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(54) METHOD AND APPARATUS FOR TRAINING MUSCLE STRENGTH THROUGH PROGRESSIVE RESISTANCE EXERCISE

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(57) **ABSTRACT**

An apparatus for enhancing muscle strength is designed based on a curve of relation between joint angle and producible muscle strength, and includes a resistance-varying device that provides progressive resistances to give a trainee's body area being trained the most suitable load when the joint angle at the trained area changes. The resistance-varying device is embodied through serially connected four-bar linkages, two-bar linkages, or tension cords pivotally connected to one lateral side of weights of the apparatus with pins. Strength exerted by the trainee at the trained area is transmitted via a steel cord to pull a top weight upward and sequentially stretch the linkages or tension cords open, so that subsequent weights are pulled upward one by one until the last linkage or tension cord is fully stretched. A method using the apparatus to enhance muscle strength meets the human engineering and avoids unwanted injury of trained muscles.

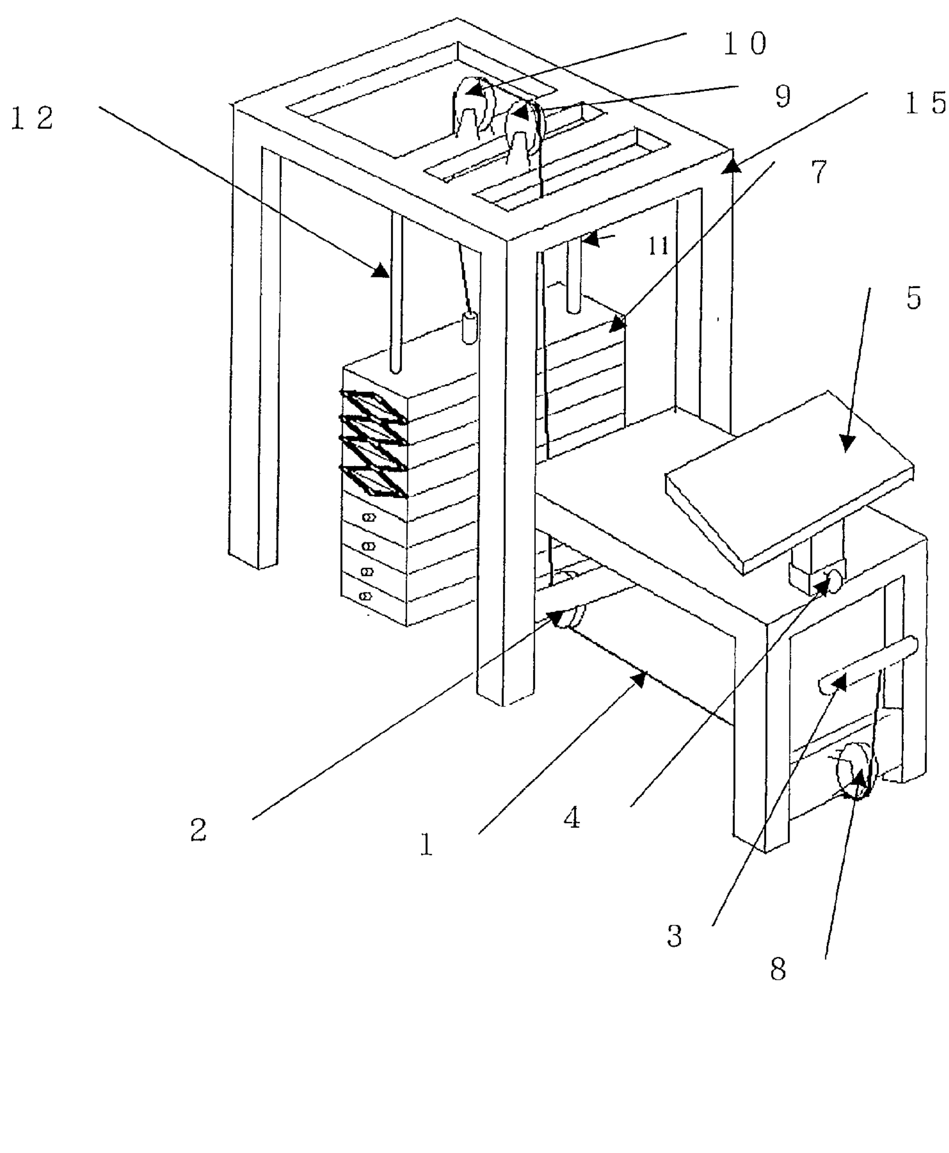


FIG.1

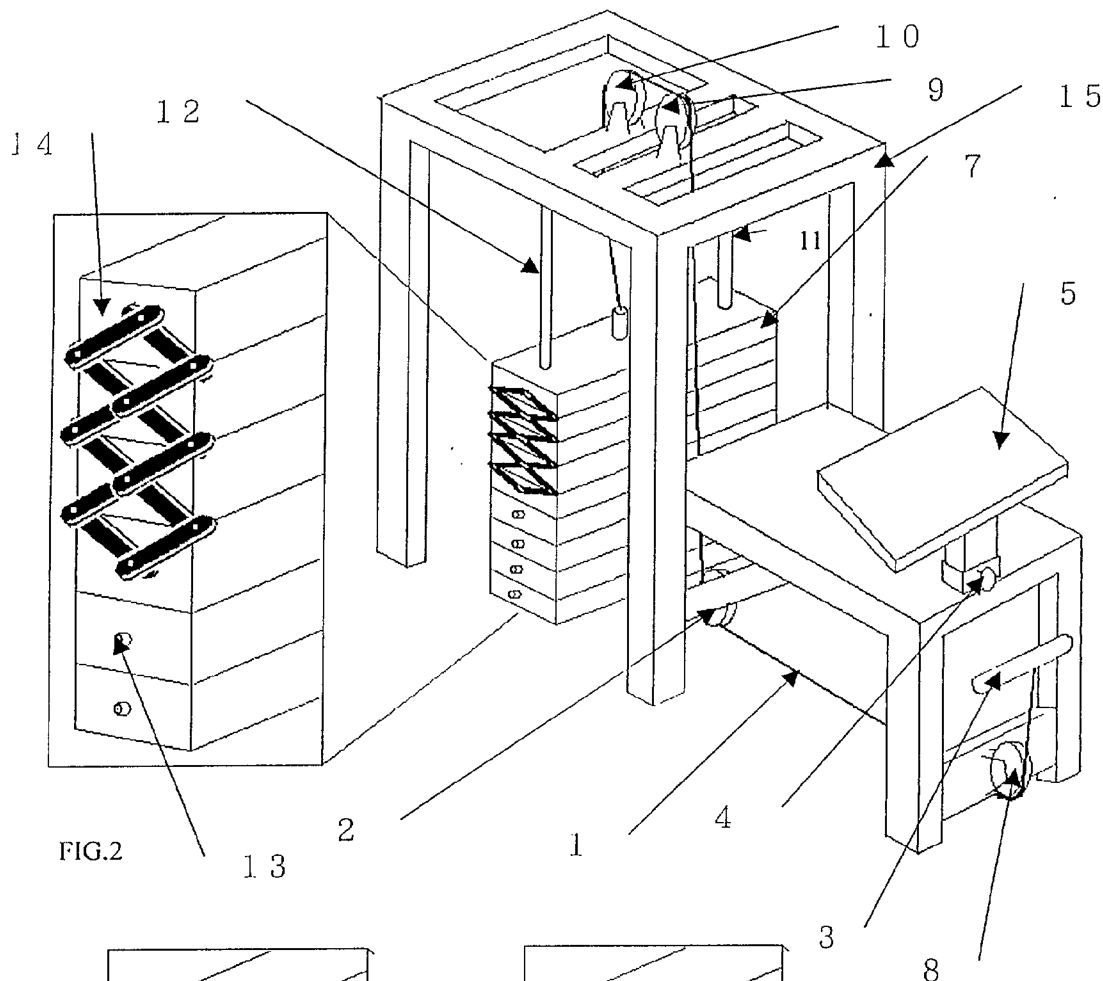
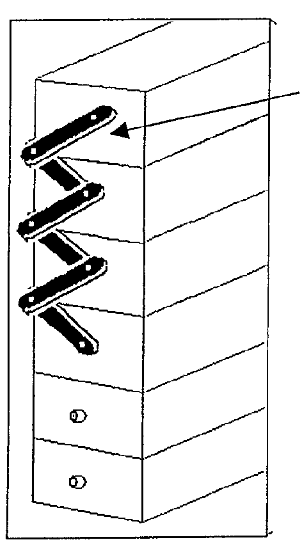


