(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 732 763 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
14.09.2016 Bulletin 2016/37

(51) Int Cl.:
A61B 5/22 *(2006.01)* ***A61B 5/0488*** *(2006.01)*
A61B 5/00 *(2006.01)*

(21) Application number: **13192609.9**

(22) Date of filing: **13.11.2013**

(54) **One repetition maximum (1RM) estimating apparatus and method**

Schätzvorrichtung und -verfahren für ein Maximum von einer einmaligen Wiederholung (1RM)

Appareil et procédé d'estimation de répétition maximum (1RM)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **16.11.2012 KR 20120130458**

(43) Date of publication of application:
21.05.2014 Bulletin 2014/21

(73) Proprietor: **Samsung Electronics Co., Ltd**
Gyeonggi-do 443-742 (KR)

(72) Inventors:
- **Kim, Youn Ho**
446-712 Gyeonggi-do (KR)
- **Bae, Sang Kon**
446-712 Gyeonggi-do (KR)
- **Choi, Chang Mok**
446-712 Gyeonggi-do (KR)
- **Ko, Byung Hoon**
446-712 Gyeonggi-do (KR)
- **Shin, Kun Soo**
446-712 Gyeonggi-do (KR)

(74) Representative: **Grünecker Patent- und Rechtsanwälte**
PartG mbB
Leopoldstraße 4
80802 München (DE)

(56) References cited:
EP-A1- 1 413 250 **WO-A1-2007/021062**
US-A1- 2008 204 225

- **DE SOUZA CASTELO OLIVEIRA A ET AL: "Lumbar muscles recruitment during resistance exercise for upper limbs", JOURNAL OF ELECTROMYOGRAPHY AND KINESIOLOGY, ELSEVIER, AMSTERDAM, NL, vol. 19, no. 5, 1 October 2009 (2009-10-01), pages 737-745, XP026501780, ISSN: 1050-6411, DOI: 10.1016/J.JELEKIN.2008.04.004 [retrieved on 2008-05-21]**

EP 2 732 763 B1

Description

BACKGROUND

1. Field

[0001] The following description relates to an apparatus and method for estimating a one repetition maximum (1 RM) of a user using a sensor.

2. Description of Related Art

[0002] The one repetition maximum is the maximum amount of weight a user can lift in a single repetition for a given exercise. In a conventional method of measuring a one repetition maximum (1 RM) of a user, the user lifts a suitable amount of a weight until a maximum muscular strength of the user is exhausted. The 1 RM of the user may be measured by using a look-up table. In addition, the 1RM of the user may be measured using a separate muscle mass measuring apparatus. The 1 RM of the user may be measured with respect to 100% of a muscular strength of the user.

[0003] However, measuring the 1RM of the user using such a measuring conventional method may be difficult because the conventional measuring method may injure a user's body because the user may be requested to lift a weight repeatedly until the maximum muscular strength is exhausted. Accordingly, the user's body may be injured, resulting in a muscular pain or injury. In addition, the user may expend a considerable amount of time until the measurement is completed.

[0004] WO 2007/021062 A1 discloses a unit for measuring one repetition maximum, and more specifically, a measuring unit that is detachably mounted on a weight instrument and a method for sensing vertical upward load from a weight of a weight instrument by using such a measuring unit as as to measure one repetition maximum.

[0005] EP 1 413 250 A1 discloses a device for measurement of muscular volume, wherein bioelectric impedances are measured by use of a plurality of electrodes, which are brought into contact with body parts of a living body.

[0006] US 2008/204225 A1 discloses a system for recording force and motion data obtained from the user during exercise workout or other physical movement.

[0007] The document "Lumbar muscles recruitment during resistance exercise for upper limbs" by de Souza Castelo Oliveira et al. (XP 026501780) discloses a study for evaluating electromyography activity of lumbar muscles, in particular during resistance exercise.

SUMMARY

[0008] In one general aspect, an apparatus for estimating a one repetition maximum (1 RM) according to claim 1 is provided. Preferred embodiments are defined in the dependent claims 2-5.

[0009] The 1 RM estimating unit may include an envelope determining unit configured to determine an envelope of amplitudes of the potential signal; a frequency spectrum determining unit configured to determine a frequency spectrum based on a mean frequency of the potential signal; and a gradient determining unit configured to determine a gradient based on the envelope and the frequency spectrum. The frequency spectrum may be determined by performing frequency conversion / transformation of the potential signal. The mean frequency may correspond to the frequency where the maximum of the frequency spectrum is located. Further, the frequency spectrum may be limited to a specific range including the mean frequency, in particular a range of predetermined size.

[0010] The envelope determining unit may be further configured to determine the envelope based on an absolute value of the potential signal. Therefore, rapid changes may be smoothed which can be done by averaging for a period in time. Using the absolute value of the potential signal, i.e. when the potential signal is negative it is multiplied by -1 to become positive, has the advantage that the signal is independent of the direction of muscle activity, which is not important for the 1 RM.

[0011] The frequency spectrum determining unit may be further configured to determine the frequency spectrum based on the potential signal of a predetermined interval based on a maximum value of the envelope. When using the maximal value of the envelope, in particular a range of frequencies including the maximal value, a significant part for obtaining the 1 RM may be obtained and insignificant parts of the spectrum can be omitted, so as to reduce the computational amount. Accordingly, parts of the spectrum that are not important for determining the gradient and finally the 1 RM can be omitted.

[0012] The gradient determining unit may be further configured to determine the gradient based on a plurality of feature points in the frequency spectrum corresponding to peaks of the envelope. The peaks may correspond to repetitions performed by the user during an exercise. When using these peaks, the gradient can be determined in a simple way. This gradient may be used to extrapolate a decline in the frequency spectrum, for example.

[0013] In another general aspect, an apparatus for estimating a one repetition maximum (1 RM) includes a sensing unit configured to sense a potential signal of a muscle of a user; and a 1 RM estimating unit configured to estimate a 1 RM of the user based on the potential signal. Using such a sensing unit provides detailed information on the muscle performance, in particular on the weakening of the strength over time. The sensor may be an electromyography sensor for sensing the electrical activity of a muscle. The electrical source is the muscle membrane potential and the measured potential may be in the range of less than 50μV to 30 mV, depending on the particular muscle. Further, repetition rates of muscle firings are in the range of 7 to 20 Hz.

[0014] The 1 RM estimating unit may include an envelope determining unit configured to determine an envelope of amplitudes of the potential signal; a frequency spectrum determining unit configured to determine a frequency spectrum based on a mean frequency of the potential signal; and a gradient determining unit configured to determine a gradient based on the envelope and the frequency spectrum. See above for advantages of this development.

[0015] The envelope determining unit may be further configured to determine the envelope based on an absolute value of the potential signal. See above for advantages of this development.

[0016] The frequency spectrum determining unit may be further configured to determine the frequency spectrum based on the potential signal of a predetermined interval based on a maximum value of the envelope. See above for advantages of this development.

[0017] The gradient determining unit may be further configured to determine the gradient based on a plurality of feature points in the frequency spectrum corresponding to peaks of the envelope. See above for advantages of this development.

[0018] In another general aspect, a method of estimating a one repetition maximum (1 RM) according to claim 6 is provided. Preferred embodiments are defined in the dependent claims 7-10. The advantages of the method according to the invention and the further developments described below, correspond to the respective advantages of the apparatus according to the invention.

[0019] The estimating may include determining an envelope of amplitudes of the potential signal; determining a frequency spectrum based on a mean frequency of the potential signal; and determining a gradient based on the envelope and the frequency spectrum.

[0020] The determining of the envelope may include determining the envelope based on an absolute value of the potential signal.

[0021] The determining of the frequency spectrum may include determining the frequency spectrum based on the potential signal of a predetermined interval based on a maximum value of the envelope.

[0022] The determining of the gradient may include determining the gradient based on a plurality of feature points in the frequency spectrum corresponding to peaks of the envelope.

[0023] In another general aspect, a method of estimating a one repetition maximum (1 RM) includes sensing a potential signal of a muscle of a user; and estimating a 1 RM of the user based on the potential signal.

[0024] The estimating may include determining an envelope of amplitudes of the potential signal;

[0025] determining a frequency spectrum based on a mean frequency of the potential signal; and determining a gradient based on the envelope and the frequency spectrum.

[0026] The determining of the envelope may include determining the envelope based on an absolute value of the potential signal.

[0027] The determining of the frequency spectrum may include determining the frequency spectrum based on the potential signal of a predetermined interval based on a maximum value of the envelope.

[0028] The determining of the gradient may include determining the gradient based on a plurality of feature points corresponding to peaks of the envelope.

[0029] Other features and aspects will be apparent from the following detailed description, the drawings, and the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030]

FIG. 1 is a block diagram illustrating an example of a one repetition maximum (1 RM) estimating apparatus.

FIG. 2 is a block diagram illustrating an example of a 1 RM estimating unit included in a 1 RM estimating apparatus.

FIG. 3 is a block diagram illustrating an example of an operation of a 1 RM estimating apparatus.

FIG. 4 is a block diagram illustrating an example of a detailed configuration of the 1 RM estimating apparatus of FIG. 3.

FIG. 5 is a block diagram illustrating another example of a 1 RM estimating apparatus.

FIG. 6 is a block diagram illustrating another example of a 1 RM estimating unit included in a 1RM estimating apparatus.

FIG. 7 is a block diagram illustrating another example of an operation of a 1 RM estimating apparatus.

FIG. 8 is a block diagram illustrating an example of a detailed configuration of the 1 RM estimating apparatus of FIG. 7.

FIG. 9 is a diagram illustrating an example of a process of estimating an actual 1 RM.

FIG. 10 is a graph illustrating an example of a change in a normalized frequency spectrum based on a muscle fatigue degree of a user.

FIG. 11 is a graph illustrating an example of a process of estimating a 1 RM using a feature point that is a criterion for a gradient.

FIG. 12 is a diagram illustrating an example of a process of estimating a 1RM corresponding to an exercise goal of a user and providing an exercise program suitable for the 1RM.

DETAILED DESCRIPTION

[0031] The following detailed description is provided to assist the reader in gaining a comprehensive understanding of the methods, apparatuses, and/or systems described herein. However, various changes, modifications, and equivalents of the methods, apparatuses, and/or systems described herein will be apparent to one of ordinary skill in the art. The sequences of operations described herein are merely examples, and are not limited to those set forth herein, but may be changed as will be apparent to one of ordinary skill in the art, with the exception of operations necessarily occurring in a certain order. Also, description of functions and constructions that are well known to one of ordinary skill in the art may be omitted for increased clarity and conciseness.

[0032] Throughout the drawings and the detailed description, the same reference numerals refer to the same elements. The drawings may not be to scale, and the relative size, proportions, and depiction of elements in the drawings may be exaggerated for clarity, illustration, and convenience.

[0033] FIG. 1 is a block diagram illustrating an example of a one repetition maximum (1 RM) estimating apparatus 102. Referring to FIG. 1, the 1RM estimating apparatus 102 includes a potential signal receiving unit 103 and a 1 RM estimating unit 104. The 1 RM estimating apparatus 102 may be separated from an electromyography (EMG) sensor 101, and may be included in a user terminal capable of communicating with the EMG sensor 101 wirelessly.

[0034] The EMG sensor 101 may be attached to a skin of a user. The EMG sensor 101 may measures a potential signal of a muscle of the user. To measure the potential signal of the muscle, the user may repeatedly lift a weight less than a maximum weight that the user can lift. As an example, the user may repeatedly lift a weight of 20 kilograms (kg) that is 50% of a maximum weight of 40 kg that the user can lift. Accordingly, fatigue and an amount of time to be expended for measuring the potential signal of the muscle may be minimized since the user repeatedly lifts the weight less than the maximum weight that the user can lift.

