105, 124),	(−4, 14)	3.1
13	(39, 59),	(71, 77),	(125, 145),	(12, 40)	3.2
14	(60, 63),	(71, 77),	(118, 145),	(8, 19)	3.2
15	(39, 59),	(74, 82),	(134, 145),	(19, 40)	3.3
16	(60, 63),	(74, 82),	(124, 145),	(15, 24)	3.3
17	(39, 59),	(83, 101),	(146, 180),	(14, 70)	3.4
18	(60, 63),	(83, 100),	(136, 180),	(20, 50)	4.4
19	(69, 76),	(84, 100),	(110, 145),	(10, 31)	4.1
20	(77, 83),	(86, 100),	(110, 130),	(9, 23)	4.2
21	(84, 88),	(86, 111),	(104, 120),	(−2, 27)	4.3
22	(70, 76),	(77, 83),	(107, 130),	(7, 19)	5.1
23	(77, 83),	(83, 100),	(110, 121),	(6, 23)	5.1
24	(71, 76),	(85, 100),	(126, 166),	(13, 29)	5.2
25	(64, 68),	(70, 79),	(102, 142),	(2, 16)	5.2
26	(64, 68),	(78, 88),	(102, 146),	(8, 28)	5.3
27	(64, 68),	(86, 100),	(102, 150),	(12, 34)	5.3

[0098] These 27 conditions of transition processes are translated into 7 levels of adaptation reserve as shown below:

LEVEL #	CONDITION NUMBER
LEVEL 1:	1, 8, 11, 14, 17
LEVEL 2:	2, 9, 12, 15, 18
LEVEL 3:	3, 10, 13, 16, 19
LEVEL 4:	4, 26, 27
LEVEL 5:	5, 20, 23, 25
LEVEL 6:	6, 21, 24
LEVEL 7:	7, 22

3. Fitness Score Assessment

[0099] After all mentioned above steps are performed, we present graphical approach to analysis of the overall fitness score based on two parameters: wellness level and level of adaptation reserve. Please refer to the FIG. **6**, which contains graph with 7 levels of adaptation reserve (on y-axis) and 13 wellness levels (on x-axis). The best fitness score is represented by the point (1, 1) on the graph, and the worst fitness score is at the point (13, 7). FIG. **6** is the typical presentation for the hand-held device. On FIG. **7**, we show Fitness Score presentation provided on a regular computer with more detailed information about transition process.

What is claimed is:

1. A hand-held or watch type device for use in completely self-guided fitness score evaluation comprising of:

1.1 A portable device including a memory, a microprocessor, a power source, R-wave, or Pulse-wave generating and transmitting device (any heart rate monitor produced by Polar or any other company), input/output interface for a user to input data and view outputs including results from processing the input data according to predetermined formulas relating to fitness score evaluation for at least one individual;

1.2 Software capable of running on the device for automatically calculating predetermined, select formulas associated with factors relevant to at least one individual's physical fitness;

1.3 The device is capable of automatically generating the outputs;

1.4 The outputs are capable of being provided in a printable format for providing a hard copy;

1.5 The software includes the formulas in an executable format when data is input by the user for the automatic calculation of select, predetermined factors relevant for an individual's fitness score evaluation and testing;

1.6 The outputs are diagnostic physical fitness indicators presented on a graph.

2. A method of assessment of the effectiveness of the body's regulatory mechanisms based on the principles of optimum and equilibrium status during any intervention and as a result representing on a system of two coordinates full range of subregions related to different levels of discrepancy between optimum and equilibrium status. A method is represented by a graph, where:

x-axis reflects the optimum level of regulatory mechanisms on a stage before intervention. The bigger the value of the x-axis, the more optimum the level of regulatory mechanisms is. The smaller the value, the less optimum the level of the regulatory mechanisms. The best optimum level is usually identified in healthy people who regularly exercise and have a great genetic ability.

y-axis reflects the equilibrium level of regulatory mechanisms. The bigger the value, the less the equilibrium level meaning that there is a high level of discrepancy of regulatory mechanism before and after intervention.

3. A method of assessment of fitness score by heart rate variability analysis during orthostatic intervention through calculation of two main parameters—wellness level which is based on the claimed above general principles of optimum and equilibrium and level of adaptation reserve—comprising of the steps of:

3.1 A method of dividing of the area on the graph of optimum and equilibrium into 32 subregions related to our particular method of intervention—orthostatic intervention.

3.2 A method of translating numbers of subregions into 13 wellness levels, which in essence is assessment of the effectiveness of the body's regulatory mechanisms during orthostatic intervention and displaying it in graphical representation;

3.3 A method of assessment of the level of adaptation reserve based on analysis of the transition period between supine and upright position during orthostatic intervention, which determines adaptability of the myocardium and compensatory ability of the peripheral vascular system, comprising of the steps of:

3.3.1 A method of representing types of transition period between supine and upright position into five group with different relationship between 1st and 2^{nd} phase of the transition period;

3.3.2 A method of determining 5 types of transition period by 27 conditions of the next 4 parameters: C**1**, C**2**, Iot and C**1**-C**2**;

3.3.3 A method of translating these 27 conditions of transition period into 7 levels of adaptation reserve reflected on the graph;

3.4 A method of combining and translating these two separately calculated parameters (wellness level and level of adaptation reserve) in order to determine the fitness score for a particular individual;

3.5 Outputting this result of our method with individual fitness score in graphical as well as numerical format for convenient use.

* * * * *

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摘要(译)

健身监视器等本发明涉及健身监视器等。本发明更具体地涉及一种用于促进定量评估身体健康水平（健康分数）的装置和方法，包括PC或手持式或具有输入和输出装置的手表式电子装置，其基于用于计算身体健康水平的公式。通过评估两个主要参数，如适应储备水平和健康水平，通过直立干预期间的心率变异性分析。