FIG.2



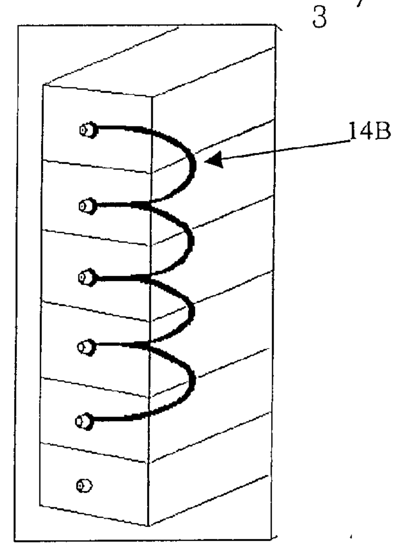


FIG.3

FIG.4

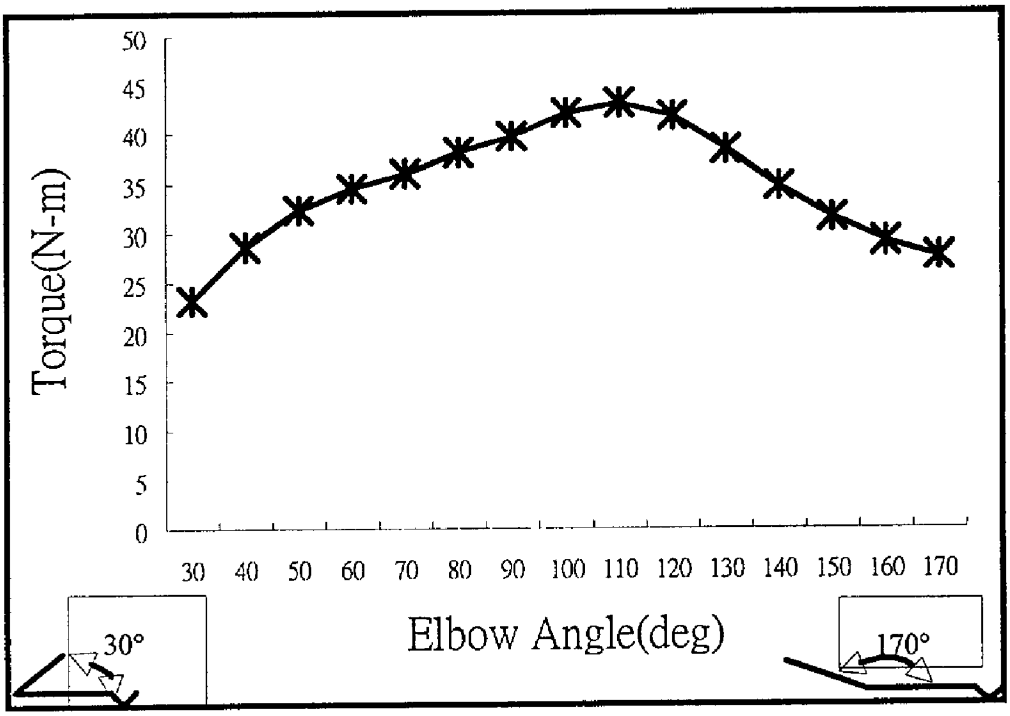

50
45
40
35
30
25
20
15
10
5
0
Torque(N-m)
30 40 50 60 70 80 90 100 110 120 130 140 150 160 170
Elbow Angle(deg)
30°
170°

FIG.5

METHOD AND APPARATUS FOR TRAINING MUSCLE STRENGTH THROUGH PROGRESSIVE RESISTANCE EXERCISE

BACKGROUND OF THE INVENTION

[0001] The present invention relates to method and apparatus for enhancing muscle strength through progressive resistance, and more particularly to a muscle training apparatus that provides progressively increased resistance to a trainee's body area being trained to meet a curve of relation between joint angle and producible strength thereof.