[0035] The EMG sensor 101 may determine an intensity of the measured potential signal of the muscle. The EMG sensor 101 may amplify the potential signal of the muscle based on the intensity of the potential signal. As an example, when the intensity of the potential signal of the muscle is relatively weak, the EMG sensor 101 may amplify the potential signal of the muscle to obtain a signal large enough to be analyzed. In addition, the EMG sensor 101 may transmit the potential signal of the muscle to the 1 RM estimating apparatus 102.

[0036] The potential signal receiving unit 103 may receive the potential signal of the muscle from the EMG sensor 101.

[0037] The 1 RM estimating unit 104 may estimate a 1 RM of the user based on the received potential signal of the muscle. The 1 RM estimating unit 104 may determine an envelope of amplitudes of the potential signal, may determine a frequency spectrum based on a mean frequency of the potential signal, and may determine a gradient based on the envelope of the amplitudes of the potential signal and the frequency spectrum.

[0038] The 1 RM estimating unit 104 may estimate the 1 RM of the user based on the determined gradient. The 1 RM estimating apparatus 102 may display the envelope of the amplitudes of the potential signal and the frequency spectrum to the user.

[0039] The 1 RM estimating apparatus 102 may provide an exercise program suitable for an exercise ability of the used based on the 1 RM of the user.

[0040] The 1 RM estimating apparatus 102 may estimate the 1 RM of the user using a weight less than a maximum weight that the user can lift, thereby stably and rapidly estimating a 1 RM using a relatively small amount of time and power of the user. In addition, the 1 RM estimating apparatus 102 may evaluate a maximum muscular strength of the user using a reasonable weight, and may determine an objective and quantitative exercise load of the user.

[0041] FIG. 2 is a block diagram illustrating an example of a 1 RM estimating unit 201 included in a 1 RM estimating apparatus. Referring to FIG. 2, the 1 RM estimating unit 201 includes an envelope determining unit 202, a frequency spectrum determining unit 203, and a gradient determining unit 204.

[0042] The envelope determining unit 202 may determine an envelope of amplitudes of a potential signal. The envelope determining unit 202 may determine the envelope based on an absolute value of the potential signal. For example, the envelope determining unit 202 may determine the envelope by integrating the absolute value of the potential signal. The envelope determining unit 202 may employ a method of deriving feature points of the potential signal.

[0043] The frequency spectrum determining unit 203 may determine a frequency spectrum based on a mean frequency of the potential signal. The frequency spectrum determining unit 203 may determine the frequency spectrum based on a maximum value of the envelope. The frequency spectrum determining unit 203 may use a potential signal of a predetermined interval based on the maximum value of the envelope. The frequency spectrum determining unit 203 may perform frequency conversion with respect to the potential signal of the predetermined interval. The frequency spectrum determining unit 203 may determine the frequency spectrum by the frequency conversion of the potential signal.

[0044] To reduce an amount of calculation resulting from the frequency conversion, the frequency spectrum determining unit 203 may perform the frequency conversion on the potential signal of the predetermined interval based on the maximum value of the envelope.

[0045] The gradient determining unit 204 may determine a gradient based on the envelope and the frequency spectrum. The gradient determining unit 204 may determine the gradient based on a plurality of feature points in the frequency spectrum corresponding to peaks of the envelope. The gradient determining unit 204 may normalize the plurality of feature points. For example, the gradient determining unit 204 may separately normalize feature points differing from each other based on the maximum value among a plurality of feature points input sequentially.

[0046] The gradient determining unit 204 may calculate the gradient based on the plurality of normalized feature points. In addition, the gradient determining unit 204 may estimate a 1 RM of a user based on the calculated gradient. The gradient calculation will be further described in detail below with reference to FIG. 8.

[0047] The 1 RM estimating apparatus may be configured separately from an EMG sensor. The 1 RM estimating apparatus may receive a potential signal of a muscle of a user from the EMG sensor through a wired or wireless communication. The 1 RM estimating apparatus configured separately from the EMG sensor may be used in various spaces and places when the user exercises outdoors.

[0048] FIG. 3 is a block diagram illustrating an example of an operation of a 1 RM estimating apparatus. Referring to FIG. 3, a sensing device 301, a user terminal 303, and a server 305 may interoperate with one another. The server 305 may be included or excluded depending on a usage environment of the 1 RM estimating apparatus.

[0049] The sensing device 301 may be the EMG sensor 101 of FIG. 1. For example, the sensing device 301 may perform muscle strengthening exercise monitoring 302. The sensing device 301 may measure a potential signal of a muscle of a user. The sensing device 301 may differentially amplify the measured potential signal of the muscle based on an intensity. For example, when an intensity of the measured potential signal of the muscle is large enough to be analyzed, the sensing device 301 may not amplify the measured potential signal of the muscle.

[0050] The sensing device 301 may be connected to the user terminal 303 and may interoperate with the user terminal 303 using a wireless communication. The sensing device 301 may transmit the measured potential signal of the muscle to the user terminal 303 capable of interoperating with the sensing device 301.

[0051] The user terminal 303 may include the 1 RM estimating apparatus 102 of FIG. 1. For example, the user terminal 303 may include the 1 RM estimating apparatus 102, and may estimate a 1 RM of the user. The user terminal 303 may receive the potential signal of the muscle from the sensing device 301. The user terminal 303 may perform 1 RM estimation 304. The user terminal 303 may integrate an absolute value of potential signal of a muscle. The user terminal 303 may determine an envelope of amplitudes of the potential signal of the muscle based on the integrated absolute value. In addition, the user terminal 303 may perform frequency conversion with respect to a potential signal of a predetermined interval based on a maximum value of the envelope using a mean frequency.

[0052] The user terminal 303 may extract a plurality of feature points in the frequency spectrum corresponding to peaks of the envelope. The user terminal 303 may normalize the plurality of feature points. The user terminal 303 may estimate the 1 RM of the user by calculating a gradient of the plurality of normalized feature points.

[0053] The user terminal 303 may set an exercise goal of the user based on the 1 RM of the user. The user terminal 303 may provide the user with the set exercise goal of the user using a speaker or a display.

[0054] The server 305 may receive and store the 1 RM of the user, and/or the exercise goal of the user set based on the 1 RM of the user. The server 305 may share the stored exercise goal of the user through a social network. The server 305 may be included or excluded depending on a usage environment of the 1 RM estimating apparatus.

[0055] FIG. 4 is a block diagram illustrating an example of a detailed configuration of the 1 RM estimating apparatus of FIG. 3. Referring to FIG. 4, a sensing device 401 includes an electrode unit 402, a differential amplifying unit 403, and a transmitting unit 404. The sensing device 401 may be the EMG sensor 101 of FIG. 1.

[0056] The electrode unit 402 may measures a potential signal of a muscle of a user.

[0057] The differential amplifying unit 403 differentially amplifies the potential signal based on an intensity of the measured potential signal of the muscle.

[0058] The transmitting unit 404 may transmit the amplified potential signal of the muscle to a user terminal capable of receiving the potential signal. The user terminal may be a portable terminal of the user.

[0059] A user terminal 405 includes a receiving unit 406, an amplitude absolute value integrating unit 407, a frequency spectrum determining unit 408, a feature point extracting unit 409, a normalizing unit 410, a feature point gradient measuring unit 411, a 1 RM estimating unit 412, an exercise goal setting unit 413, and a display unit 414. Depending on a usage environment, the user terminal 405 may further include a speaker unit 415.

[0060] The receiving unit 406 may receive a potential signal from the transmitting unit 404 of the sensing device 401. The potential signal may be an amplified potential signal amplified based on an intensity of the measured potential signal. The receiving unit 406 may receive the potential signal in real time.

[0061] The amplitude absolute value integrating unit 407 integrates an absolute value of the received potential signal of the muscle. For example, the amplitude absolute value integrating unit 407 may obtain an absolute value of the potential signal of the muscle. The amplitude absolute value integrating unit 407 may integrate the absolute value of the potential signal of the muscle. The amplitude absolute value integrating unit 407 may determine an envelope of amplitudes of the potential signal of the muscle based on the integrated absolute value.

[0062] The frequency spectrum determining unit 408 may determine a frequency spectrum based on a mean frequency. For example, the frequency spectrum determining unit 408 may perform frequency conversion with respect to a potential signal of a predetermined interval based on a maximum value of the envelope. The frequency spectrum determining unit 408 may determine the frequency-converted potential signal to be the frequency spectrum. The frequency spectrum determining unit 408 may perform the frequency conversion with respect to the potential signal of the predetermined interval, thereby minimizing an amount of calculation required.

[0063] The feature point extracting unit 409 may extract extracts a plurality of feature points in the frequency spectrum corresponding to peaks of the envelope. The feature point extracting unit 409 may extract the plurality of feature points to measure a muscle fatigue degree of the user from the frequency spectrum. For example, the feature point extracting unit 409 may extract the plurality of feature points based on the envelope determined by the amplitude absolute value integrating unit 407 and the frequency spectrum determined by the frequency spectrum determining unit 408.

[0064] The normalizing unit 410 normalizes the plurality of extracted feature points. The normalizing unit 410 may normalize feature points differing from each other based on a feature point having a maximum value among the plurality of feature points. The normalizing unit 410 may extract the muscle fatigue degree of the user by normalizing the feature points.

[0065] The feature point gradient measuring unit 411 may measures a gradient of the normalized feature points. The feature point gradient measuring unit 411 may calculate a gradient based on a feature point following the feature point having the maximum value among the normalized feature points. The gradient may represent a correlation between the muscle fatigue degree and a number of repetitions of a test for the user. The muscle fatigue degree may increase by a similar level corresponding to an increase in the number of the repetitions of the test for the user. For example, the correlation between the muscle fatigue degree and the number of the repetitions of the test may be a criterion for measuring a 1 RM of the user.

[0066] For example, the feature point gradient measuring unit 411 may perform a test using 50% of a muscular strength of the user. The feature point gradient measuring unit 411 may verify a state of a muscle fatigue degree for the 50% of the muscular strength of the user. The feature point gradient measuring unit 411 may estimate a state of a muscle fatigue degree for 100% of the muscular strength of the user based on a gradient of the verified muscle fatigue degree. For example, the feature point gradient measuring unit 411 may estimate a maximum number of repetitions of the test in the state of the muscle fatigue degree for the 100% of the muscular strength of the user based on the gradient of the muscle fatigue degree.

[0067] For example, the feature point gradient measuring unit 411 may determine an envelope of amplitudes of the potential signal based on the measured potential signal. The feature point gradient measuring unit 411 may determine a frequency spectrum based on a maximum value of the envelope. The 1 RM estimating apparatus may divide remaining values based on a maximum value of the frequency spectrum to perform normalization. By performing the normalization, the feature point gradient measuring unit 411 may calculate a gradient indicating that a value of a feature point decreases as a number of repetitions of a test increases.

[0068] The 1 RM estimating unit 412 may estimate a 1 RM of the user based on the gradient calculated through the test. The 1 RM estimating unit 412 may measure the 1 RM of the user in view of the number of the repetitions of the test for the feature point based on the calculated gradient and the maximum value.

[0069] For example, the 1 RM estimating unit 412 may estimate an actually non-measured maximum number of repetitions of the test in a state of 100% of the muscle fatigue degree of the user based on a gradient of a muscle fatigue degree corresponding to the state of 50% of the muscle fatigue degree of the user. The 1 RM estimating unit 412 may estimate a 1 RM of the user based on the gradient of the muscle fatigue degree.

[0070] The 1 RM estimating apparatus may use a Wathan equation as a 1 RM estimating equation as expressed by the following Equation 1:

$$1RM = \frac{load}{0.488 + \left(0.538 \cdot e^{-0.075 \cdot REPS}\right)} \qquad (1)$$

[0071] In Equation 1, load denotes a weight lifted by a muscle, for example, a weight of a dumbbell, and *REPS* denotes a number of repetitions. Alternatively, other equations for calculating 1 RM may be used, such as the Epley formula, the Brzycki formula, the Lander formula, the Mayhew formula or the O'Connor fomula, for example.

