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(54) **Motor function evaluation device and motor function evaluation method**

Motorfunktionsauswertungsvorrichtung und Motorfunktionsauswertungsverfahren

Dispositif d'évaluation de la fonction de moteur et procédé d'évaluation de la fonction de moteur

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(73) Proprietor: **Tanita Corporation**
Tokyo 174-8630 (JP)

(72) Inventors:
- **Sakai, Yoshio**
  Tokyo, 174-8630 (JP)
- **Takehara, Tomoko**
  Tokyo, 174-8630 (JP)
- **Okura, Tomohiro**
  Ibaraki, 305-8577 (JP)
- **Tsuji, Taishi**
  Ibaraki, 305-8577 (JP)

(74) Representative: **Müller-Boré & Partner Patentanwälte PartG mbB**
Friedenheimer Brücke 21
80639 München (DE)

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Description

[0001] This application is based on and claims the benefit of priority from Japanese Patent Application No. 2013-051148, filed on 14 March 2013.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The present invention relates to a motor function evaluation device and a motor function evaluation method.

Related Art

[0003] Conventionally, replies to questionnaire surveys and results of physical performance tests have been used to evaluate motor functions.

[0004] However, criteria for judging the questionnaire surveys are not clear, and hence evaluation results are less objective.

[0005] Further, the physical performance tests are performed on a large scale as different kinds of equipment, time and space are required to carry out various test items. With the physical performance tests, there are risks of injuries due to falling and the like even though considerations are given to safety, especially when a subject is the elderly. Further, professional judgment and advice in a comprehensive manner are required in order to judge test results of the respective items. Furthermore, it is considered to be important to capture changes overtime in the motor function evaluation. However, due to the large scale of the physical performance tests as described above, it is difficult to perform the physical performance tests many times.

[0006] In view of the above, there is an evaluation device of lower-limb muscle strength that measures the body weight of a subject on a measurement base, and measures the lower-limb muscle strength of the subject based on a maximum peak and a minimum peak of a load applied to the measurement base when the subject changes his or her posture from a crouching posture to a standing posture on the measurement base (refer to Japanese Unexamined Patent Application, Publication No. 2008-92979)

[0007] However, the evaluation device of the lower-limb muscle strength according to Japanese Unexamined Patent Application, Publication No. 2008-92979 evaluates the lower-limb muscle strength only.

[0008] JP 2006-051158 describes a method for measuring health indices of a subject by detecting the variation in a load on a step of the weight scale, calculating characteristic values of variation in the load in a prescribed period of time, and measuring the health indices of the subject based on the calculated characteristic values. The characteristic values of variation in the load are values corresponding to the area of a zone surrounded by a graph of the average of the load in the prescribed period of time and a graph of variation in the load.

[0009] GB 24 22 790 describes a method of obtaining a fitness index representing the ability of one's own muscles to move one's own mass. The measure is obtained by defining an initial position of the body from which the body is to be moved to a final position, causing the motion, such as standing up from a knees-bent position against gravity, by muscular effort, as quickly as possible, assessing the peak acceleration achieved during the motion; and recording and displaying this peak acceleration.

[0010] US 4,831,527 describes measuring the fat-to-lean ratio of tissue on a human subject with the subject standing on a platform, raising his or her heels, then allowing his or her weight to fall onto the board near a transducer to produce a force. A sensor transmits a voltage signal to an AID converter. The subject's stomach, buttocks, and other flesh will continue moving in a downward direction after the skeleton has stopped moving. This results in a downward force on the board which is registered as a data peak in a computer through the action of the sensor and the A/D converter. Tissue elasticity will cause the stomach and buttocks to then move upward, above their normal resting position. This will result in a lessening of the force and a corresponding minimum in the output wave, which is analyzed to result in an "excess pendulous fatty tissue index" which is indicated by humanly sensible readout display.

[0011] US 2008/059097 describes a digital scale which computes a weight value based on a predetermined scale interval, comprising data acquiring means, computation means, storage means, judging means, and scale interval switching means, wherein the data acquiring means acquires digital data of a load continuously, the computation means computes a predetermined number or a fluctuation range in a predetermined time of the acquired digital data, the storage means stores scale intervals set at multiple levels and allowable ranges of the fluctuation range that correspond to the scale intervals, the judging means determines the degree of variation of the digital data by comparing the computed fluctuation range with the allowable range of the fluctuation range which is stored for each scale interval, and the scale interval switching means switches the scale interval based on the determined degree of variation. The scale computes a body weight value based on a scale interval corresponding to the body motion of a subject in measurement of body weight.

[0012] US 7,163,516 describes a system for collecting patient screening data. The system includes a force measuring apparatus for measuring weight and for measuring balance forces, and a stimuli delivery apparatus for delivering first stimuli designed to evaluate visual acuity, for delivering second stimuli designed to evaluate hearing acuity, and for accepting patient responses to the first stimuli and the second stimuli. A processing unit is associated with and manages the operation of the force measuring apparatus and the stimuli delivery apparatus for collecting weight and balance force measurements from the force measuring apparatus and patient responses from the stimuli delivery apparatus.

[0013] US 2003/088197 describes an apparatus that acquires a value involving in a physical condition, such as a value relating to a body constitution, a value relating to a basic physical strength or a value relating to a motive ability, based on said value, specifies the physical information involving in the physical strength related phase of the daily-life disability, such as a value relating to the basic strength, a value relating to the motive ability, or a value relating to a daily-life disability, and outputs the specified information.

[0014] US 2006/179938 describes a leg strength measuring apparatus capable of measuring a gravity center distribution of loads and leg strength which in turn serves as a reference for the selection of a ski, a snowboard, ski boots, or snowboarding boots appropriate for a user of the apparatus. The leg strength measuring apparatus includes two footplates upon which a person steps separately with his left and right feet, and load sensors for detecting loads applied to each of the footplates at least at three points.

[0015] JP 2011-045480 describes a health measuring device for determining the fracture risk of the user. The risk of falling of a user is calculated based on a muscular amount level as a body composition component and a parameter as a gravity center trembling characteristic, in a falling risk determining part provided with a body composition component measuring part for calculating the body composition component of a user, and a gravity center trembling measuring part for measuring the gravity center trembling characteristic of a body, by a load sensor provided in a stepstool loaded with a foot of the user.

[0016] JP 2008-092979 describes a method for evaluating lower-limb muscular power, wherein the weight of the subject climbing on a pedestal is measured, and the muscular power of the lower limbs of the subject is measured based on the maximum peak or the peak appearing after the maximum peak and the minimum peak of the load on the pedestal when the subject changes the posture from the crouching posture to the standing posture on the pedestal. Then, the evaluation value of the lower-limb muscular power of the subject is computed based on the measured weight of the subject and the measured lower-limb muscular power of the subject.

SUMMARY OF THE INVENTION

[0017] It is an object of the present invention to provide a motor function evaluation device and a motor function evaluation method capable of evaluating a motor function of a subject comprehensively and easily.

[0018] The above and other objects are achieved by a motor function evaluation device and a motor function evaluation method as defined in independent claims 1 and 6. Further preferred embodiments are set forth in the dependent claims.

[0019] The present invention is made to achieve the object by the following means. It should be noted that, in order to facilitate understanding, the numerals corresponding to the embodiment of the present invention are added for explanation, but this is not restrictive. Components to be explained with the numerals may be modified as appropriate, and may be at least partially substituted by other components.

[0020] A first aspect of the present invention provides A motor function evaluation device (1) comprising a measurement base (11), a load measurement unit (14) configured to measure load change over time of a subject applied to the measurement base (11) and an arithmetic unit (24) configured to determine a balance ability indicator of the subject determined by the load change over time measured by the load measurement unit (14), wherein the load change over time has a damped free vibration-like motion of load value in which increase and decrease of the load value relative to a body weight are repeated after the load value shows a maximum value as a first peak in a standing up motion of the subject and then the load value is stabilized, the balance ability indicator is defined as a time period between a time of the first peak and a time of a stable point in the load change over time, wherein the time of the stable point is set, in the damped free vibration-like motion, as a time after a lapse of two cycles from the maximum value or a time where the load change over time has the same value as the body weight after the lapse of the two cycles from the maximum value.

[0021] A second aspect of the present invention provides the motor function evaluation device (1) of the first aspect of the present invention further including an impedance measurement unit (15) configured to determine a biological impedance of the subject on the measurement base (11) in which the motor function indicator includes a muscle strength indicator, a balance ability indicator, and a muscle mass indicator that is obtained by an arithmetic computation based on the biological impedance determined by the impedance measurement unit (15).

[0022] A third aspect of the present invention provides the motor function evaluation device (1) according to any one of the first to the second aspects of the present invention, in which the arithmetic unit (24) is configured to determine the muscle strength indicator and the balance ability indicator from variation of the load overtime measured by the load measurement unit (14) when the subject stands up from a chair onto the measurement base (11).

[0023] A further aspect of the present invention provides a motor function evaluation method comprising the steps of measuring load change over time of a subject applied to a measurement base (11), determining a balance ability indicator of the subject by an arithmetic computation based on the measured load change over time, wherein the load change over time has a damped free vibration-like motion of load value in which increase and decrease of the load value relative to a body weight are repeated after the load value shows a maximum value as a first peak in a standing up motion of the subject and then the load value is stabilized, the balance ability indicator is defined as a time period between a time of the first peak and a time of a stable point in the load change over time and wherein the time of the stable point is set, in the damped free vibration-like motion, as a time after a lapse of two cycles from the maximum value or a time where the load change over time has the same value as the body weight after the lapse of the two cycles from the maximum value.

[0024] The following effects can be obtained by the present invention.

[0025] According to the first aspect of the present invention, the motor function of the subject can be measured by an easy standing up motion, and therefore, risks of injuries due to falling and the like can be reduced especially when the subject is the elderly.

[0026] Further, the motor function evaluation can be made by the standing up motion, which can be performed conveniently and easily.

[0027] The motor function indicator is determined by the load change over time of the subject that is measured by the load measurement unit, which is objective as compared with the motor function evaluation by the questionnaire survey, the physical performance tests and the like. Further, the motor function evaluation can be made without using different kinds of equipment, time, space and the like.