[0002] Muscle contraction is a source of strength needed by humans in their motions. When muscles contract, bones connected to the muscles are brought to turn about joints as a result of leverage, allowing the torso and limbs to translate, turn, etc. When multiple joints cooperatively work at the same time, a person can do various motions, such as running, jumping, throwing, etc. Movement of joints involves leverage between muscles and bones, as well as the muscular contractible length. The strength producible by muscles has relation to the lengths of muscles, and muscles are connected at outer ends to bones to provide points of application. When the muscles contract to produce strength, the produced strength acts on the bones at these points of application to cause turning of joints, and therefore changes the direction of applied force as well as the angle contained between arms of force (that is, the bones that turn about the joints). Thus, the strength producible at a joint has absolute relation to the joint angle. Similarly, the strength producible by a person's torso and limbs has relation to joint angles. And, the relation between the joint angle and the producible strength thereof varies with joint motions. Taking the flexion of an elbow joint as an example, a Curve of Relation Between Elbow Angle and Torque (Ping-chan Lai, (1999) Master's thesis from the Graduate Institute of Coaching Science National College of Physical Education & Sports) shown in **FIG. 5** indicates when the elbow flexes from a horizontal position (stretched to 180 degrees) toward the torso, the producible strength increases with the increased degree of flexion (or decreased elbow angle), and the producible strength reaches a peak value when the elbow angle is about 110 degrees, and then the producible strength decreases with the gradually decreased elbow angle.

[0003] According to muscular physiology, by "muscle contraction", it means a group of muscle fibers become shortened when they slide relative to one another. Generally speaking, muscle contraction can be divided into isometric contraction, isotonic contraction, isokinetic contraction, etc. according to the form of contraction. Wherein, the isotonic contraction can be further divided into concentric contraction and eccentric contraction according to the consistence in the directions of the applied force and the muscle contraction. Muscles can be trained in different ways based on the characteristics of muscle contraction as follows:

[0004] 1. Isoload training—In this way of training, muscles contract at a speed and in a tension that vary with time.

[0005] 2. Isometric training—In this way of training, muscles contract with the lengths thereof keeping unchanged.

[0006] 3. Isotonic training—In this way of training, muscles contract with the tensions thereof keeping unchanged.

[0007] 4. Isokinetic training—In this way of training, muscles contract at a constant speed.

[0008] 5. Functional isometric training—In this way of training, muscles first contract isometrically and then contract isotonically.

[0009] 6. Plyometrics training—In this way of training, muscles are first passively stretched (that is, to contract eccentrically) and then quickly contract concentrically. This type of training is characterized in a stretch shortening cycle (SSC).

[0010] 7. Train muscles by giving electrical stimulation to cause passive contraction of muscles.

[0011] Among the above-described muscle training ways, the isometric, the isotonic, and the isokinetic trainings are widely acceptable by the general public. As to other muscle training ways, they are adopted by specific groups of people, such as athletes, patients requiring rehabilitation, etc.

[0012] The isometric training has the advantages of (a) not requiring any special instrument, (b) performable at any place and at any time, and (c) easy to perform; and the disadvantages of (a) having lower training effect, (b) tending to cause fatigued muscles, and (c) failing to provide concentrated training of particular muscle groups.

[0013] The isotonic training has the advantages of (a) providing pretty good training effect, (b) enabling concentrated training of particular muscle groups, and (c) easy to perform; and the disadvantages of (a) having theoretical limitations, (b) requiring training instruments, and (c) tending to cause fatigued and injured muscles.

[0014] The isokinetic training has the advantages of (a) providing very good training effect, (b) enabling concentrated training of particular muscle groups, and (c) meeting related theories, and the disadvantages of (a) requiring special training instruments, (b) requiring high cost for the special instruments, and (c) not easy to operate the special instruments.

[0015] Currently, the isometric training is normally adopted only at an initial stage of rehabilitation and not widely utilized among the general public because it does not provide good effect in enhancing the muscle strength and fails to provide training of specific muscle groups, though it can be performed without using any special instrument.

[0016] Generally, the isotonic training must be performed with some instruments, such as free-weight and training machines. Training machines are widely employed in muscle training and formed from rather simple link mechanisms. In a machine for isotonic training, the heaviness of weights serves as a resistance and is transmitted via a steel cord and many direction-control pulleys to a trainee's torso and limbs to be trained. The training machine can be designed to train specific muscle groups and manufactured at rather low cost. It occupies only a very small space, and can be conveniently operated for a user to use it independently, and is therefore widely accepted among the general public. A disadvantage of the isotonic training is it tends to cause delayed muscle soreness (DOMS) after performing the training. Moreover, the isotonic training does not provide so good training effect as compared with the isokinetic training.