[0072] The exercise goal setting unit 413 may set an exercise suitable for the user based on the measured 1 RM of the user. For example, the exercise goal setting unit 413 may set a weight, a number of times exercising, and other exercise information for the user based on basic information of the user input by the user. The exercise goal setting unit 413 may set an exercise goal suitable for each type of exercise depending on a type of exercise desired by the user. The exercise goal setting unit 413 will be described in detail below with reference to FIG. 12.

[0073] The display unit 414 may display the set exercise goal of the user on the user terminal 405. The display unit 414 may display an exercise condition of the user. For example, the display unit 414 may display a current weight, a current number of times exercising of the user, and other exercise information so the user may verify the weight, the number of times exercising, and the other exercise information. For example, the display unit 414 may display a body weight of the user, a 1 RM-measured value of the user, a number of times exercising of the user, a goal, and other user and exercise information. The display unit 414 may display various information associated with the user depending on settings set by the user.

[0074] The speaker unit 415 may provide the user with items associated with the set exercise goal of the user through a speaker. The speaker unit 415 may provide the user with the weight, the number of times exercising, and the other exercise information set according to the exercising condition of the user. For example, the speaker unit 415 may provide the user with a number of sets of the exercise currently being performed by the user, or a number of repetitions of the exercise, through the speaker.

[0075] The user terminal 405 may be connected with the server 416 and may interoperate with the server 416 using a wireless communication. The server 416 may receive the 1RM of the user and/or the exercise goal of the user set based on the 1 RM of the user from the user terminal 405. The server 416 may store the 1 RM of the user and/or the exercise goal of the user set based on the 1RM of the user. In addition, the server 416 may be included or excluded depending on a usage environment.

[0076] FIG. 5 is a block diagram illustrating another example of a 1 RM estimating apparatus 501. Referring to FIG. 5, the 1 RM estimating apparatus 501 includes a sensing unit 502 and a 1 RM estimating unit 503. The 1 RM estimating apparatus 501 may be included in an EMG sensor to estimate 1 RM, and the EMG sensor may transfer the estimated 1 RM to a user terminal through a wireless communication.

[0077] The sensing unit 502 may sense a potential signal of a muscle from the EMG sensor included in the 1 RM estimating apparatus 501. The sensing unit 502 may amplify the potential signal of the muscle to a signal large enough to be analyzed based on an intensity of the potential signal of the muscle.

[0078] The IRM estimating unit 503 may estimate a 1 RM of the based on the received potential signal of the muscle. The 1 RM estimating unit 503 may determine an envelope of amplitudes of the potential signal. The 1 RM estimating unit 503 may determine a frequency spectrum based on a mean frequency of the potential signal. The 1 RM estimating unit 503 may determine a gradient based on the frequency spectrum and the envelope of the amplitudes of the potential signal. The 1 RM estimating unit 503 may estimate the 1 RM of the user based on the determined gradient.

[0079] The 1 RM estimating unit 503 will be described in detail below with reference to FIG. 6.

[0080] FIG. 6 is a block diagram illustrating another example of a 1 RM estimating unit 601 included in a 1 RM estimating apparatus. Referring to FIG. 6, the 1 RM estimating unit 601 includes an envelope determining unit 602, a frequency spectrum determining unit 603, and a gradient determining unit 604.

[0081] The envelope determining unit 602 may determine an envelope of amplitudes of a potential signal based on an absolute value of the potential signal. For example, the envelope determining unit 602 may determine the envelope by integrating the absolute value of the potential signal.

[0082] The frequency spectrum determining unit 603 may determine a frequency spectrum based on a potential signal of a predetermined interval based on a maximum value of the envelope. The frequency spectrum determining unit 603 may determine the frequency spectrum by performing frequency conversion with respect to the potential signal of the predetermined interval.

[0083] The gradient determining unit 604 may determine a gradient based on a plurality of feature points in the frequency spectrum corresponding to peaks of the envelope. The gradient determining unit 604 may separately normalize feature points differing from each other based on the maximum value among the plurality of feature points input sequentially. In addition, the gradient determining unit 604 may estimate a 1 RM of the user based on the gradient calculated based on the plurality of normalized feature points. For example, the gradient determining unit 604 may estimate the 1 RM based on a number of feature points according to the gradient.

[0084] The 1 RM estimating apparatus 601 may be provided in an integrated structure in which an EMG sensor is included. For example, the 1 RM estimating apparatus 601 may be included in the EMG sensor.

[0085] For example, the 1 RM estimating apparatus 601 may include an EMG sensor, and may be attached to a body of the user. The 1 RM estimating apparatus 601 may verify a state of a muscle fatigue degree of the user according to a maximum number of repetitions of a test. The 1 RM estimating apparatus 601 may measure a maximum number of repetitions of the test corresponding to 50% of a muscular strength of the user. The 1 RM estimating apparatus 601 may verify a muscle fatigue degree corresponding to the maximum number of the repetitions of the test. The 1 RM estimating apparatus 601 may estimate a muscle fatigue degree of 100% of the muscular strength of the user based on a gradient of the muscle fatigue degree of the user. The 1 RM estimating apparatus 601 may estimate a 1 RM of the user based on the gradient of the muscle fatigue degree of the user.

[0086] FIG. 7 is a block diagram illustrating another example of an operation of a 1 RM estimating apparatus. Referring to FIG. 7, a sensing device 701 may perform muscle strengthening exercise monitoring 702, and 1 RM estimation 703. The sensing device 701 may be the EMG sensor described with reference to FIG. 5.

[0087] The sensing device 701 may include the 1RM estimating apparatus 501 of FIG. 5. For example, the sensing device 701 may estimate a 1 RM of a user based on a potential signal of a muscle of the user sensed by the 1 RM estimating apparatus.

[0088] For example, the sensing device 701 may sense a potential signal of a muscle. The sensing device 701 may differentially amplify the sensed potential signal of the muscle based on an intensity of the potential signal. The sensing device 701 may determine an envelope of amplitudes of the potential signal of the muscle by integrating an absolute value of the potential signal of the muscle. The sensing device 701 may determine a frequency spectrum by performing frequency conversion of a potential signal of a predetermined interval based on a maximum value of the envelope. The sensing device 701 may estimate a 1 RM of the user by extracting a plurality of feature points in the frequency spectrum corresponding to peaks of the envelope, and multiplexing the plurality of extracted feature points. The sensing device 701 may set an exercise goal suitable for the user based on the 1 RM of the user. The sensing device 701 may be connected with a user terminal 704, and may interoperate with the user terminal 704 using a wireless communication.

[0089] A server 705 may store the 1 RM of the user received from the user terminal 704, and/or the exercise goal of the user set based on the 1 RM of the user. The server 705 may interoperate with the user terminal 704 or may not interoperate with the user terminal 705 depending on a usage environment.

[0090] FIG. 8 is a block diagram illustrating an example of a detailed configuration of the 1 RM estimating apparatus of FIG. 7. Referring to FIG. 8, a sensing device 801 includes an electrode unit 802, a differential amplifying unit 803, an amplitude absolute value integrating unit 804, a frequency spectrum determining unit 805, a feature point extracting unit 806, a normalizing unit 807, a feature point gradient measuring unit 808, a 1 RM estimating unit 809, and an exercise goal setting unit 810.

[0091] The electrode unit 802 may sense a potential signal of a muscle. For example, the electrode unit 802 may sense the potential signal of the muscle of a user. The differential amplifying unit 803 differentially amplifies the sensed potential signal of the muscle based on an intensity of the sensed potential signal.

[0092] The amplitude absolute value integrating unit 804 may determine an envelope of amplitudes of the potential signal of the muscle based on an absolute value of the potential signal of the muscle. The amplitude absolute value integrating unit 804 may determine the envelope by integrating the absolute value of the potential signal of the muscle.

[0093] The frequency spectrum determining unit 805 may determine a frequency spectrum by performing frequency conversion with respect to a potential signal of a predetermined interval based on a maximum value of the envelope. The frequency spectrum determining unit 805 may perform the frequency conversion with respect to the potential signal of the predetermined interval, thereby minimizing an amount of calculation required. For example, the frequency conversion may include a fast Fourier transform (FFT) or other frequency conversion known to one of ordinary skill in the art.

[0094] The feature point extracting unit 806 extracts a plurality of feature points in the frequency spectrum corresponding to peaks of the envelope. The feature point extracting unit 806 may extract the plurality of feature points to measure a muscle fatigue degree of the user based on the frequency spectrum.

[0095] The normalizing unit 807 normalizes he plurality of extracted feature points. The normalizing unit 807 may normalize feature points differing from each other based on a feature point having a maximum value among the plurality of feature points. The normalizing unit 807 may extract the muscle fatigue degree of the user.

[0096] The feature point gradient measuring unit 808 may measures a gradient of a feature point using the plurality of normalized feature points. The feature point gradient measuring unit 808 may calculate a gradient based on the feature point having the maximum value among the normalized feature points.

[0097] The 1 RM estimating unit 809 may estimate a 1 RM of the user based on the calculated gradient. The 1 RM estimating unit 809 may measure a number of feature points starting from a feature point having a maximum value of the gradient. The 1RM estimating apparatus 809 may estimate the 1 RM of the user based on the measured feature points.

[0098] The exercise goal setting unit 810 may set a weight, a number of times exercising, and the other exercise information for the user to be suitable for basic information of the user input by the user based on the measured 1 RM of the user. The exercise goal setting unit 810 will be described in detail below with reference to FIG. 12.

[0099] A user terminal 811 includes a display unit 812 and a communication unit 814. Depending on a usage environment, the user terminal 811 may further include a speaker unit 813.

[0100] The display unit 812 displays the set exercise goal of the user on the user terminal 811. The display unit 812 may display an exercise condition of the user. For example, the display unit 812 may display a current weight, a current number of times exercising of the user, and other exercise information so the user may verify the weight, the number of times exercising, and the other exercise information.

[0101] The speaker unit 813 may provide the user with items associated with the set exercise goal of the user through a speaker. The speaker unit 813 may provide the user with the weight, the number of times exercising, and the other exercise information set based on the exercising condition of the user through the speaker.

[0102] The communication unit 814 may communicate with the sensing device 801. The communication unit 814 may receive the exercise goal set based on the 1 RM of the user and other information.

[0103] A server 815 may interoperate with the user terminal 811. The server 815 may receive the 1 RM and/or the exercise goal of the user set based on the 1 RM from the user terminal 811, and may store the 1 RM and/or the exercise goal of the user. In addition, the server 815 may share data regarding the user associated with a social network. The server 815 may interoperate with the user terminal 811 or may not interoperate with the user terminal 811 depending on a usage environment.

[0104] The server described with reference to FIGS. 3, 4, 7, and 8 may be included or excluded depending on a usage environment.

[0105] FIG. 9 is a diagram illustrating an example of a process of estimating an actual 1 RM. In operation 910, an EMG sensor or a sensor amplifies a potential signal to obtain a potential signal large enough to be analyzed.

[0106] In operation 920, an envelope determining unit may calculate an absolute value of the amplified potential signal relative to an X axis. The envelope determining unit may calculate the absolute value of the potential signal to maximize an intensity of the potential signal.

[0107] In operation 930, the envelope determining unit may determine an envelope of amplitudes of the potential signal by integrating the absolute value of the potential signal. The envelope determining unit may extract a maximum value of the envelope to minimize an amount of computation to be performed for extracting feature points.

[0108] In operation 940, a frequency spectrum determining unit may determine a frequency spectrum by performing frequency conversion of the potential signal of operation 910 of a predetermined interval based on the maximum value of the envelope of operation 930. The frequency spectrum determining unit may use the maximum value of the envelope for reducing an amount of computation to be performed to calculate the entire frequency spectrum. The frequency spectrum determining unit may perform frequency conversion of the potential signal of the predetermined interval based on the maximum value, thereby deriving features of the received or sensed potential signal of the muscle.