[0028] Moreover, it is possible to choose an optimum time as the time until when the load variation is stabilized, as the stagger of the subject, who is standing up onto the load measurement unit, has the two cycles after when the load applied to the load measurement unit is maximized, in most cases. Thus, the motor function indicator can be determined accurately.

[0029] According to the second aspect of the present invention, the muscle mass indicator by the biological impedance can also be added to the comprehensive motor function evaluation.

[0030] According to the third aspect of the present invention, the motor function can be measured by the easy standing up motion from the measurement base. Therefore, the risks of injuries due to the falling and the like can be reduced especially when the subject is the elderly. Further, the motor function evaluation can be made comprehensively by the standing up motion from the measurement base, which can be performed conveniently and easily.

[0031] According to a further aspect of the present invention, the muscle strength indicator is determined from a value obtained by dividing a maximum value of the load that is measured by the load measurement unit by a body weight of the subject. The muscle strength indicator that is determined by a maximum value to body weight ratio F/Wt has higher accuracy than a muscle strength indicator that is determined by F/Wt obtained by dividing a difference ΔF between the maximum value and a minimum value by the body weight.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032]

Fig. 1 is a view showing the appearance of a motor function evaluation device according to an embodiment of the present invention;

Fig. 2 is a block diagram showing the inside of the motor function evaluation device;

Figs. 3 are views showing motions of a subject at the time of motor function evaluation;

Fig. 4 is a graph showing load variation in a time series, corresponding to the motions of the subject as shown in Figs. 3 ;

Fig. 5(a) is a graph showing a maximum increasing rate in a time series, and Fig. 5(b) is the same graph as Fig. 4 shown for comparison with Fig. 5(a) ;

Fig. 6 is the same graph as Fig. 4 , in which a maximum value, a stable value, and a time ST until a load is stabilized are described for valance ability measurement;

Figs. 7 are graphs explaining a stable point;

Fig. 8(a) is an example of displaying a deviation value relative to 50, and Fig. 8(b) is an example of displaying a motor function age;

Figs. 9 show other examples of displaying an overall motor function indicator MF that is determined as above, in which Fig. 9(a) shows ranking in the total, and Fig. 9(b) shows ranking by age; and

Figs. 10 show examples of modifications of displaying the overall motor function indicator MF.

EXPLANATION OF REFERENCE NUMERALS

[0033] 1: motor function evaluation device, 10: measurement unit, 11: measurement base, 12: load sensors, 13: electrodes, 14: load measurement circuit (load measurement unit), 15: impedance measurement circuit (impedance measurement unit), 20: display screen, 20: display unit, 21: display screen, 22: output port, 23: operating switches, 24: CPU (arithmetic unit, evaluation unit), 30: chair

DETAILED DESCRIPTION OF THE INVENTION

[0034] Hereinafter, a motor function evaluation device 1 according to an embodiment of the present invention will be explained with reference to the accompanying drawings. Fig. 1 is a view showing the appearance of the motor function evaluation device 1 according to the embodiment of the present invention. Fig. 2 is a block diagram showing the inside of the motor function evaluation device 1.

[0035] As shown in Fig. 1, the motor function evaluation device 1 includes a measurement unit 10 and a display unit 20.

[0036] The measurement unit 10 has a horizontal measurement base 11 to be stepped on by a subject. As shown in Fig. 2, the measurement unit 10 includes in its inside load sensors 12 for performing load measurement, electrodes 13 (13a and 13b) for performing biological impedance measurement, a load measurement circuit 14, and an impedance measurement circuit 15.

[0037] Each of the load sensors 12 is formed by a load cell or the like, and is arranged at four corners of the rectangular measurement base 11.

[0038] Although detailed illustration is omitted, each of the load sensors 12 includes a strain body that is deformed in response to an inputted load, and a strain gage that is pasted onto the strain body and outputs an electric signal (detection signal) having a value corresponding to the deformation of the strain body. It is preferable to provide three or more load sensors 12 in order to perform gravity center fluctuation measurement, and four load sensors 12 are contained according to this embodiment.

[0039] Each of the load sensors 12 generates and outputs the detection signal corresponding to the load acting perpendicularly on an area where the load sensor 12 is provided.

[0040] The respective load sensors 12 are connected to the load measurement circuit 14. When the subject steps onto the measurement base 11 of the measurement unit 10, the load applied to the measurement base 11 is detected by the respective load sensors 12. The respective load sensors 12 output the detection signals corresponding to the load to the load measurement circuit 14. Based on the detection signals outputted from the respective load sensors 12, the load measurement circuit 14 recognizes load values detected by the respective load sensors 12.

[0041] The four electrodes 13, each having a thin-plate shape, are arranged on the measurement base 11 with spaces therebetween. According to this embodiment, two electrodes 13a out of the four electrodes 13 are current-carrying electrodes, and the remaining two electrodes 13b are measuring electrodes.

[0042] The impedance measurement circuit 15 is able to supply a predetermined weak electrical current to the current-carrying electrodes 13a, and to measure a voltage across the measuring electrodes 13b. Based on current values applied by the current-carrying electrodes 13a and a voltage value measured across the measuring electrodes 13b, the impedance measurement circuit 15 is able to calculate a biological impedance of a person to be measured. Based on measurement results of the biological impedance of the subject, biological information such as body fat is derived.

[0043] The display unit 20 is connected to the measurement unit 10 via a cable, as shown in the drawing. However, this is not restrictive, and the display unit 20 may be attached to the top of a post that is attached onto the measurement unit 10, or the display unit and the measurement unit may be connected wirelessly, or may be formed integrally.

[0044] The display unit 20 includes a display screen 21 that displays the measurement results, a plurality of operating switches 23, an output port 22, and a CPU 24. Power is supplied to the display unit 20 from an external power supply 26.

[0045] The CPU 24 is a control device that performs centralized control of the motor function evaluation device 1. The operating switches 23 and the display screen 21 are connected to the CPU 24. Further, the CPU 24 is connected to the load measurement circuit 14 and the impedance measurement circuit 15 in the measurement unit 10 via cables 25.

[0046] The CPU 24 performs motor function evaluation based on an output from the load measurement circuit 14, an output from the impedance measurement circuit 15, other information of the subject inputted via the operating switches

23 and the like, as will be described later.

[0047] The operating switches 23 are the switches used for turning on/off the motor function evaluation device 1, inputting the information of the subject, inputting start of the measurement, and the like.

[0048] The display screen 21 displays a command and data that are inputted by the operation of the subject, and overall motor function evaluation.

[0049] The output port 22 is able to transmit data and the like to an external PC, as shown in Fig. 1.

(Overall flow of motor function evaluation)

[0050] Next, the motor function evaluation in the motor function evaluation device 1 will be explained.

[0051] Figs. 3 are views showing motions of a subject A at the time of the motor function evaluation. Fig. 4 is a graph showing load variation in a time series in the motor function evaluation device 1, corresponding to the motions of the subject A as shown in Figs. 3. The motions of the subject A during the measurement, as shown in Figs. 3, are shown under the graph of Fig. 4, in order to facilitate understanding.

[0052] As shown in Figs. 3, when performing the motor function evaluation in the motor function evaluation device 1, a chair 30 is first arranged next to the motor function evaluation device 1. The subject A sits down on the chair 30 while putting his or her feet on the measurement base 11 of the measurement unit 10 of the motor function evaluation device 1, as shown in Fig. 3(a). Next, the subject A, who is sitting on the chair 30, stands up onto the motor function evaluation device 1, as shown in Fig. 3(b). Then, the subject A waits until his or her body stops staggering and is stabilized, as shown in Fig. 3(c).

[0053] During the above-described standing up motion of the subject A, the load measurement circuit 14 determines the load variation associated with the standing up motion of the subject A based on the detection signals from the load sensors 12, and outputs the load variation to the CPU 24.

[0054] Further, the electrodes 13 apply the weak electrical current to the subject A, and the impedance measurement circuit 15 measures the voltage across the electrodes 13a and 13b to determine the biological impedance of a living body, and outputs the biological impedance to the CPU 24.

[0055] When the subject A, who is sitting on the chair 30 while putting his or her feet on the measurement base 11, stands up, as shown in Fig. 4, the load is lightened at a position P in an early stage after the motion is started, and thereafter, a maximum load is recorded at a position Max. This is because the load is first shifted to the chair and buttocks, when the subject A tries to stand up from the chair.

[0056] After the position Max where a maximum load F is recorded, the load is reduced to be smaller than an actual body weight Wt of the subject A and a minimum load is recorded at a position Min that is smaller than the actual body weight Wt. Thereafter, the load goes up and down while its amplitude being damped, and the load is converged to the actual body weight Wt.

[0057] Based on the load variation and the measured biological impedance, the motor function evaluation device 1 is able to evaluate the motor function of the subject A including (1) muscle strength, (2) balance ability, and (3) muscle mass, as will be explained in detail later.

[0058] Incidentally, according to this embodiment, the motor function is evaluated based on the load variation by the standing up motion of the subject A who is sitting on the chair 30. However, this is not restrictive, and the subject A may stand up from a crouching state, without sitting on the chair 30.

[0059] It should be noted that, however, a heavy physical burden may be imposed on the subject A at the time of standing up from the crouching state, when the subject A is the elderly or has weak muscle strength. The burden is not so heavy when the subject A stands up from the chair 30, as described in this embodiment.

[0060] Further, the chair 30 is arranged next to the measurement unit 10 according to this embodiment. However, this is not restrictive, and the chair 30 may be arranged on the measurement unit 10 when there is enough space.

[0061] Hereinafter, the above-described (1) muscle strength, (2) balance ability, and (3) muscle mass will be explained for each in detail.

(1) Muscle strength

(1-1) Example of muscle strength evaluation

[0062] The CPU 24 determines the maximum value F of the load from the measurement data of the load shown in Fig. 4 that is based on the load values transmitted from the load measurement circuit 14, and performs an arithmetic computation of a maximum value to body weight ratio F/Wt which is division of the maximum value F of the load by the actual body weight Wt of the subject. This F/Wt becomes an indicator of the muscle strength.