[0109] In operation 950, a gradient determining unit extracts a plurality of feature points in the frequency spectrum corresponding to peaks of the envelope of operation 930. The gradient determining unit may normalize the extracted feature points. For example, the gradient determining unit may normalize the extracted feature points based on a feature point having a maximum value among the extracted feature points.

[0110] FIG. 10 is a graph illustrating an example of a change in a normalized frequency spectrum based on a muscle fatigue degree of a user. The upper graph in FIG. 10 illustrates 1 RMs measured with respect to subjects A, B, C, and D. The subjects A, B, C, and D may be tested using respective predetermined weights. In addition, the subjects A, B, C, and D may perform the test repeatedly until muscle fatigue degrees of the subjects A, B, C, and D reach respective maximum values.

[0111] The subjects A, B, and C may perform the test based on a conventional method. For example, the subjects A, B, and C may perform an exercise repeatedly with respective maximum weights that the subjects A, B, and C can lift until muscular strengths of the subjects A, B, and C are exhausted. In the conventional method, a number of repetitions of the test for each subject may be measured. The subjects A, B, and C may have different numbers of repetitions of the test due to different muscular strengths. Based on the numbers of repetitions, different 1 RMs may be estimated for the subjects A, B, and C. Referring to the upper graph, the 1 RM of the subject C performing the test a greater number of times may be estimated to be higher than the 1 RMs of the subjects A and B. However, according to the conventional method, the subjects may be requested to perform the test repeatedly until the respective muscular strengths of the subjects are exhausted to estimate the 1 RMs, which may cause bodies of the subjects to be injured.

[0112] The subject D may perform the test based on a 1 RM estimating method described in this application. As an example, a 1 RM of the subject D may be estimated using the 1 RM estimating method. The subject D may be tested using a weight less than a maximum weight that the subject D can lift. The subject D may perform an exercise repeatedly until a muscle fatigue degree reaches a maximum value. For example, the subject D may perform the exercise until the muscle fatigue degree reaches the maximum value starting from 0% of the muscle fatigue degree. For example, a number of times exercising at 100% of the muscle fatigue degree may be estimated based on a trend in the muscle fatigue degree until the muscle fatigue degree corresponds to 50%.

[0113] In the 1 RM estimating method, a maximum number of repetitions of the test may be estimated using a regression equation between a number of times performing a maximum muscular strength exercise and an increase rate of a muscle fatigue degree. In the 1 RM estimating method, a characteristic of the muscle fatigue degree increasing as the number of times increases as illustrated in the lower graph in FIG. 10 may be used.

[0114] In the 1 RM estimating method, the 1 RM of the subject D may be estimated by substituting the estimated number of times and a test weight used for estimating 1 RM in a 1 RM calculating equation. The 1 RM calculating equation may be a Wathan equation used for estimating the 1 RM, or any one of the other various equations used for estimating the 1 RM known to one of ordinary skill in the art.

[0115] FIG. 11 is a graph illustrating an example of a process of estimating 1 RM using a feature point that is a criterion for a gradient. Referring to FIG. 11, gradients with respect to a subject A 1101 and a subject B 1102 may be configured in various forms.

[0116] A gradient may be measured based on a feature point having a maximum value among a plurality of feature points. In a case of the subject A 1101, a gradient determining unit may determine a gradient based on a first feature point having a maximum value among a plurality of feature points. The first feature point may be a reference point in time for estimating a 1 RM of a user based on muscular strength exercise. In a case of the subject B 1102, the gradient determining unit may determine a gradient based on a third feature point having a maximum value among a plurality of feature points. The third feature point may be a reference point in time for estimating a 1 RM of a user based on muscular strength exercise. The gradient determining unit may calculate a gradient based on feature points following the feature point that is a reference point in time. For example, in the case of the subject A 1101, the gradient determining unit may calculate the gradient based on first to sixth feature points. In the case of the subject B 1102, the gradient determining unit may calculate the gradient based on third to sixth feature points. The gradient determining unit may estimate a 1 RM of the user based on the calculated gradient.

[0117] A difference between the subject A 1101 and the subject B 1102 may result from a difference in a mean frequency for each user. As the user may perform the 1 RM test a greater number of times, a probability that a mean frequency will occur at a first time may decrease. For example, in a case of a user performing the test a relatively greater number of times, a mean frequency value may occur after the first to third times from the beginning of the test. Accordingly, the gradient determining unit may calculate the gradient based on a trend line from a position at which the mean frequency with respect to the maximum value of the user occurs to a final time.

[0118] The gradient determining unit may obtain the gradient according to the trend line from the number of repetitions of the test until energy of the user performing the test is exhausted based on the maximum mean frequency, thereby estimating the 1 RM of the user.

[0119] The gradient determining unit of FIG. 8 may be the gradient determining unit 204 of FIG. 2 or and the gradient determining unit 604 of FIG. 6.

[0120] FIG. 12 is a diagram illustrating an example of a process of estimating a 1RM corresponding to an exercise goal of a user and providing an exercise program suitable for the 1RM. Referring to FIG. 12, a 1RM estimating apparatus may receive an input of basic information of a user from the user. For example, the 1 RM estimating apparatus may receive an input of information about a body weight of the user, an exercise type, a body part to be exercised, a weight for exercise ability evaluation. The weight for exercise ability evaluation may be used for measuring a 1 RM of the user, and may be a weight less than a maximum weight that the user can lift.

[0121] The 1 RM estimating apparatus may perform exercise ability evaluation of the user based on the basic information of the user. For example, the 1 RM estimating apparatus may estimate a 1 RM of the user based on a test using the weight for exercise ability evaluation.

[0122] The 1 RM estimating apparatus may provide an exercise program to the user based on the estimated 1 RM and the basic information of the user. For example, the 1 RM estimating apparatus may provide a number of repetitions of the test of the user, the 1 RM of the user, for example, a maximum muscular strength of the user, and the exercise program based on the test. The exercise program may include exercise information, for example, a weight with which the user may exercise, a number of repetitions of the exercise, a number of sets per time, and other exercise information.

[0123] The 1 RM estimating apparatus 102, the potential signal receiving unit 103, and the 1 RM estimating unit 104 illustrated in FIG. 1, the 1 RM estimating unit 201, the envelope determining unit 202, the frequency spectrum determining unit 203, and the gradient determining unit 204 illustrated in FIG. 2, the sensing device 301, the user terminal 303, and the server 305 illustrated in FIG. 3, the sensing device 401, the electrode unit 402, the differential amplifying unit 403, the transmitting unit 404, the user terminal 405, the receiving unit 406, the amplitude absolute value integrating unit 407, the frequency spectrum determining unit 408, the feature point extracting unit 409, the normalizing unit 410, the feature point gradient measuring unit 411, the 1 RM estimating unit 412, the exercise goal setting unit 413, the display unit 414, the speaker unit 415, and the server 416 illustrated in FIG. 4, the 1 RM estimating apparatus 501, the sensing unit 502, and the 1RM estimating unit 503 illustrated in FIG. 5, the 1RM estimating unit 601, the envelope determining unit 602, the frequency spectrum determining unit 603, and the gradient determining unit 604 illustrated in FIG. 6, the sensing device 701, the user terminal 704, and the server 705 illustrated in FIG. 7, the sensing device 801, the electrode unit 802, the differential amplifying unit 803, the amplitude absolute value integrating unit 804, the frequency spectrum determining unit 805, the feature point extracting unit 806, the normalizing unit 807, the feature point gradient measuring unit 808, the 1 RM estimating unit 809, the exercise goal setting unit 810, the user terminal 811, the display unit 812, the speaker unit 813, the communication unit 814, and the server 815 illustrated in FIG. 8, and the 1 RM estimating apparatus illustrated in FIG. 12 that perform the operations illustrated in FIGS. 3, 7, and 9-12 may be implemented using one or more hardware components, one or more software components, or a combination of one or more hardware components and one or more software components.

[0124] A hardware component may be, for example, a physical device that physically may perform one or more operations, but is not limited thereto. Examples of hardware components include resistors, capacitors, inductors, power supplies, frequency generators, operational amplifiers, power amplifiers, low-pass filters, high-pass filters, band-pass filters, analog-to-digital converters, digital-to-analog converters, and processing devices.

[0125] A software component may be implemented, for example, by a processing device controlled by software or instructions to perform one or more operations, but is not limited thereto. A computer, controller, or other control device may cause the processing device to run the software or execute the instructions. One software component may be implemented by one processing device, or two or more software components may be implemented by one processing device, or one software component may be implemented by two or more processing devices, or two or more software components may be implemented by two or more processing devices.

[0126] A processing device may be implemented using one or more general-purpose or special-purpose computers, such as, for example, a processor, a controller and an arithmetic logic unit, a digital signal processor, a microcomputer, a field-programmable array, a programmable logic unit, a microprocessor, or any other device capable of running software or executing instructions. The processing device may run an operating system (OS), and may run one or more software applications that operate under the OS. The processing device may access, store, manipulate, process, and create data when running the software or executing the instructions. For simplicity, the singular term "processing device" may be used in the description, but one of ordinary skill in the art will appreciate that a processing device may include multiple processing elements and multiple types of processing elements. For example, a processing device may include one or more processors, or one or more processors and one or more controllers. In addition, different processing configurations are possible, such as parallel processors or multi-core processors.

[0127] A processing device configured to implement a software component to perform an operation A may include a processor programmed to run software or execute instructions to control the processor to perform operation A. In addition, a processing device configured to implement a software component to perform an operation A, an operation B, and an operation C may have various configurations, such as, for example, a processor configured to implement a software component to perform operations A, B, and C; a first processor configured to implement a software component to perform operation A, and a second processor configured to implement a software component to perform operations B and C; a first processor configured to implement a software component to perform operations A and B, and a second processor configured to implement a software component to perform operation C; a first processor configured to implement a software component to perform operation A, a second processor configured to implement a software component to perform operation B, and a third processor configured to implement a software component to perform operation C; a first processor configured to implement a software component to perform operations A, B, and C, and a second processor configured to implement a software component to perform operations A, B, and C, or any other configuration of one or more processors each implementing one or more of operations A, B, and C. Although these examples refer to three operations A, B, C, the number of operations that may implemented is not limited to three, but may be any number of operations required to achieve a desired result or perform a desired task.

[0128] Software or instructions for controlling a processing device to implement a software component may include a computer program, a piece of code, an instruction, or some combination thereof, for independently or collectively instructing or configuring the processing device to perform one or more desired operations. The software or instructions may include machine code that may be directly executed by the processing device, such as machine code produced by a compiler, and/or higher-level code that may be executed by the processing device using an interpreter. The software or instructions and any associated data, data files, and data structures may be embodied permanently or temporarily in any type of machine, component, physical or virtual equipment, computer storage medium or device, or a propagated signal wave capable of providing instructions or data to or being interpreted by the processing device. The software or instructions and any associated data, data files, and data structures also may be distributed over network-coupled computer systems so that the software or instructions and any associated data, data files, and data structures are stored and executed in a distributed fashion.

[0129] For example, the software or instructions and any associated data, data files, and data structures may be recorded, stored, or fixed in one or more non-transitory computer-readable storage media. A non-transitory computer-readable storage medium may be any data storage device that is capable of storing the software or instructions and any associated data, data files, and data structures so that they can be read by a computer system or processing device. Examples of a non-transitory computer-readable storage medium include read-only memory (ROM), random-access memory (RAM), flash memory, CD-ROMs, CD-Rs, CD+Rs, CD-RWs, CD+RWs, DVD-ROMs, DVD-Rs, DVD+Rs, DVD-RWs, DVD+RWs, DVD-RAMs, BD-ROMs, BD-Rs, BD-R LTHs, BD-REs, magnetic tapes, floppy disks, magneto-optical data storage devices, optical data storage devices, hard disks, solid-state disks, or any other non-transitory computer-readable storage medium known to one of ordinary skill in the art.