[0063] According to this embodiment, the muscle strength indicator is thus determined by the CPU 24 from the maximum value to body weight ratio F/Wt. However, this is not restrictive, and the muscle strength indicator may be defined as

ΔF/Wt which is division of a difference ΔF between the maximum value F of the load and a minimum value of the load by the body weight Wt.

[0064] It should be noted that, however, the muscle strength indicator determined from the maximum value to body weight ratio F/Wt, as in this embodiment, has higher accuracy than the muscle strength indicator determined from ΔF/Wt.

[0065] This is because the difference ΔF between the maximum value F of the load and the minimum value of the load has low reliability and hence the ΔF/Wt also has low reliability, as it may be hard in the actual measurement to identify a point Min showing the minimum value, which is clearly shown in Fig. 4, when, for example, the subject A has the weak muscle strength.

[0066] Here, the point Max at which the load value shows the maximum value corresponds to the timing when the buttocks of the subject A get off the chair 30. It may also be hard to identify the maximum point Max in the actual measurement. Therefore, in this embodiment, a point having the maximum value, out of points at which the load equal to or greater than 105% of the body weight is recorded, after the detection of a point P at which the load fall to 20% or less of the body weight, is defined as the maximum point Max.

[0067] In the standing up motion from the state of sitting on the chair 30, the load is lightened in the early stage after the motion is started, and the maximum value is recorded after that. This is because the body weight is first shifted to the chair 30 and the buttocks when the subject A tries to stand up from the chair 30. Triggered by this, the maximum load point is detected.

[0068] Incidentally, the point P at which the load fall to 20% or less of the body weight may be a point at which the load is reduced by 30% (numerical value may be freely selected) of the body weight.

[0069] By identifying the maximum value by such a method using characteristics of the standing up motion of the subject A, it is possible to detect the maximum value point without fail.

(1-2) Modification of muscle strength evaluation

[0070] The muscle strength indicator is not limited to the above-described maximum value to body weight ratio F/Wt, and a maximum increasing rate to body weight ratio (load change amount) RFD/Wt may be employed.

[0071] Fig. 5(a) is a graph showing the maximum increasing rate of the load in a time series. The same graph as Fig. 4 is shown as Fig. 5(b) for comparison to Fig. 5(a) in order to facilitate understanding. The maximum increasing rate RFD corresponds to inclination of a part having the steepest inclination in Fig. 5(a).

[0072] Thus, the maximum increasing rate to body weight ratio RFD/Wt can also be employed as the muscle strength indicator.

(2) Balance ability

(2-1) Example of balance ability evaluation

[0073] Fig. 6 is the same graph as Fig. 4, in which the maximum value of the load, a stable value, and a time ST until the load is stabilized are described, in order to explain balance ability evaluation.

[0074] According to the balance ability evaluation, the time ST from the point Max at which the load shows the maximum value until a point S at which the load is stabilized is measured, and the time ST is defined as a balance ability indicator.

[0075] When the subject A can stand up from the chair immediately, the ST becomes shorter. Meanwhile, when the subject A lacks horizontal balance, for example, the ST becomes longer.

[0076] By using the ST like this, it is possible to evaluate the balance during the standing up motion (under the load) in a natural motion.

[0077] In this embodiment, the time ST from the point Max at which the load shows the maximum value until the point S at which the load is stabilized is defined as the balance ability indicator. This is because the point Max showing the maximum value can be found more easily as compared with other points. However, this is not restrictive, and a time from when the load starts to rise until the point S at which the load is stabilized may be defined as the balance ability indicator.

[0078] Further, the point S at which the load is stabilized corresponds to the timing when the subject S is stabilized in a standing position, and when the load is near the body weight value.

[0079] Incidentally, the subject A may be regarded as being stabilized after the standing up motion on condition that the "variation in the load values falls within a certain range". However, when the subject A is the elderly, for example, and experiences a large stagger after standing up, a longer time is required before he or she is stabilized.

[0080] Therefore, in this embodiment, a point at which the load passes through the body weight value for the fourth time after the maximum value is detected is defined as a stable point. Figs. 7 are views explaining such stable point S.

[0081] After standing up, a "stagger due to the standing up motion (quickness)" is followed by a "stagger in the standing state (gravity center fluctuation)". Therefore, the above two sections need to be divided in order to evaluate the balance in the standing up motion.

[0082] After the maximum value is detected (point Max) in the standing up motion, the load values of the load sensors 12 rebound to become smaller than the body weight. Thereafter, the load increases and decreases relative to the body weight Wt of the subject repeatedly for several times, before it is stabilized. That is, in the standing up motion, the load value after passing the maximum value shows a damped free vibration-like motion.

[0083] The staggers in the actual standing up motion include two cycles in most cases, as shown in Fig. 7(b). Even in exceptional cases, the staggers include one or more, up to three, cycles.

[0084] Therefore, a time from when the maximum value of the "stagger due to the standing up motion (quickness)" is detected (point Max) until the point S at which the load is stabilized after the two cycles is defined as a stabilizing time ST. The following load increase and decrease relative to the body weight are defined as the "stagger in the standing state". Thus, the "stagger due to the standing up motion (quickness)" is separated from the "stagger in the standing state (gravity center fluctuation)".

[0085] The point S at which the load is stabilized after the two cycles is illustrated as the point S after a lapse of the two cycles from the maximum value. However, this is not restrictive, and a point S' that has the same value as the body weight after the lapse of the two cycles may be employed.

(2-2) Modification of balance ability evaluation

[0086] In this embodiment, the ST value is defined as the balance ability indicator as explained above. However, according to other examples which are not part of the claimed invention, a locus length per time unit (L/T) as one of gravity center fluctuation indicators may be measured and employed as the balance ability indicator.

[0087] In this case, after the muscle strength is measured, the gravity center fluctuation measurement is performed after the stable point S (after being stabilized) to measure the locus length per time unit (L/T). Specifically, after the standing up motion, the gravity center fluctuation measurement is performed for a fixed period of time from the point S at which the load is stabilized, to determine a locus of the center of gravity. Then, a locus length is calculated and divided by the time, so as to obtain the locus length per time unit. The locus length per time unit is measured and calculated similarly to the general gravity center fluctuation measurement. Other gravity center fluctuation indicators, such as an area of the center of gravity (environmental, rectangular, and root mean square value) and horizontal balance, may be employed, instead of the locus length per time unit.

(3) Muscle mass

(3-1) Example of muscle mass evaluation

[0088] After the gravity center fluctuation measurement, the motor function evaluation device 1 applies the electrical current to the electrodes 13, detects the voltage value across the electrodes by the impedance measurement circuit 15, and performs the arithmetic computation of the biological impedance value by the CPU 24, so as to determine leg muscle mass Lm.

[0089] According to this embodiment, the CPU 24 determines the leg muscle mass Lm according to the following expression.

$$Lm = a_1 \times \text{leg imp}/Ht^2 + b_1 \quad \text{Expression (1)}$$

[0090] Incidentally, the leg muscle mass Lm may be determined according to the following expressions (2) and (3), instead of the expression .(1).

$$Lm = \text{whole body muscle mass} - \text{arm muscle mass} - \text{trunk muscle mass} \quad \text{Expression (2)}$$

$$Lm = c_1 \times \text{whole body imp}/Ht^2 - d_1 \times \text{arm imp}/Ht^2 - e_1 \times \text{trunk imp}/Ht^2 + f_1 \quad \text{Expression (3)}$$

[0091] In the above-described expressions (1) to (3),

Lm is the leg muscle mass,
imp is the biological impedance,
Ht is the height (or may be the length of the respective regions), and
a_1, b_1, c_1, d_1, e_1, and f_1 are coefficients.

(Modification of muscle mass evaluation)

[0092] In addition, "leg muscle mass/body weight" or "leg muscle mass/height^2" may be employed as an indicator for the muscle mass. Further, the muscle mass of the whole body and limbs may be employed, and the muscle mass may be standardized by the height or the body weight.

(4) Calculation of overall motor function indicator

(4-1) Example of calculation of overall motor function indicator

[0093] Weights are assigned to the three indicators determined earlier by weighting factors a_2, b_2 and c_2 that are determined by multiple regression analysis, so as to calculate an overall motor function indicator MF based on the following expression.

$$MF = a_2 \times F/Wt + b_2 \times ST + c_2 \times Lm + d_2 \quad \text{Expression (4)}$$

Where, MF is the motor function indicator,
F/Wt is the maximum value to body weight ratio (muscle strength indicator),
ST is the stabilizing time (balance indicator),
Lm is the leg muscle mass (muscle mass indicator), and
a_2, b_2, c_2 and d_2 are coefficients.

(Example of display)

[0094] Figs. 8 show examples of displaying the overall motor function indicator MF that is determined as described above. Fig. 8(a) is an example of displaying the overall motor function indicator MF according to a deviation value relative to 50, and Fig. 8(b) is an example of expressing the overall motor function indicator MF according to a motor function age.

[0095] Figs. 9 show other examples of displaying the overall motor function indicator MF that is determined as described above, and show comparison with others, that is, ranking of the obtained overall motor function indicator MF. Ranking obtained by the comparison with data measured by using the same device in the past, ranking among the persons to be measured of his or her age, or the like is displayed as the ranking. Fig. 9(a) shows the ranking in the total, and Fig. 9(b) shows the ranking by age.

[0096] By displaying the results with the ranking in this way, such effects can be expected as to notify the results in an easier to understand manner and to increase motivation to improve and maintain the motor function.

(Modification of display)

[0097] Instead of displaying the determined overall motor function indicator MF as above, the respective indicators may be displayed separately. Further, from the measurement results, advice on weak points, how to exercise in order to overcome the weak points and the like may be displayed.

[0098] Figs. 10 show examples of modifications of displaying the overall motor function indicator MF. When, for example, all of the muscle strength, the muscle mass, and the balance are higher than average values, as shown in Fig. 10(a), such comments as "You have high muscle strength, relatively large amount of muscle mass, and nice balance. Risk of falling is low. Exercise appropriately to keep this state." may be displayed.