[0130] Functional programs, codes, and code segments for implementing the examples disclosed herein can be easily constructed by a programmer skilled in the art to which the examples pertain based on the drawings and their corresponding descriptions as provided herein.

[0131] While this disclosure includes specific examples, it will be apparent to one of ordinary skill in the art that various changes in form and details may be made in these examples without departing from the scope of the claims. The examples described herein are to be considered in a descriptive sense only, and not for purposes of limitation. Descriptions of features or aspects in each example are to be considered as being applicable to similar features or aspects in other examples. Suitable results may be achieved if the described techniques are performed in a different order, and/or if components in a described system, architecture, device, or circuit are combined in a different manner, and/or replaced or supplemented by other components or their equivalents. Therefore, the scope of the disclosure is defined not by the detailed description, but by the claims, and all variations within the scope of the claims are to be construed as being included in the disclosure.

Claims

1. An apparatus (102, 501) for estimating a one repetition maximum (1RM), the apparatus **characterised in that** it comprises:

a potential signal receiving unit (103) configured to receive a signal of a muscle membrane potential from a sensor (301, 502, 701) attached to a user repeatedly lifting a weight; and
a 1RM estimating unit (104, 201, 304, 503, 601, 703) configured to estimate a 1RM of the user based on the muscle membrane potential signal.

2. The apparatus of claim 1, wherein the 1 RM estimating unit comprises:

an envelope determining unit (202, 602) configured to determine an envelope of amplitudes of the muscle membrane potential signal;
a frequency spectrum determining unit (203, 603) configured to determine a frequency spectrum including a mean frequency of the muscle membrane potential signal; and
a gradient determining unit (204, 604) configured to determine a gradient based on a plurality of feature points in the frequency spectrum corresponding to peaks of the envelope.

3. The apparatus of claim 2, wherein the envelope determining unit (202, 602) is further configured to determine the envelope based on an absolute value of the muscle membrane potential signal.

4. The apparatus of claim 3, wherein the envelope determining unit (202, 602) is configured to determine the envelope by integrating the absolute value of the muscle membrane potential signal, in particular by integrating for a predetermined time period.

5. The apparatus of one of claims 2 to 4, wherein the frequency spectrum determining unit (203, 603) is further configured to determine the frequency spectrum based on the muscle membrane potential signal of a predetermined interval based on a maximum value of the envelope.

6. A method of estimating a one repetition maximum (1 RM), the method **characterised in that** it comprises:

receiving a signal of a muscle membrane potential from a sensor attached to a user repeatedly lifting a weight; and
estimating a 1 RM of the user based on the muscle membrane potential signal.

7. The method of claim 6, wherein the estimating comprises:

   determining an envelope of amplitudes of the muscle membrane potential signal;
   determining a frequency spectrum based on a mean frequency of the muscle membrane potential signal; and
   determining a gradient based on a plurality of feature points in the frequency spectrum corresponding to peaks of the envelope.

8. The method of claim 7, wherein the determining of the envelope comprises determining the envelope based on an absolute value of the muscle membrane potential signal.

9. The method of claim 8, wherein the determining of the envelope comprises determining the envelope by integrating the absolute value of the muscle membrane potential signal, in particular by integrating for a predetermined time period.

10. The method of one of claims 7 to 9, wherein the determining of the frequency spectrum comprises determining the frequency spectrum based on the muscle membrane potential signal of a predetermined interval based on a maximum value of the envelope.

Patentansprüche

1. Vorrichtung (102, 501) zum Schätzen eines Maximums für eine Wiederholung (1 RM), wobei die Vorrichtung **dadurch gekennzeichnet ist, dass** sie umfasst:

   eine Potentialsignal-Empfangseinheit (103), die dazu konfiguriert ist, ein Signal eines Muskelmembranpotentials von einem Sensor (301, 502, 701) zu empfangen, der an einem Benutzer befestigt ist, welcher wiederholt ein Gewicht hebt; und
   eine 1 RM-Schätzeinheit (104, 201, 304, 503, 601, 703), die dazu konfiguriert ist, 1RM des Benutzers basierend auf dem Signal des Muskelmembranpotentials zu schätzen.

2. Vorrichtung nach Anspruch 1, wobei die 1 RM-Schätzeinheit umfasst:

   eine Hüllkurven-Bestimmungseinheit (202, 602), die dazu konfiguriert ist, eine Hüllkurve der Amplituden des Signals des Muskelmembranpotentials zu bestimmen;
   eine Frequenzspektrum-Bestimmungseinheit (203, 603), die dazu konfiguriert ist, ein Frequenzspektrum zu bestimmen, welches eine mittlere Frequenz des Signals des Muskelmembranpotentials beinhaltet; und
   eine Gradienten-Bestimmungseinheit (204, 604), die dazu konfiguriert ist, einen Gradienten basierend auf einer Vielzahl von Merkmalspunkten in dem Frequenzspektrum zu bestimmen, welche Spitzen der Hüllkurven entsprechen.

3. Vorrichtung nach Anspruch 2, wobei die Hüllkurven-Bestimmungseinheit (202, 602) des Weiteren dazu konfiguriert ist, die Hüllkurve basierend auf einem absoluten Wert des Signals des Muskelmembranpotentials zu bestimmen.

4. Vorrichtung nach Anspruch 3, wobei die Hüllkurven-Bestimmungseinheit (202, 602) dazu konfiguriert ist, die Hüllkurve durch Integrieren des absoluten Werts des Signals des Muskelmembranpotentials, insbesondere durch Integrieren für eine vorgegebene Zeitspanne zu bestimmen.

5. Vorrichtung nach einem der Ansprüche 2 bis 4, wobei Frequenzspektrum-Bestimmungseinheit (203, 603) des Weiteren dazu konfiguriert ist, das Frequenzspektrum basierend auf dem Signal des Muskelmembranpotentials eines vorgegebenen Intervalls basierend auf einem Maximalwert der Hüllkurve zu bestimmen.

6. Verfahren zum Schätzen eines Maximums für eine Wiederholung (1RM), **dadurch gekennzeichnet, dass** es umfasst:

   Empfangen eines Signals eines Muskelmembranpotentials von einem Sensor, der an einem Benutzer befestigt ist, welcher wiederholt ein Gewicht hebt; und
   Schätzen von 1RM des Benutzers basierend auf dem Signal des Muskelmembranpotentials.

7. Verfahren nach Anspruch 6, wobei das Schätzen umfasst:

Bestimmen einer Hüllkurve der Amplituden des Signals des Muskelmembranpotentials;
Bestimmen eines Frequenzspektrums basierend auf einer mittleren Frequenz des Signals des Muskelmembranpotentials; und
Bestimmen eines Gradienten basierend auf einer Vielzahl von Merkmalspunkten in dem Frequenzspektrum, welche Spitzen der Hüllkurven entsprechen.

8. Verfahren nach Anspruch 7, wobei das Bestimmen der Hüllkurve das Bestimmen der Hüllkurve basierend auf einem absoluten Wert des Signals des Muskelmembranpotentials umfasst.

9. Verfahren nach Anspruch 8, wobei das Bestimmen der Hüllkurve das Bestimmen der Hüllkurve durch Integrieren des absoluten Werts des Signals des Muskelmembranpotentials, insbesondere durch Integrieren für eine vorgegebene Zeitspanne umfasst.

10. Verfahren nach einem der Ansprüche 7 bis 9, wobei das Bestimmen des Frequenzspektrums das Bestimmen des Frequenzspektrums basierend auf dem Signal des Muskelmembranpotentials eines vorgegebenen Intervalls basierend auf einem Maximalwert der Hüllkurve umfasst.

Revendications

1. Appareil (102, 501) pour estimer un maximum sans répétition (1RM), l'appareil étant **caractérisé en ce qu'**il comprend :

une unité réceptrice de signal de potentiel (103) configurée pour recevoir un signal d'un potentiel de membrane de muscle de la part d'un capteur (301, 502, 701) attaché à l'utilisateur soulevant un poids de façon répétitive ; et
une unité d'estimation 1RM (104, 201, 304, 503, 601, 703) configurée pour estimer un 1 RM de l'utilisateur sur la base du signal de potentiel de membrane de muscle.

2. Appareil selon la revendication 1, dans lequel l'unité d'estimation 1 RM comprend :

une unité de détermination d'enveloppe (202, 602) configurée pour déterminer une enveloppe d'amplitudes du signal de potentiel de membrane de muscle ;
une unité de détermination de spectre de fréquence (203, 603) configurée pour déterminer un spectre de fréquence incluant une fréquence moyenne du signal de potentiel de membrane de muscle ; et
une unité de détermination de gradient (204, 604) configurée pour déterminer un gradient sur la base d'une pluralité de points représentatifs dans le spectre de fréquence correspondant à des pics de l'enveloppe.

3. Appareil selon la revendication 2, dans lequel l'unité de détermination d'enveloppe (202, 602) est en outre configurée pour déterminer l'enveloppe sur la base d'une valeur absolue du signal de potentiel de membrane de muscle.

4. Appareil selon la revendication 3, dans lequel l'unité de détermination d'enveloppe (202, 602) est configurée pour déterminer l'enveloppe par intégration de la valeur absolue du signal de potentiel de membrane de muscle, en particulier par intégration sur une durée prédéterminée.

5. Appareil selon l'une des revendications 2 à 4, dans lequel l'unité de détermination de spectre de fréquence (203, 603) est en outre configurée pour déterminer le spectre de fréquence sur la base du signal de potentiel de membrane de muscle d'un intervalle prédéterminé sur la base d'une valeur maximale de l'enveloppe.

6. Procédé d'estimation d'un maximum sans répétition (1 RM), le procédé étant **caractérisé en ce qu'**il comprend :

la réception d'un signal d'un potentiel de membrane de muscle de la part d'un capteur attaché à un utilisateur soulevant un poids de façon répétitive ; et
l'estimation d'un 1RM de l'utilisateur sur la base du signal de potentiel de membrane de muscle.

7. Procédé selon la revendication 6, dans lequel l'estimation comprend :

la détermination d’une enveloppe d’amplitudes du signal de potentiel de membrane de muscle ;
la détermination d’un spectre de fréquence sur la base d’une fréquence moyenne du signal de potentiel de membrane de muscle ; et
la détermination d’un gradient sur la base d’une pluralité de points représentatifs dans le spectre de fréquence correspondant à des pics de l’enveloppe.

8. Procédé selon la revendication 7, dans lequel la détermination de l’enveloppe comprend la détermination de l’enveloppe sur la base d’une valeur absolue du signal de potentiel de membrane de muscle.

9. Procédé selon la revendication 8, dans lequel la détermination de l’enveloppe comprend la détermination de l’enveloppe par intégration de la valeur absolue du signal de potentiel de membrane de muscle, en particulier par intégration sur une durée prédéterminée.

10. Procédé selon l’une des revendications 7 à 9, dans lequel la détermination du spectre de fréquence comprend la détermination du spectre de fréquence sur la base du signal de potentiel de membrane de muscle d’un intervalle prédéterminé sur la base d’une valeur maximale de l’enveloppe.

FIG. 1

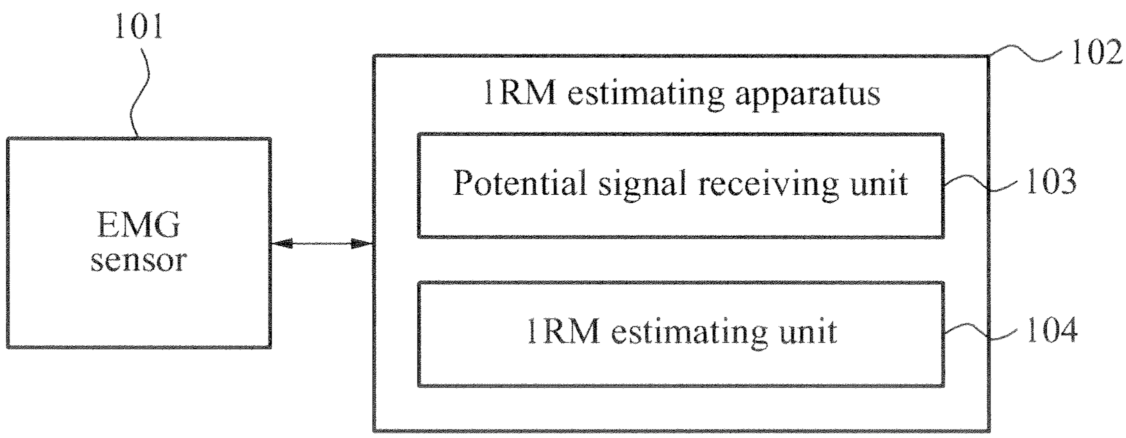

101
EMG sensor
102
1RM estimating apparatus
Potential signal receiving unit
103
1RM estimating unit
104

FIG. 2

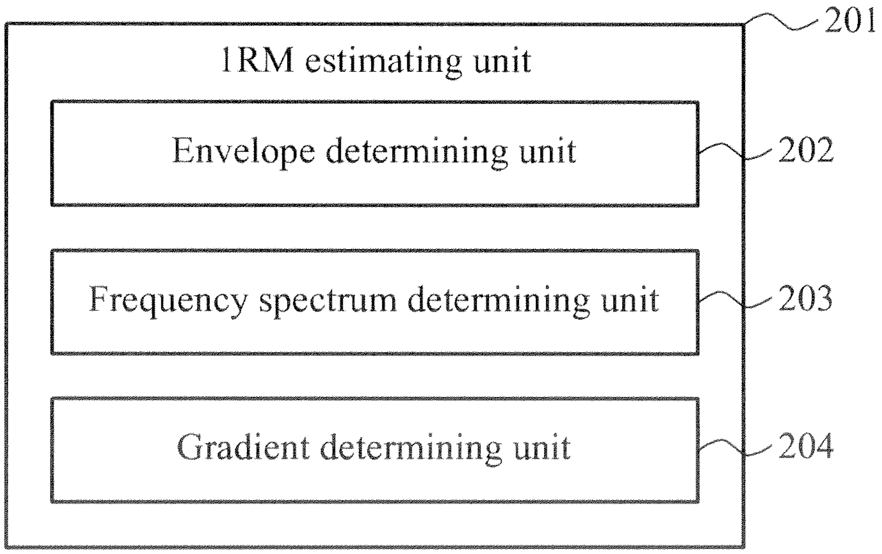

201
1RM estimating unit
Envelope determining unit
202
Frequency spectrum determining unit
203
Gradient determining unit
204

FIG. 3

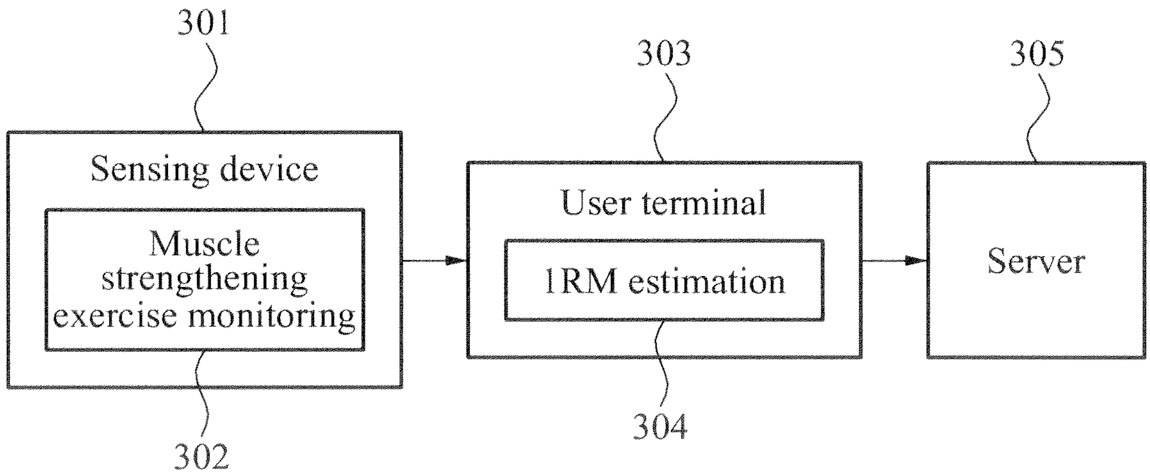

301
303
305
Sensing device
Muscle strengthening exercise monitoring
User terminal
1RM estimation
Server
302
304

FIG. 4

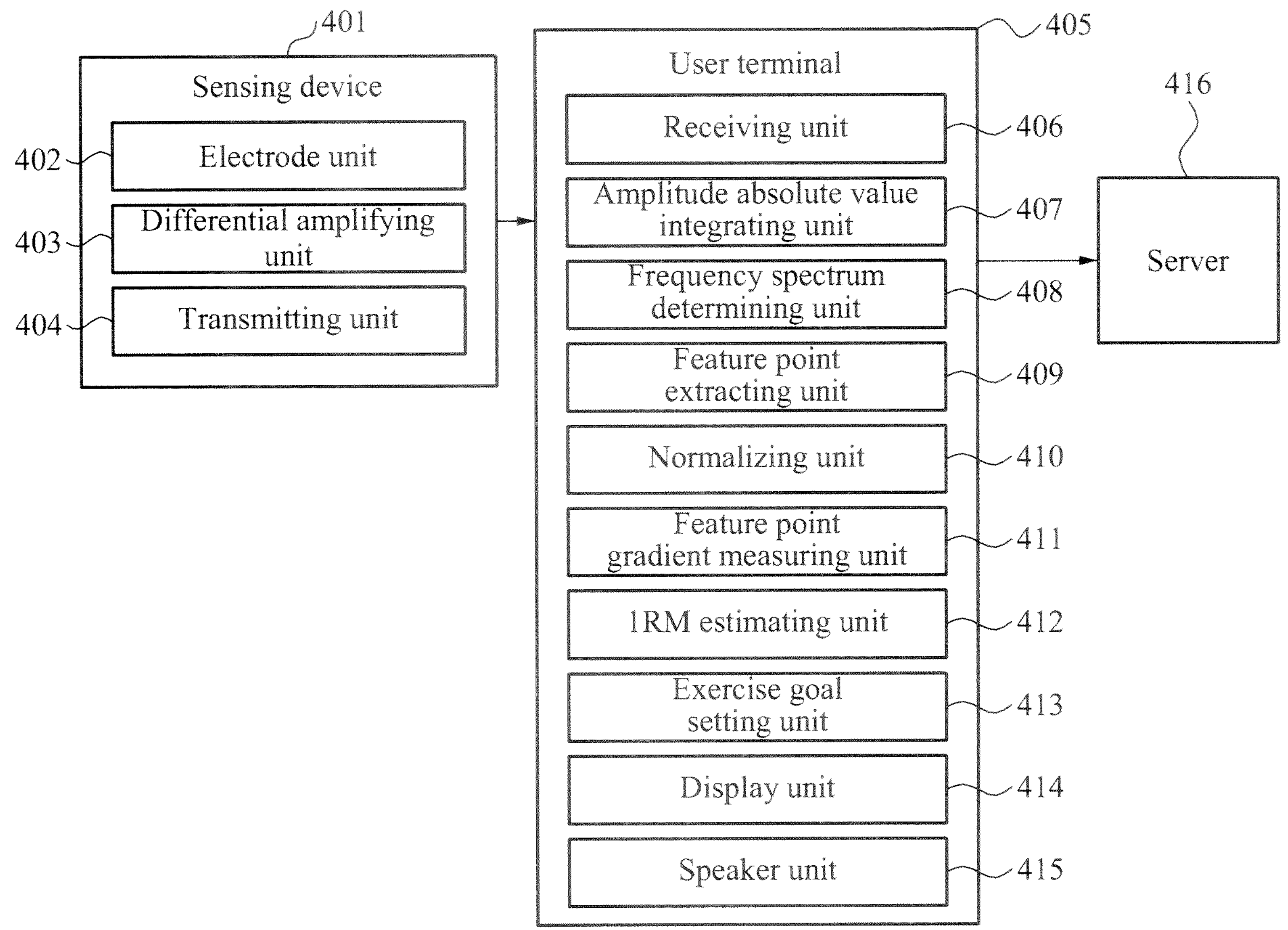

401
Sensing device
402
Electrode unit
403
Differential amplifying unit
404
Transmitting unit
405
User terminal
Receiving unit
406
Amplitude absolute value integrating unit
407
Frequency spectrum determining unit
408
Feature point extracting unit
409
Normalizing unit
410
Feature point gradient measuring unit
411
1RM estimating unit
412
Exercise goal setting unit
413
Display unit
414
Speaker unit
415
416
Server

FIG. 5

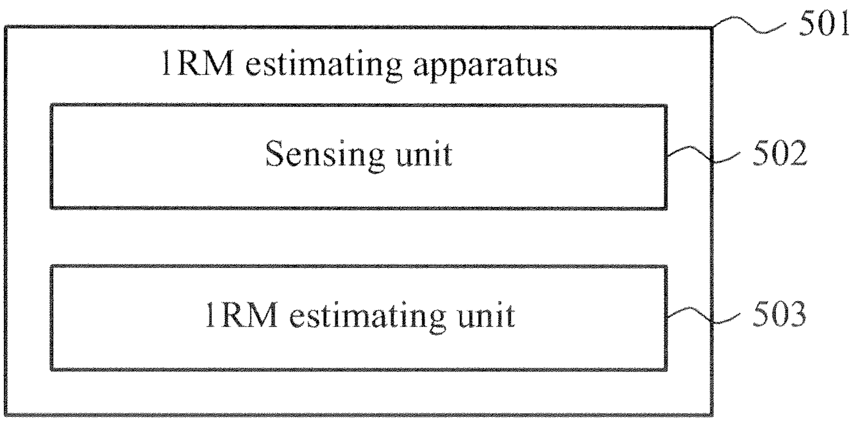

1RM estimating apparatus
Sensing unit
1RM estimating unit
501
502
503

FIG. 6

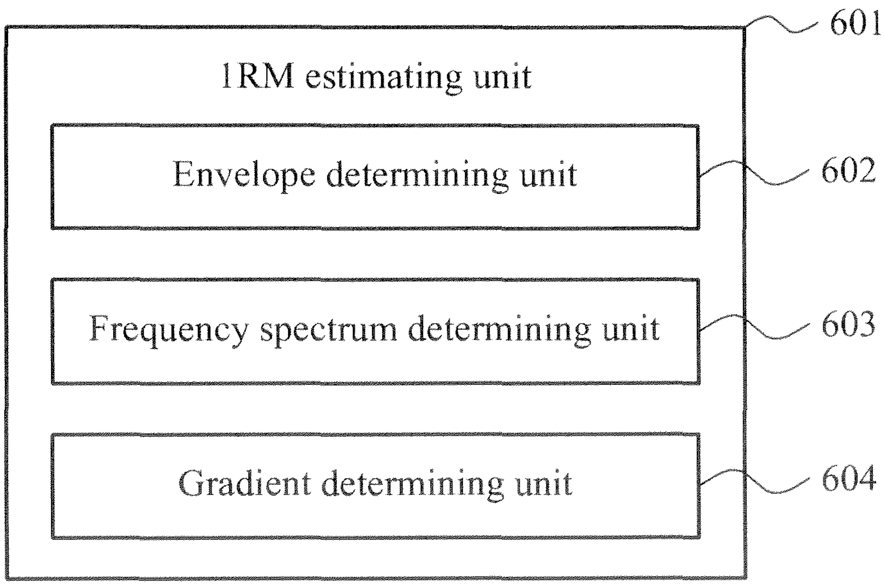

601
1RM estimating unit
Envelope determining unit
602
Frequency spectrum determining unit
603
Gradient determining unit
604