[0099] Further, when the muscle mass is above average but the muscle strength and the balance are lower than the average values, as shown in Fig. 10(b), such comments as "You have relatively large amount of muscle mass, but low muscle strength and slightly unfavorable balance. There is risk of falling. Daily exercise to improve muscle strength is recommended." may be displayed.

(4-2) Modification of calculation of overall motor function indicator

[0100] According to the above-described explanation, the overall motor function indicator MF is calculated from the three indicators of the muscle strength, the balance, and the muscle mass. However, this is not restrictive, and two indicators may be used, out of the three indicators of the muscle strength, the balance, and the muscle mass, to calculate the MF.

[0101] Further, the height, body weight, gender, age and the like may be added as variables, in addition to the three indicators of the muscle strength, the balance, and the muscle mass, to calculate the overall motor function indicator MF.

[0102] Further, the example of displaying the three indicators of the muscle strength, the balance, and the muscle mass in the graph is shown in Figs. 10, but this is not restrictive. Stamina, agility, and flexibility that are measured separately may be inputted in advance via the operating switches 23 in Fig. 2, and evaluation values of the stamina, the agility, and the flexibility may be displayed together with the three indicators of the muscle strength, the balance, and the muscle mass that are measured by the motor function evaluation device 1 of this embodiment, so as to display further detailed advice. In this case, the graph becomes a radar chart having a rectangular shape to a hexagonal shape. By inputting a medical history, experiences of the falling, and status on daily activities in advance, more accurate advice can be given by taking them into consideration.

[0103] According to this embodiment, the muscle strength, the balance, and the muscle mass are determined from the measured load change and biological impedance in a time series by the CPU 24. However, the present invention is not limited thereto, and the measured load change and biological impedance in a time series may be outputted from the output port 22 to the external PC, and final calculation may be performed in the PC.

[0104] As described thus far, quantitative motor function evaluation can be made according to this embodiment.

[0105] The overall motor function indicator MF calculated in the present invention is the result of the measurement by the measuring device, which does not have a qualitative element such as comprehensive judgment of the survey and the results of the respective physical performance tests. Therefore, the overall motor function indicator MF is objective and has high reproducibility and reliability.

[0106] Further, as the indicator itself is determined in a comprehensive manner by at least two of the muscle strength, the balance ability, and the muscle mass, the reliability is higher than the case where the evaluation is made with one indicator.

[0107] Further, according to this embodiment, the evaluation of the overall motor function can be made simply, without performing the survey, the respective physical performance tests and the like. Further, as the evaluation can be made with one measuring device, it is possible to realize time saving, space saving, cost reduction and the like.

[0108] According to the measurement of the present invention, the subject stands still after the standing up motion from the chair, and keeps the standing position for several tens of seconds. This is one of the daily activities and can be performed with ease and within a short period of time. For this reason, opportunities of the measurement can be provided to various kinds of people and the measurement can be made with high frequency, which makes it possible to capture changes over time, that is the most important thing.

Claims

1. A motor function evaluation device (1) comprising:

a measurement base (11);
a load measurement unit (14) configured to measure load change over time of a subject applied to the measurement base (11); and
an arithmetic unit (24) configured to determine a balance ability indicator of the subject determined by the load change over time measured by the load measurement unit (14),
wherein the load change over time has a damped free vibration-like motion of load value in which increase and decrease of the load value relative to a body weight are repeated after the load value shows a maximum value as a first peak in a standing up motion of the subject and then the load value is stabilized,
characterized in that
the balance ability indicator is defined as a time period between a time of the first peak and a time of a stable point in the load change over time,
wherein the time of the stable point is set, in the damped free vibration-like motion, as a time after a lapse of two cycles from the maximum value or a time where the load change over time has the same value as the body weight after the lapse of the two cycles from the maximum value.

2. The motor function evaluation device (1) according to claim 1, further comprising

an impedance measurement unit (15) configured to determine a biological impedance of the subject on the measurement base (11),
wherein the arithmetic unit (24) is configured to determine a muscle strength indicator, the balance ability indicator, and a muscle mass indicator that is obtained by an arithmetic computation based on the biological impedance determined by the impedance measurement unit (15).

3. The motor function evaluation device (1) according to claim 2,
wherein the arithmetic unit (24) is configured to determine the muscle strength indicator and the balance ability indicator by variation of the load over time measured by the load measurement unit (14) when the subject stands up from a chair onto the measurement base (11).

4. The motor function evaluation device (1) according to claim 2 or 3,
wherein the arithmetic unit (24) is configured to determine the muscle strength indicator from a value that is obtained by dividing a maximum value of the load measured by the load measurement unit (14) by the body weight of the subject.

5. The motor function evaluation device (1) according to any one of claims 1 to 4,
wherein the arithmetic unit (24) is configured to cause a display to display the balance ability indicator of the subject.

6. A motor function evaluation method comprising the steps of:

measuring load change over time of a subject applied to a measurement base (11);
determining a balance ability indicator of the subject by an arithmetic computation based on the measured load change over time,
wherein the load change over time has a damped free vibration-like motion of load value in which increase and decrease of the load value relative to a body weight are repeated after the load value shows a maximum value as a first peak in a standing up motion of the subject and then the load value is stabilized,
characterized in that
the balance ability indicator is defined as a time period between a time of the first peak and a time of a stable point in the load change over time,
wherein the time of the stable point is set, in the damped free vibration-like motion, as a time after a lapse of two cycles from the maximum value or a time where the load change over time has the same value as the body weight after the lapse of the two cycles from the maximum value.

Patentansprüche

1. Motorikbewertungsvorrichtung (1), umfassend:

eine Messbasis (11);
eine Lastmesseinheit (14), die ausgestaltet ist, eine zeitliche Laständerung einer Person, die auf die Messbasis (11) angewendet wird, zu messen; und
ein Rechenwerk (24), das ausgestaltet ist, einen Gleichgewichtsfähigkeitsindikator der Person zu bestimmen, der durch die zeitliche Laständerung bestimmt wird, die durch die Lastmesseinheit (14) gemessen wird,
wobei die zeitliche Laständerung eine gedämpfte freie schwingungsartige Bewegung des Lastwerts aufweist, bei der die Zunahme und Abnahme des Lastwerts in Bezug auf ein Körpergewicht wiederholt werden, nachdem der Lastwert einen Höchstwert als eine erste Spitze in einer Aufstehbewegung der Person zeigt, und dann wird der Lastwert stabilisiert,
dadurch gekennzeichnet, dass
der Gleichgewichtsfähigkeitsindikator als eine Zeitspanne zwischen einem Zeitpunkt der ersten Spitze und einem Zeitpunkt eines Stabilisierungspunkts bei der zeitlichen Laständerung definiert ist,
wobei der Zeitpunkt des Stabilisierungspunkts in der gedämpften freien schwingungsartigen Bewegung als ein Zeitpunkt nach einem Ablauf von zwei Zyklen ab dem Höchstwert oder als ein Zeitpunkt, bei dem die zeitliche Laständerung denselben Wert wie das Körpergewicht nach dem Ablauf der zwei Zyklen ab dem Höchstwert aufweist, festgesetzt ist.

2. Motorikbewertungsvorrichtung (1) nach Anspruch 1, überdies umfassend:

eine Widerstandsmesseinheit (15), die ausgestaltet ist, einen biologischen Widerstand der Person auf der Messbasis (11) zu bestimmen,
wobei das Rechenwerk (24) ausgestaltet ist, einen Muskelstärkeindikator, den Gleichgewichtsfähigkeitsindikator und einen Muskelmasseindikator zu bestimmen, der durch eine arithmetische Berechnung erhalten wird, basierend auf dem biologischen Widerstand, der durch die Widerstandsmesseinheit (15) bestimmt wird.

3. Motorikbewertungsvorrichtung (1) nach Anspruch 2,
wobei das Rechenwerk (24) ausgestaltet ist, den Muskelstärkeindikator und den Gleichgewichtsfähigkeitsindikator durch das zeitliche Variieren der Last zu bestimmen, das durch die Lastmesseinheit (14) gemessen wird, wenn die Person von einem Stuhl auf die Messbasis (11) aufsteht.

4. Motorikbewertungsvorrichtung (1) nach Anspruch 2 oder 3,
wobei das Rechenwerk (24) ausgestaltet ist, den Muskelstärkeindikator durch einen Wert zu bestimmen, der mittels Dividierens eines Höchstwerts der durch die Lastmesseinheit (14) gemessenen Last durch das Körpergewicht der Person erhalten wird.

5. Motorikbewertungsvorrichtung (1) nach einem der Ansprüche 1 bis 4,
wobei das Rechenwerk (24) ausgestaltet ist, eine Anzeige zu veranlassen, den Gleichgewichtsfähigkeitsindikator der Person anzuzeigen.

6. Motorikbewertungsverfahren, umfassend folgende Schritte:

Messen einer zeitlichen Laständerung einer Person, die auf eine Messbasis (11) angewendet wird;
Bestimmen eines Gleichgewichtsfähigkeitsindikators der Person durch eine arithmetische Berechnung basierend auf der gemessenen zeitlichen Laständerung,
wobei die zeitliche Laständerung eine gedämpfte freie schwingungsartige Bewegung des Lastwerts aufweist, bei der die Zunahme und Abnahme des Lastwerts in Bezug auf ein Körpergewicht wiederholt werden, nachdem der Lastwert einen Höchstwert als eine erste Spitze in einer Aufstehbewegung der Person zeigt, und dann wird der Lastwert stabilisiert,
dadurch gekennzeichnet, dass
der Gleichgewichtsfähigkeitsindikator als eine Zeitspanne zwischen einem Zeitpunkt der ersten Spitze und einem Zeitpunkt eines Stabilisierungspunkts bei der zeitlichen Laständerung definiert ist,
wobei der Zeitpunkt des Stabilisierungspunkts in der gedämpften freien schwingungsartigen Bewegung als ein Zeitpunkt nach einem Ablauf von zwei Zyklen ab dem Höchstwert oder als ein Zeitpunkt, bei dem die zeitliche Laständerung denselben Wert wie das Körpergewicht nach dem Ablauf der zwei Zyklen ab dem Höchstwert aufweist, festgesetzt ist.

Revendications

1. Dispositif d’évaluation de la fonction de moteur (1) comportant :

une base de mesure (11) ;
une unité de mesure de charge (14) configurée pour mesurer un changement de charge au fil du temps d’un sujet appliqué à la base de mesure (11) ; et
une unité arithmétique (24) configurée pour déterminer un indicateur de capacité d’équilibre du sujet déterminé par le changement de charge au fil du temps mesuré par l’unité de mesure de charge (14),
dans lequel le changement de charge au fil du temps a un mouvement de type vibratoire libre amorti de valeur de charge dans lequel l’augmentation et la diminution de la valeur de charge par rapport à un poids du corps sont répétées après que la valeur de charge montre une valeur maximum en tant que premier pic dans un mouvement de levée du sujet, puis la valeur de charge est stabilisée,
caractérisé en ce que
l’indicateur de capacité d’équilibre est défini en tant que période entre un temps du premier pic et un temps d’un point stable dans le changement de charge au fil du temps,
dans lequel le temps du point stable est défini, dans le mouvement de type vibratoire libre amorti, en tant que temps après un écoulement de deux cycles à partir de la valeur maximum ou en tant que temps lorsque le changement de charge au fil du temps a la même valeur que le poids du corps après l’écoulement des deux cycles à partir de la valeur maximum.

2. Dispositif d'évaluation de la fonction de moteur (1) selon la revendication 1, comportant en outre une unité de mesure d'impédance (15) configurée pour déterminer une impédance biologique du sujet sur la base de mesure (11), dans lequel l'unité arithmétique (24) est configurée pour déterminer un indicateur de force musculaire, l'indicateur de capacité d'équilibre et un indicateur de masse musculaire qui est obtenu par un calcul arithmétique basé sur l'impédance biologique déterminée par l'unité de mesure d'impédance (15).

3. Dispositif d'évaluation de la fonction de moteur (1) selon la revendication 2, dans lequel l'unité arithmétique (24) est configurée pour déterminer l'indicateur de force musculaire et l'indicateur de capacité d'équilibre par variation de la charge au fil du temps mesurée par l'unité de mesure de charge (14) lorsque le sujet se lève d'une chaise sur la base de mesure (11).

4. Dispositif d'évaluation de la fonction de moteur (1) selon la revendication 2 ou 3, dans lequel l'unité arithmétique (24) est configurée pour déterminer l'indicateur de force musculaire à partir d'une valeur qui est obtenue par division d'une valeur maximum de la charge mesurée par l'unité de mesure de charge (14) par le poids du corps du sujet.

5. Dispositif d'évaluation de la fonction de moteur (1) selon l'une quelconque des revendications 1 à 4, dans lequel l'unité arithmétique (24) est configurée pour amener un affichage à afficher l'indicateur de capacité d'équilibre du sujet.

6. Dispositif d'évaluation de la fonction de moteur (1) comportant les étapes de :

mesure d'un changement de charge au fil du temps d'un sujet appliqué à une base de mesure (11) ;
détermination d'un indicateur de capacité d'équilibre du sujet par un calcul arithmétique basé sur le changement de charge mesuré au fil du temps,
dans lequel le changement de charge au fil du temps a un mouvement de type vibratoire libre amorti de valeur de charge dans lequel l'augmentation et la diminution de la valeur de charge par rapport à un poids du corps sont répétées après que la valeur de charge montre une valeur maximum en tant que premier pic dans un mouvement de levée du sujet, puis la valeur de charge est stabilisée,
caractérisé en ce que
l'indicateur de capacité d'équilibre est défini en tant que période entre un temps du premier pic et un temps d'un point stable dans le changement de charge au fil du temps,
dans lequel le temps du point stable est défini, dans le mouvement de type vibratoire libre amorti, en tant que temps après un écoulement de deux cycles à partir de la valeur maximum ou en tant que temps lorsque le changement de charge au fil du temps a la même valeur que le poids du corps après l'écoulement des deux cycles à partir de la valeur maximum.