FIG. 7

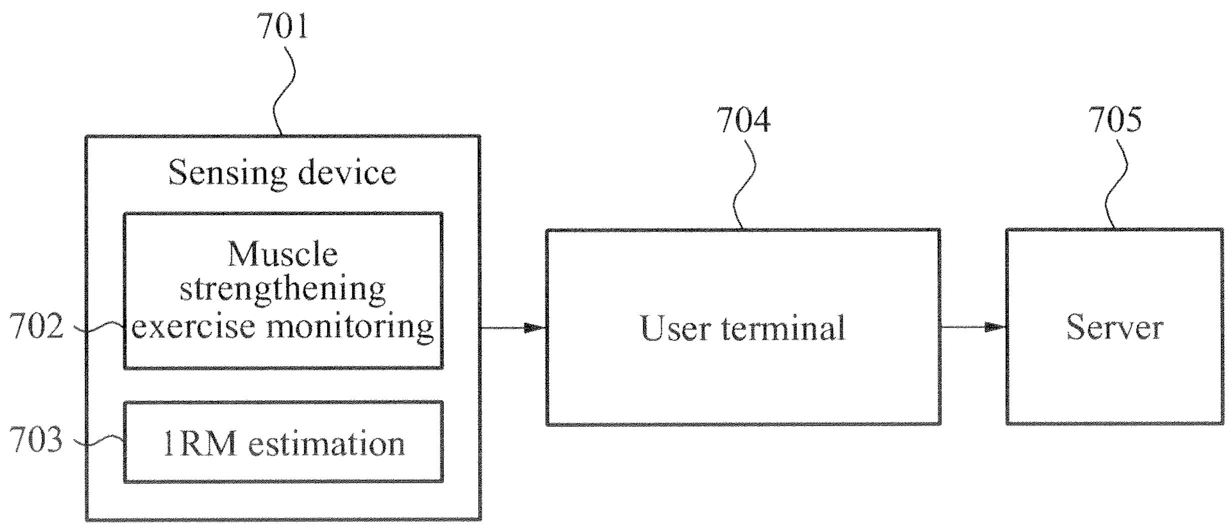

701
704
705
Sensing device
Muscle strengthening exercise monitoring
702
703
1RM estimation
User terminal
Server

FIG. 8

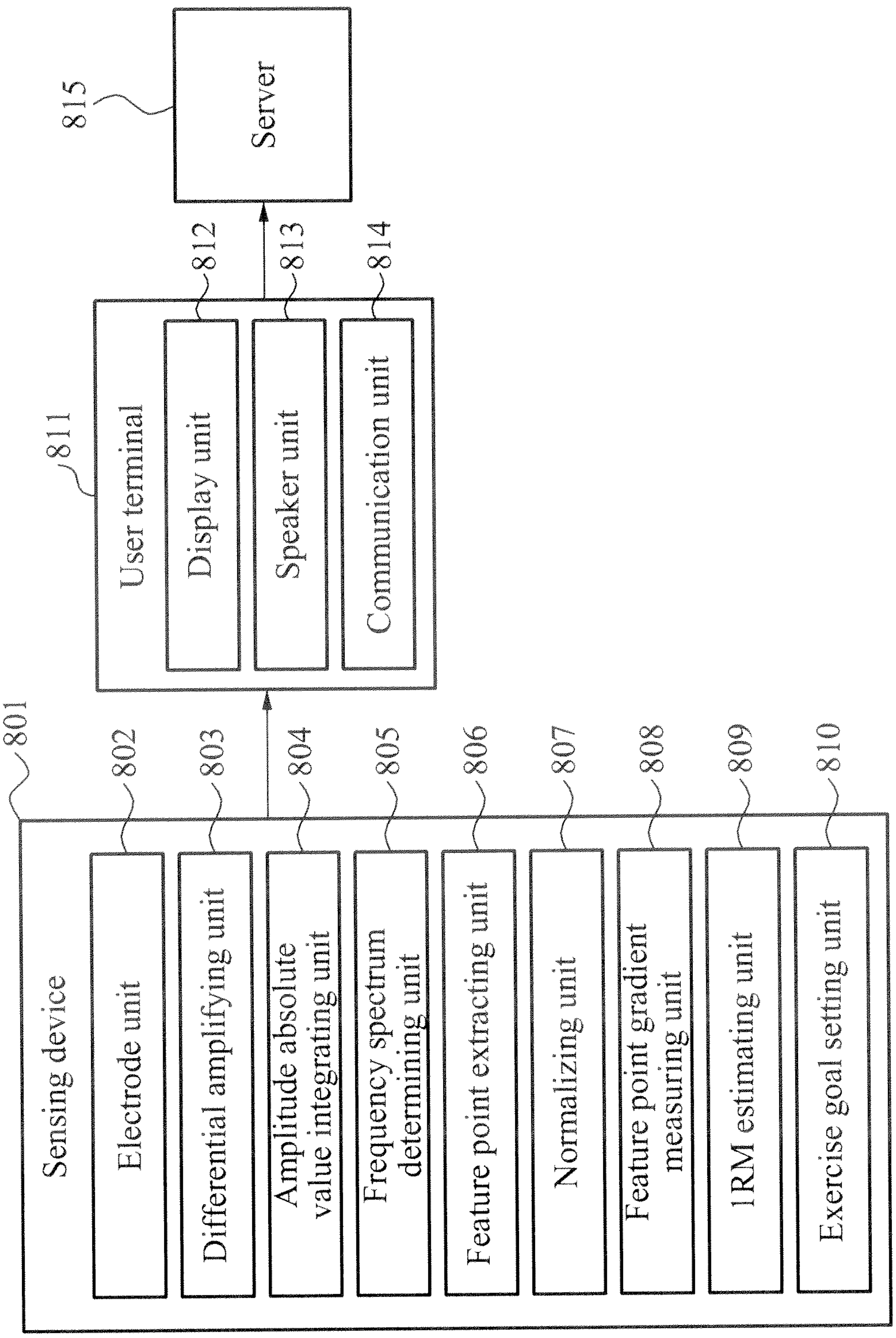

815
Server
811
User terminal
812
Display unit
813
Speaker unit
814
Communication unit
801
Sensing device
802
Electrode unit
803
Differential amplifying unit
804
Amplitude absolute value integrating unit
805
Frequency spectrum determining unit
806
Feature point extracting unit
807
Normalizing unit
808
Feature point gradient measuring unit
809
1RM estimating unit
810
Exercise goal setting unit