FIG. 1

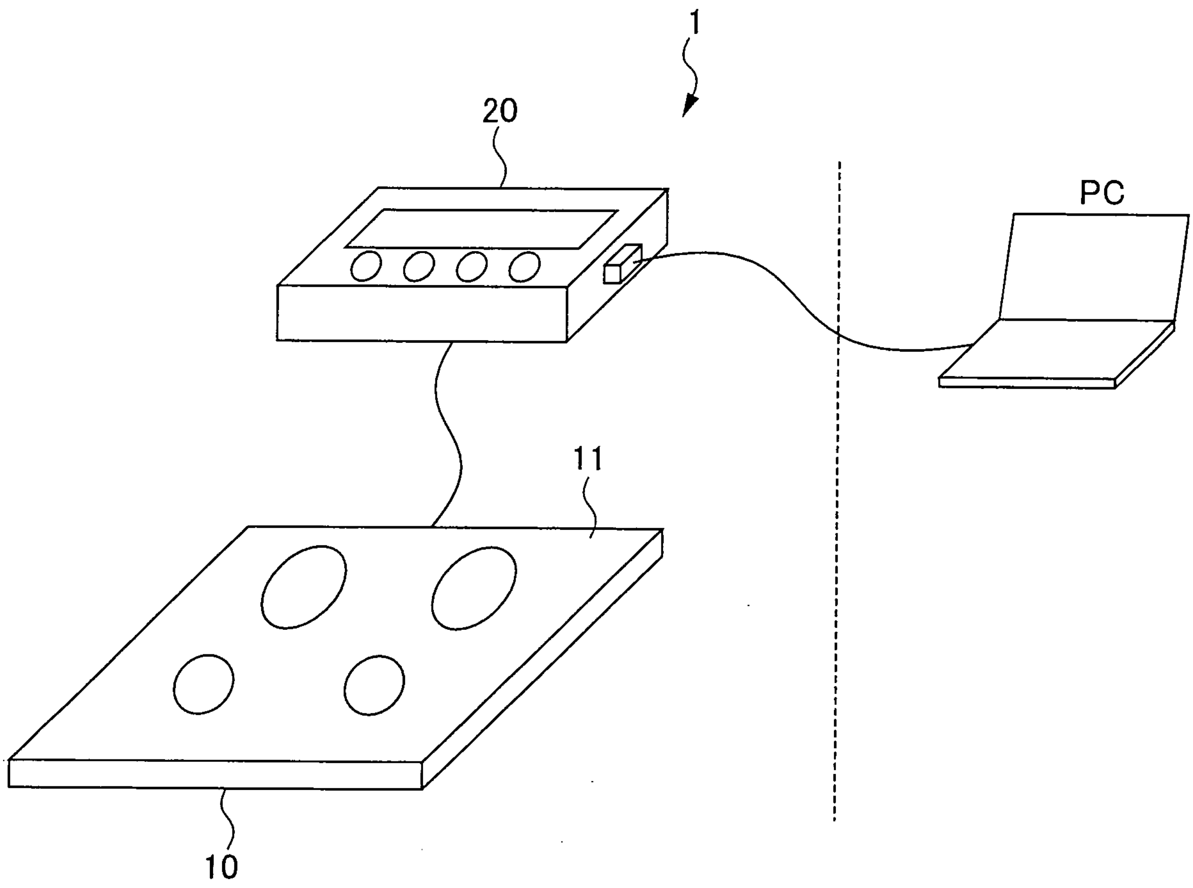


FIG. 2

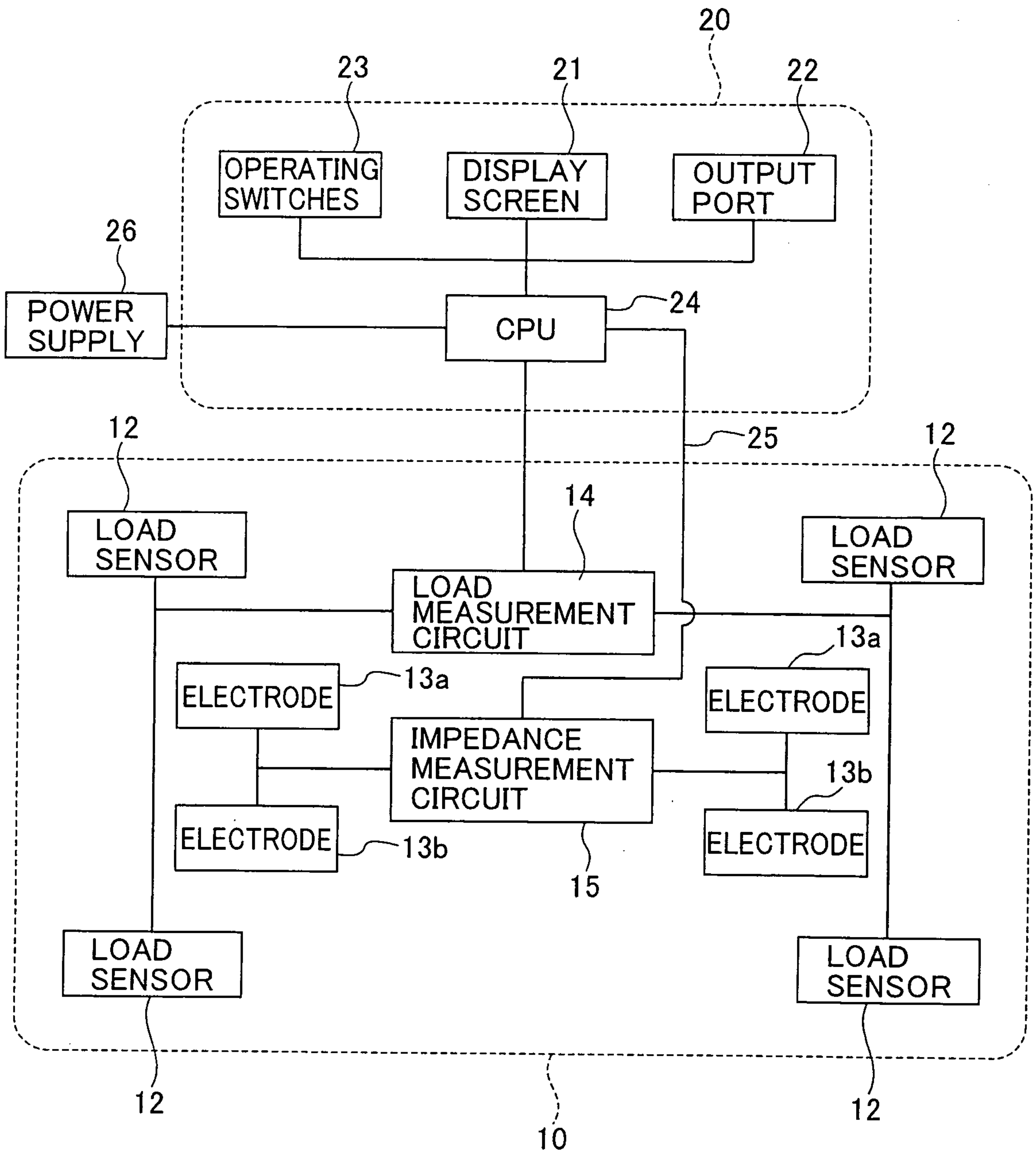

20
23
21
22
OPERATING SWITCHES
DISPLAY SCREEN
OUTPUT PORT
26
POWER SUPPLY
CPU
24
25
12
12
LOAD SENSOR
14
LOAD SENSOR
LOAD MEASUREMENT CIRCUIT
13a
ELECTRODE
13a
ELECTRODE
IMPEDANCE MEASUREMENT CIRCUIT
13b
ELECTRODE
13b
ELECTRODE
15
LOAD SENSOR
LOAD SENSOR
12
12
10

FIG. 3A

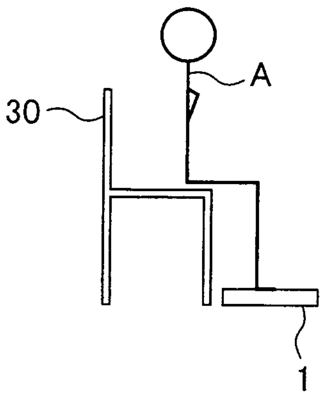


FIG. 3B

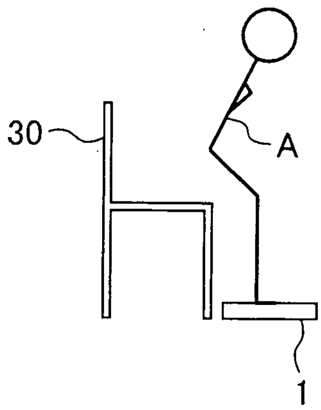


FIG. 3C

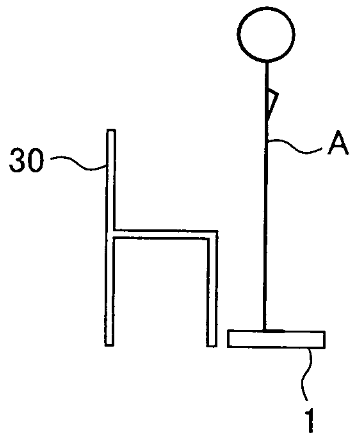


FIG. 4

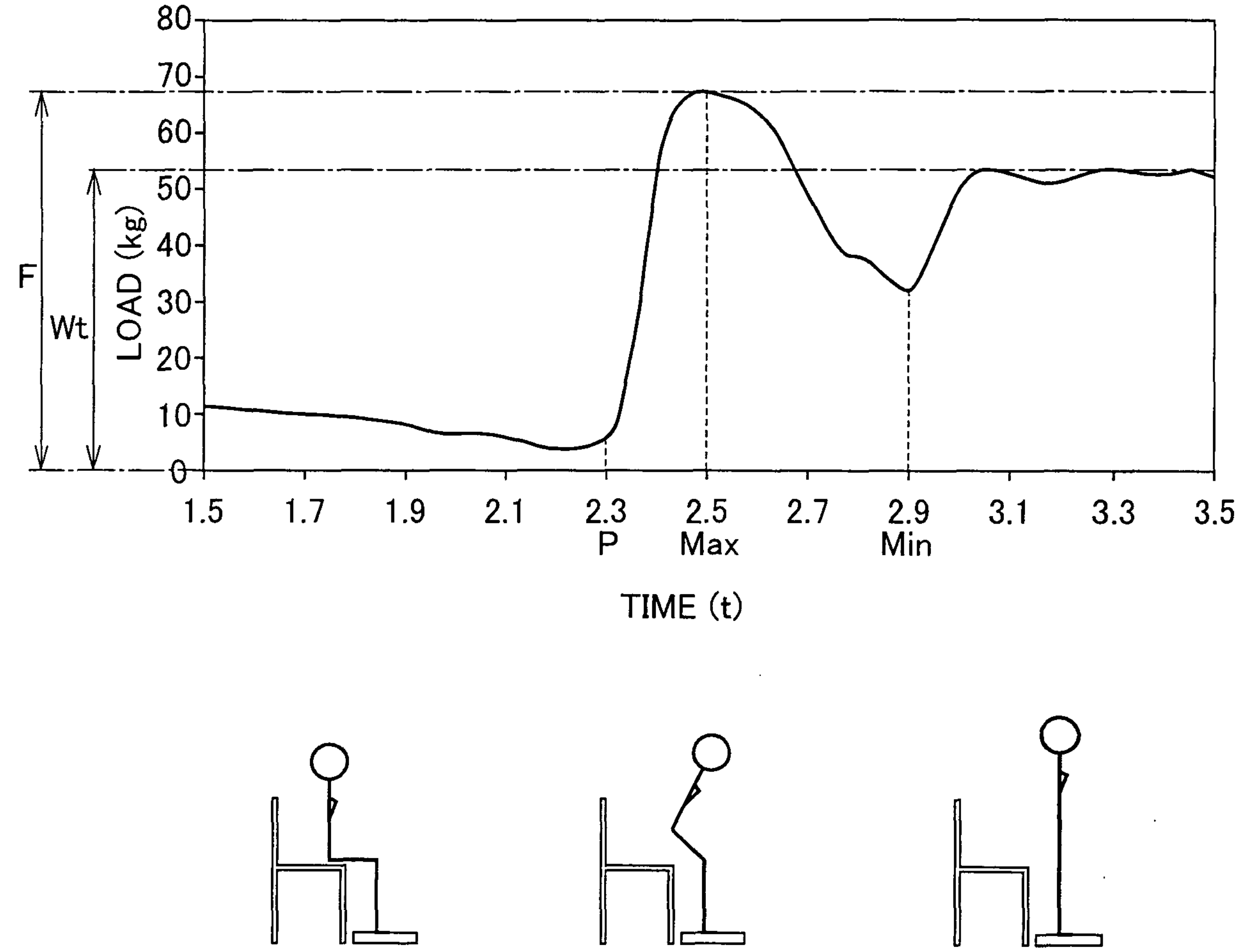

80
70
60
50
40
30
20
10
0
LOAD (kg)
F
Wt
1.5
1.7
1.9
2.1
2.3
P
2.5
Max
2.7
2.9
Min
3.1
3.3
3.5
TIME (t)

FIG. 5A

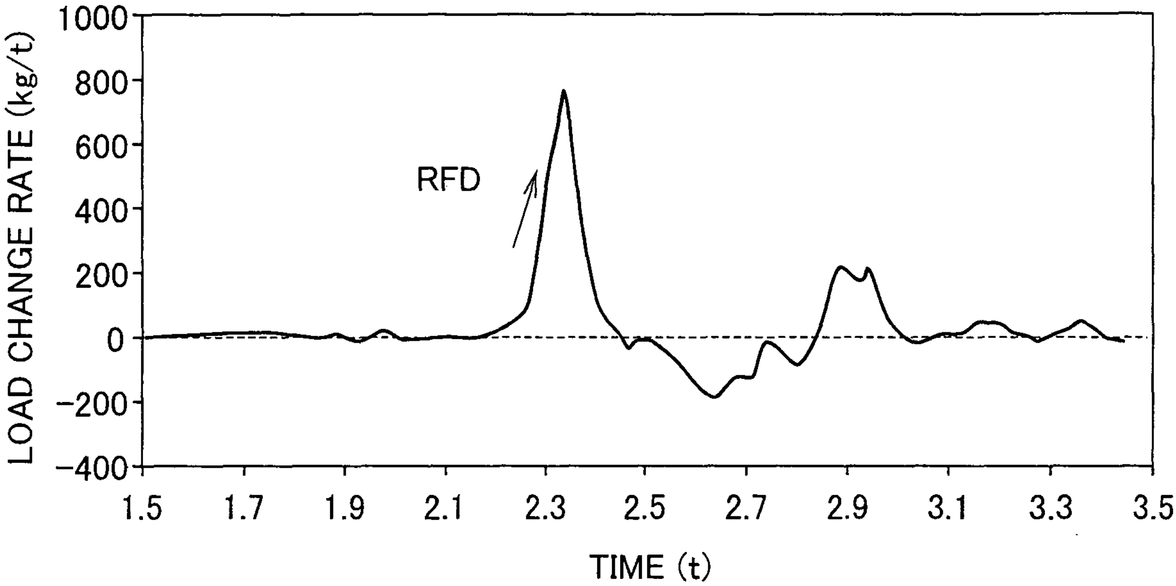

LOAD CHANGE RATE (kg/t)
1000
800
600
400
200
0
−200
−400
RFD
1.5
1.7
1.9
2.1
2.3
2.5
2.7
2.9
3.1
3.3
3.5
TIME (t)

FIG. 5B

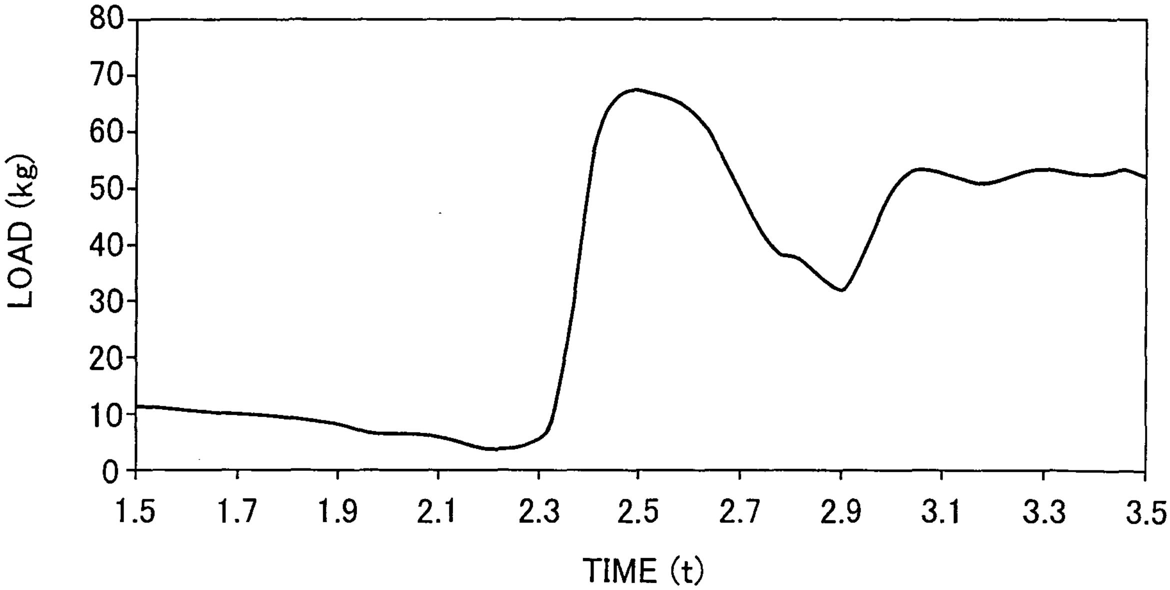
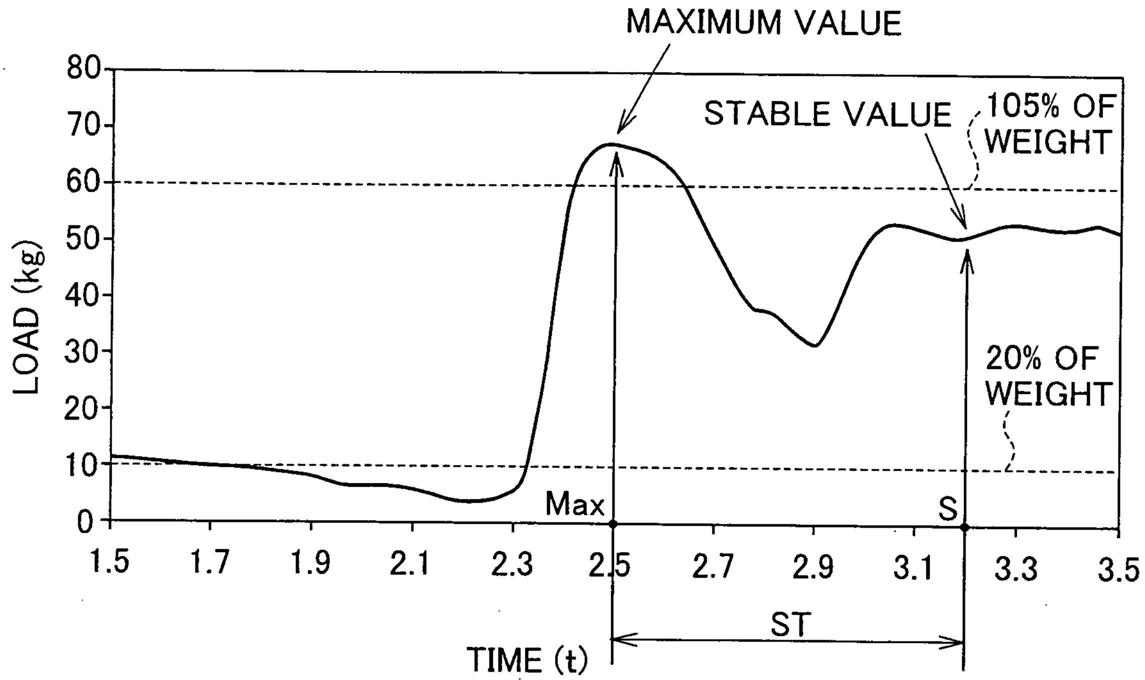

LOAD (kg)
80
70
60
50
40
30
20
10
0
1.5
1.7
1.9
2.1
2.3
2.5
2.7
2.9
3.1
3.3
3.5
TIME (t)

FIG. 6


MAXIMUM VALUE
STABLE VALUE
105% OF WEIGHT
20% OF WEIGHT
LOAD (kg)
80
70
60
50
40
30
20
10
0
Max
S
1.5
1.7
1.9
2.1
2.3
2.5
2.7
2.9
3.1
3.3
3.5
ST
TIME (t)

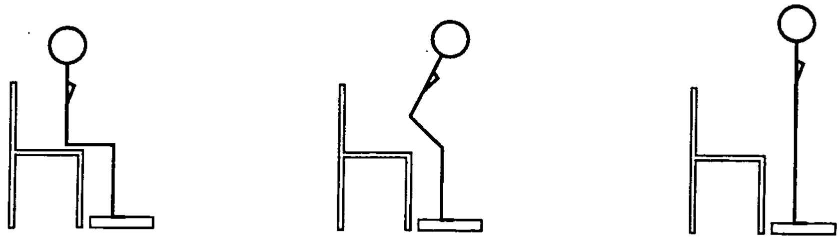


FIG. 7A

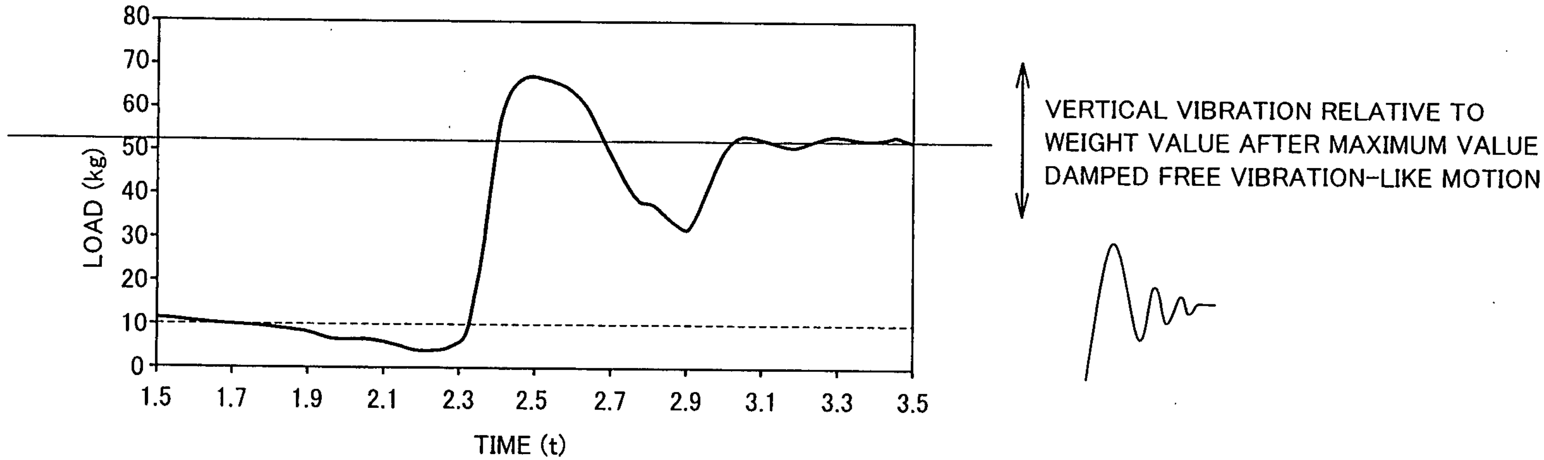

LOAD (kg)
80
70
60
50
40
30
20
10
0
1.5
1.7
1.9
2.1
2.3
2.5
2.7
2.9
3.1
3.3
3.5
TIME (t)
VERTICAL VIBRATION RELATIVE TO
WEIGHT VALUE AFTER MAXIMUM VALUE
DAMPED FREE VIBRATION-LIKE MOTION