FIG. 9

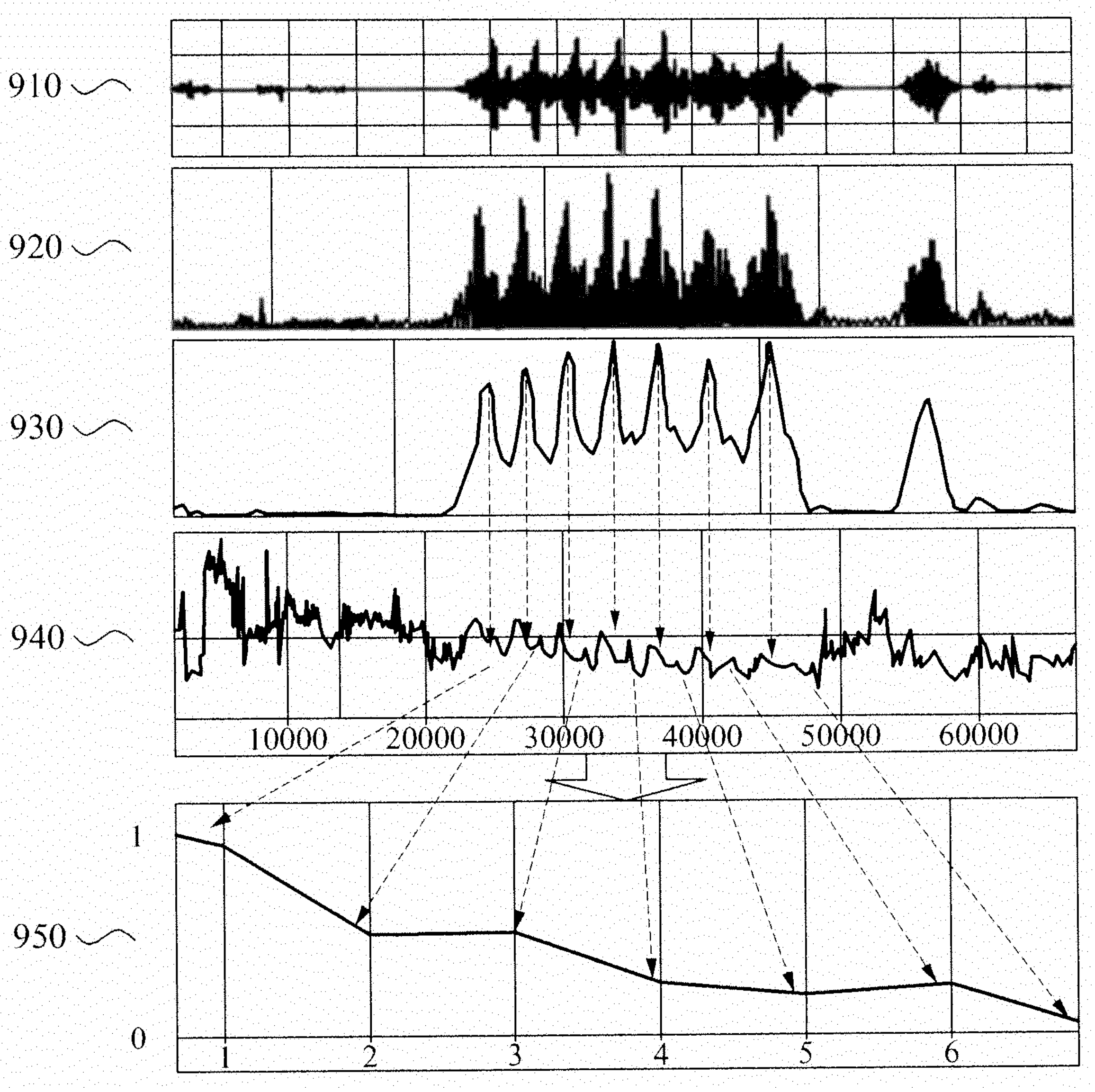

910
920
930
940
10000
20000
30000
40000
50000
60000
950
1
0
1
2
3
4
5
6

FIG. 10

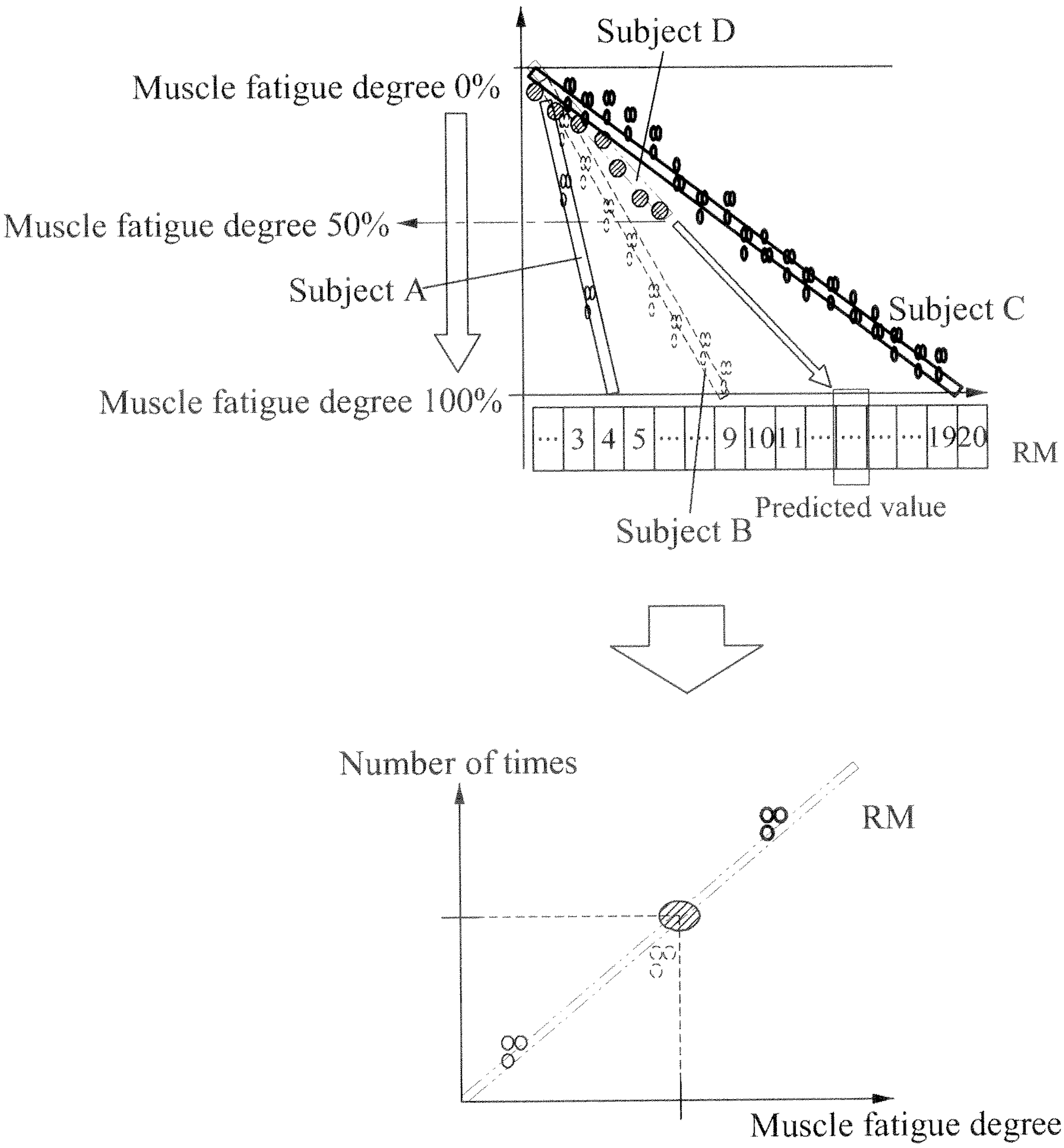

Subject D
Muscle fatigue degree 0%
Muscle fatigue degree 50%
Subject A
Subject C
Muscle fatigue degree 100%
… 3 4 5 … … 9 10 11 … … … … 19 20
RM
Predicted value
Subject B
Number of times
RM
Muscle fatigue degree

FIG. 11

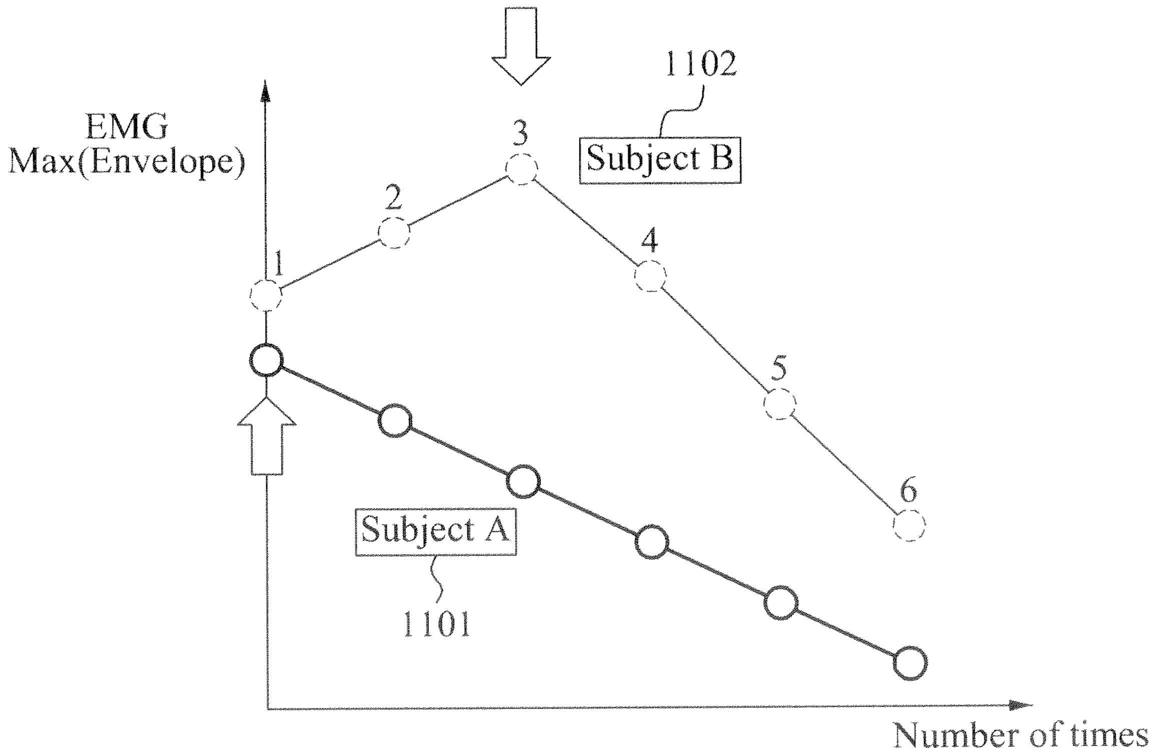
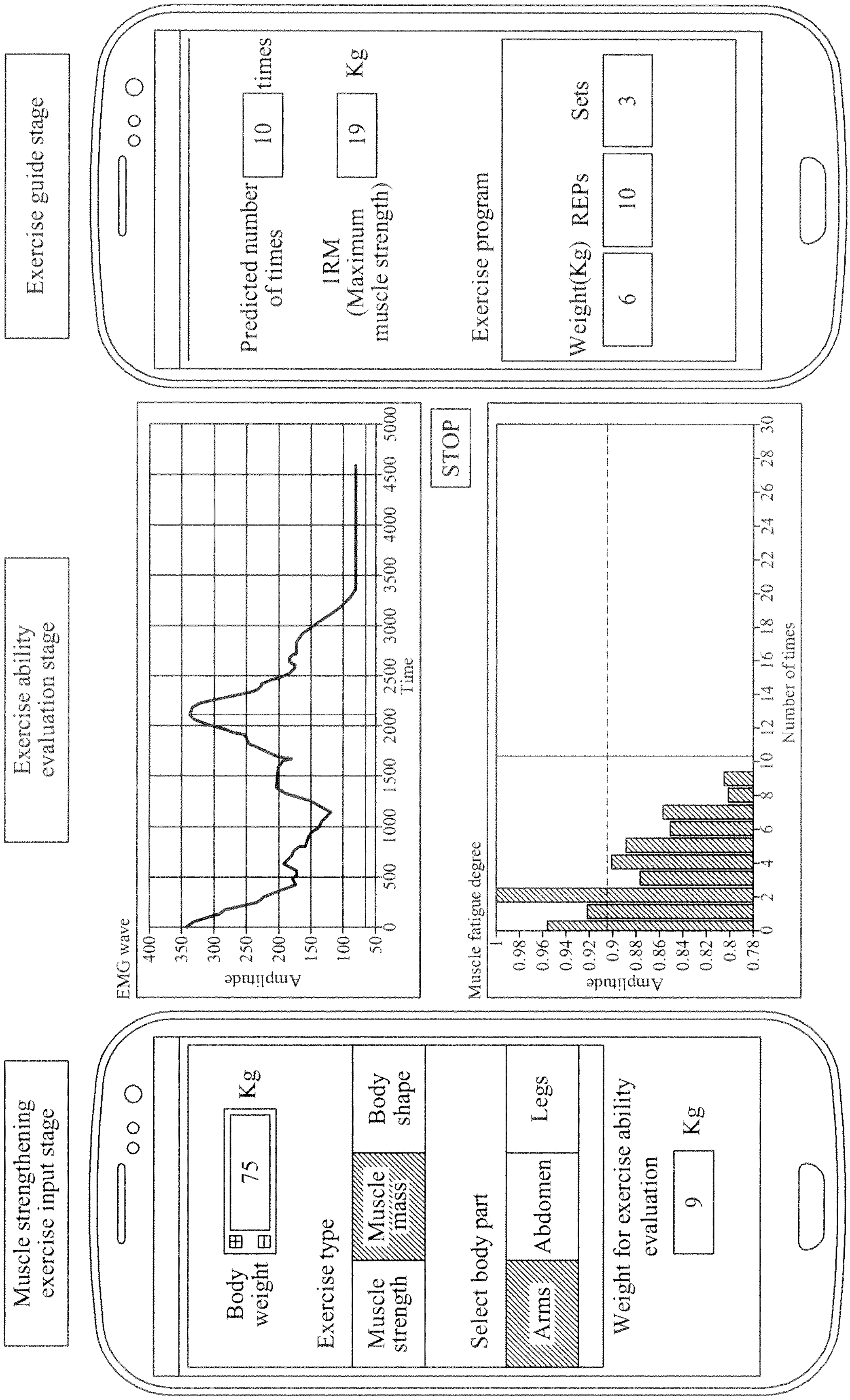

EMG
Max(Envelope)
1102
Subject B
1
2
3
4
5
6
Subject A
1101
Number of times

FIG. 12


Muscle strengthening exercise input stage
Body weight
75
Kg
Exercise type
Muscle strength
Muscle mass
Body shape
Select body part
Arms
Abdomen
Legs
Weight for exercise ability evaluation
9
Kg
Exercise ability evaluation stage
EMG wave
Amplitude
Time
STOP
Muscle fatigue degree
Amplitude
Number of times
Exercise guide stage
Predicted number of times
10
times
1RM (Maximum muscle strength)
19
Kg
Exercise program
Weight(Kg)
REPs
Sets
6
10
3

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- WO 2007021062 A1 **[0004]**
- EP 1413250 A1 **[0005]**
- US 2008204225 A1 **[0006]**

Non-patent literature cited in the description

- **SOUZA CASTELO OLIVEIRA et al.** *Lumbar muscles recruitment during resistance exercise for upper limbs* **[0007]**

专利名称(译)	一个重复最大（1RM）估计设备和方法		
公开(公告)号	[EP2732763B1]	公开(公告)日	2016-09-14
申请号	EP2013192609	申请日	2013-11-13
[标]申请(专利权)人(译)	三星电子株式会社		
申请(专利权)人(译)	三星电子有限公司		
当前申请(专利权)人(译)	三星电子有限公司		
[标]发明人	KIM YOUN HO BAE SANG KON CHOI CHANG MOK KO BYUNG HOON SHIN KUN SOO		
发明人	KIM, YOUN HO BAE, SANG KON CHOI, CHANG MOK KO, BYUNG HOON SHIN, KUN SOO		
IPC分类号	A61B5/22 A61B5/0488 A61B5/00		
CPC分类号	A61B5/224 A61B5/0488 A61B5/6801 A61B5/7235 A61B5/7242 A61B5/7257		
优先权	1020120130458 2012-11-16 KR		
其他公开文献	EP2732763A1		
外部链接	[Espacenet]		

摘要(译)

一个重复最大值（1RM）估计装置包括：电位信号接收单元，被配置为从附接到用户的传感器接收肌肉的电位信号;以及1RR估计单元，被配置为基于用户估计用户的1RR。潜在的信号。

$$1RM = \frac{load}{0.488 + \left(0.538 \cdot e^{-0.075 \cdot REPS}\right)} \quad (1)$$