FIG. 7B

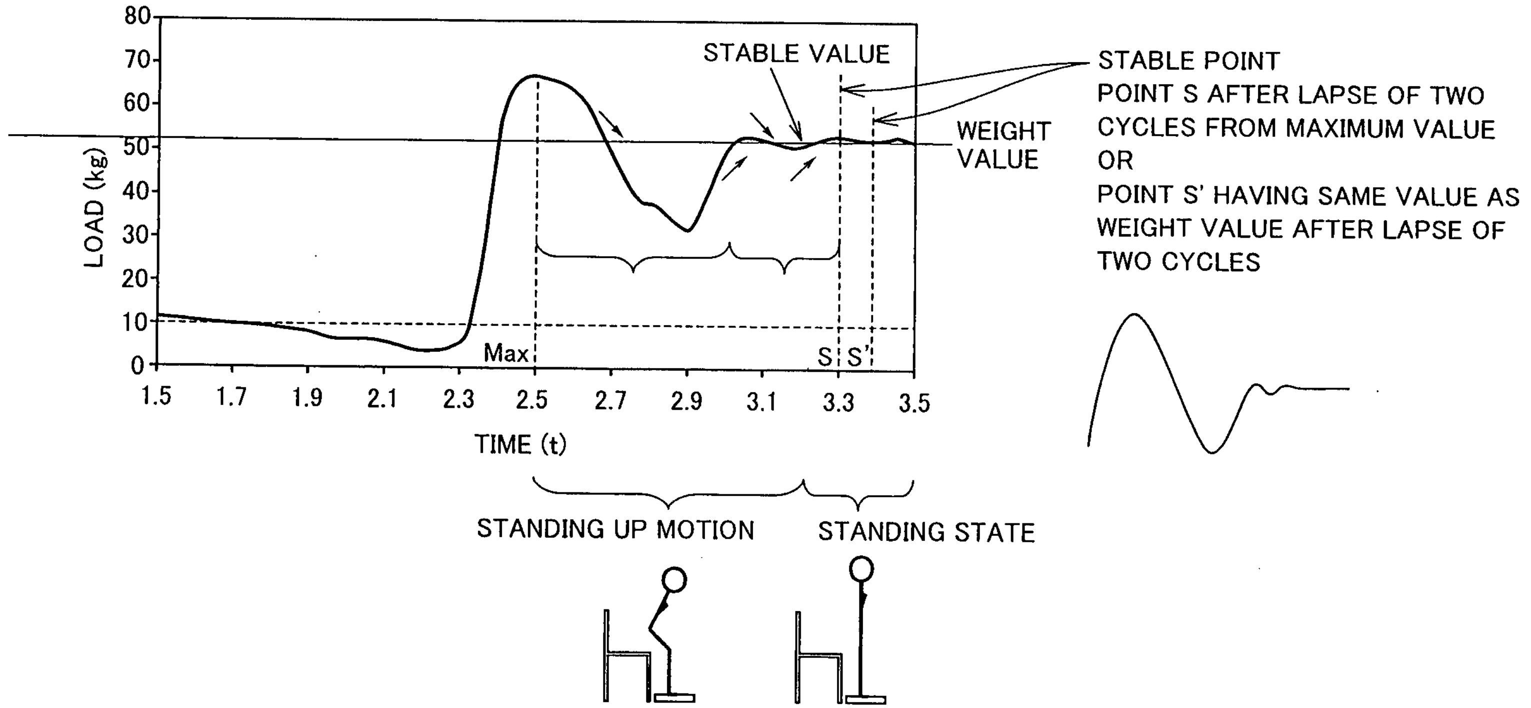

LOAD (kg)
80
70
60
50
40
30
20
10
0
1.5
1.7
1.9
2.1
2.3
2.5
2.7
2.9
3.1
3.3
3.5
TIME (t)
Max
S
S'
STABLE VALUE
WEIGHT VALUE
STABLE POINT
POINT S AFTER LAPSE OF TWO CYCLES FROM MAXIMUM VALUE
OR
POINT S' HAVING SAME VALUE AS WEIGHT VALUE AFTER LAPSE OF TWO CYCLES
STANDING UP MOTION
STANDING STATE

FIG. 8A

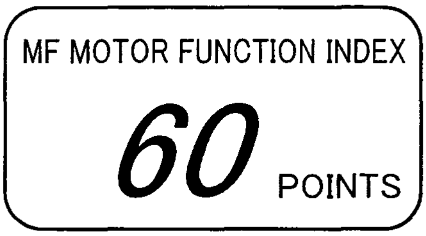

MF MOTOR FUNCTION INDEX
60
POINTS

FIG. 8B

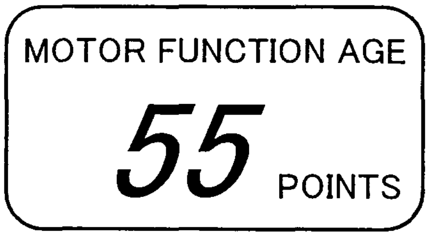

MOTOR FUNCTION AGE
55
POINTS

FIG. 9A

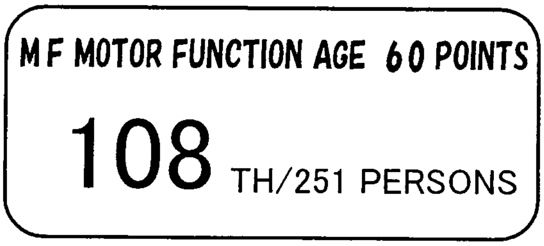

MF MOTOR FUNCTION AGE 60 POINTS
108 TH/251 PERSONS

FIG. 9B

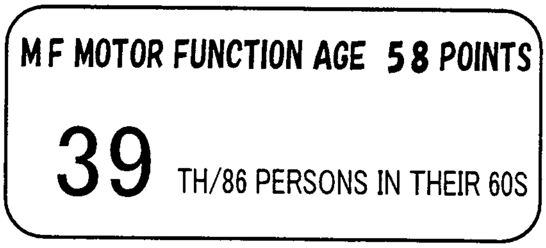
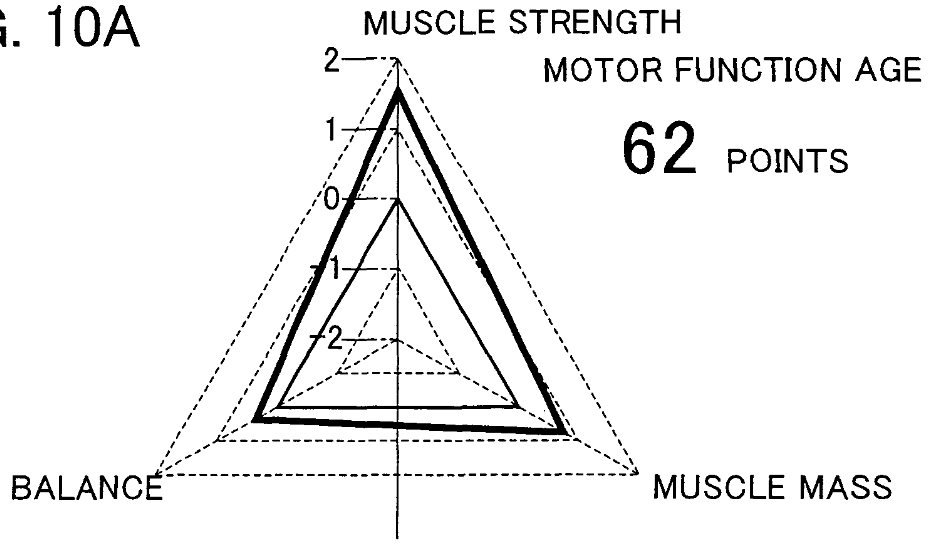
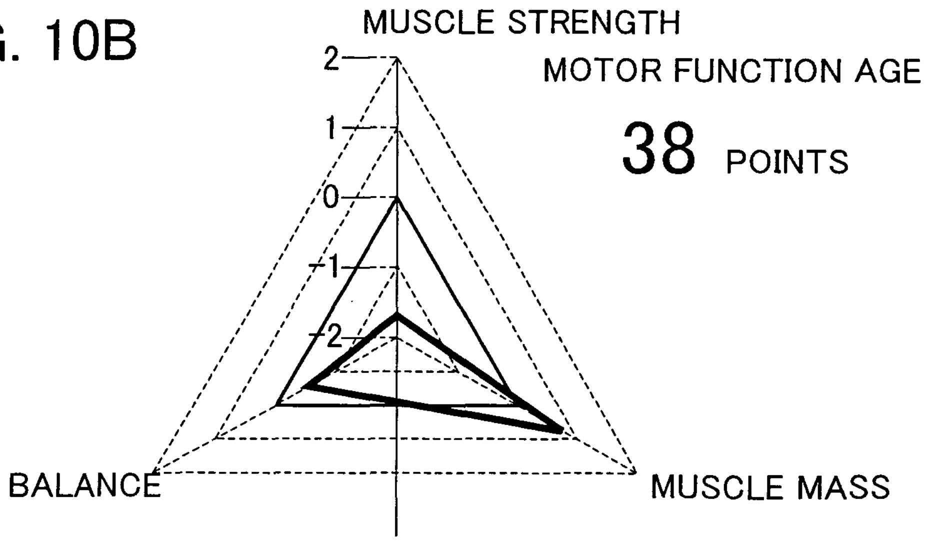

MF MOTOR FUNCTION AGE 58 POINTS
39 TH/86 PERSONS IN THEIR 60S

FIG. 10A



YOU HAVE HIGH MUSCLE STRENGTH, RELATIVELY LARGE AMOUNT OF MUSCLE MASS, AND NICE BALANCE.
RISK OF FALLING IS LOW.
EXERCISE APPROPRIATELY TO KEEP THIS STATE.

FIG. 10B



YOU HAVE RELATIVELY LARGE AMOUNT OF MUSCLE MASS, BUT LOW MUSCLE STRENGTH AND SLIGHTLY UNFAVORABLE BALANCE.
THERE IS RISK OF FALLING.
DAILY EXERCISE TO IMPROVE MUSCLE STRENGTH IS RECOMMENDED.

REFERENCES CITED IN THE DESCRIPTION

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- US 7163516 B **[0012]**
- US 2003088197 A **[0013]**
- US 2006179938 A **[0014]**
- JP 2011045480 A **[0015]**

专利名称(译)	电动机功能评估装置和电动机功能评估方法		
公开(公告)号	EP2777483B1	公开(公告)日	2019-05-01
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[标]申请(专利权)人(译)	株式会社百利达		
申请(专利权)人(译)	TANITA CORPORATION		
当前申请(专利权)人(译)	TANITA CORPORATION		
[标]发明人	SAKAI YOSHIO TAKEHARA TOMOKO OKURA TOMOHIRO TSUJI TAISHI		
发明人	SAKAI, YOSHIO TAKEHARA, TOMOKO OKURA, TOMOHIRO TSUJI, TAISHI		
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摘要(译)

提供一种能够全面且容易地评估对象的运动功能的运动功能评估装置和运动功能评估方法。本发明的电动机功能评估装置1包括测量基座11，测量施加到测量基座11的对象随时间的负载变化的负载测量单元14，以及确定平衡能力指示器的运算单元24。由负载测量单元14测量的负载随时间变化确定的对象。运算单元24从对象站立时和施加到负载测量单元14的负载最大化的时间间隔确定平衡能力指示器，直到负载变化稳定。

$$Im = a_1 \times \log(Imp/Ht^2) + b_1 \quad \text{Expression (1)}$$