[0017] The isokinetic training uses an isokinetic training machine to control the trainee's motion speed, so that the muscle groups to be trained always exert the maximal strength at any joint angle and contract dynamically at a fixed speed to adapt to contraction speeds of different types of motions. Therefore, the isokinetic training is a currently recognized most effective way of muscle training that does not easily cause any sequelae, such as fatigue or soreness of muscles. However, a full set of isokinetic training machine typically includes many instruments, such as a computer for recording purpose, a monitor for displaying data, a strength measuring system, a multipurpose chair for taking measurements, and auxiliary brackets adaptable to different joints. These instruments occupy an area of at least 10 square meters, and require well-trained personnel to watch and operate, not to mention the extremely high cost thereof.

[0018] In conclusion, the isotonic training machine has combined advantages of economical cost, convenient operation, safe for use, and good training effect, and is currently the most common means for training muscles. Although the isokinetic training machine is recognized as the most effective way for training muscles, general training organizations and users do not afford it due to the expensive price and high costs for management and maintenance thereof. As a result, the isokinetic training machine is not so popular as the isotonic training machine.

[0019] As having been mentioned above, the strength producible by torso and limbs being trained varies with joint angle. The isotonic training does not provide as good training effect as the isokinetic training mainly because a general isotonic training machine provides a fixed resistance and muscles being trained do not encounter a largest possible resistance when the joint is at an angle to produce the largest strength. It is therefore very natural only a reduced training effect can be obtained on an isotonic training machine.

[0020] Another problem with the isotonic training machine is the existence of the so-called stick point. More specifically, when the resistance is fixed, the stick point means a joint angle at which the producible muscle strength is smaller than the fixed resistance and not sufficient to lift the load. However, when the joint angle increases and exceeds the stick point, the producible muscle strength is large enough to lift the load. The stick point prevents the trainee from continuing the training motions and reduces the training effect. What is worse is the stick point would very possibly result in eccentric contraction of muscles and consequential injury, such as pulled tendon, due to the action of a suddenly generated reverse force.

[0021] An ideal training way is one that could always best respond to the strength that is producible by the muscles within the complete range of motion (ROM) of joint, and therefore allows the muscles to work at the largest tension. In this manner, the load to muscles could be effectively increased to achieve the best training effect.

[0022] Cams have been utilized in an attempt to change the resistance in the complete range of motion of joint, in order to eliminate or reduce the phenomenon of stick point that frequently occurs on general isotonic muscle training machines. Scientific researches have proven the effect of using cams to change the resistance. The following summarizes results of researches on the effects of different training ways.

[0023] In 1982, Silvester et al employed Nautilus and Universal variable-resistance training machines as well as the free weight training manner to train lower limb muscle groups for enhanced knee stretching and pushing strength. The trainings continued for 13 weeks, 3 days each week. Isometric muscle strength producible at the 135-degree stretched knee joint and at the 135-degree coxa as well as changes in vertical leap were measured and compared. The isometric muscle strength and the vertical leap increased by 6.41 kg and 0.69 cm, respectively, on the average when trained with Nautilus machine, 6.46 kg and 2.91 cm when trained with Universal machine, and 8.49 kg and 8.49 cm when trained in the manner of free weight. Only the vertical leap indicated statistical difference between trainings with the variable-resistance training machines and the free weight manner. Another experiment was designed to compare the difference in elbow joint flexions separately trained with dumbbells and Nautilus variable-resistance machine. The trainings continued 8 weeks, 3 days per week. Both trainings indicated statistical difference in the achieved enhancements, but there was not significant difference in the enhancements between the two types of trainings.

[0024] In 1989, Braith et al employed the Nautilus variable-resistance machines to train 4 groups of trainees for their knee stretching strengths. There was a control group that did not do any training. The first group was trained for 10 weeks, 2 days per week; the second group for 18 weeks, 2 days per week; the third group for 10 weeks, 3 days per week; and the fourth group for 18 weeks, 3 days per week. All the four groups showed considerable improvements in muscle strength, no matter they were trained for 10 or 18 weeks. However, the groups trained for 3 days per week showed muscle strengths higher than that of the groups trained for 2 days per week. The fourth group that was trained for total 18 weeks, 3 days per week, showed the isometric muscle strength increased by 28.4%, while the first group that was trained for 10 weeks, 2 days per week, showed the isometric muscle strength increased by 13.5%. The control group did not show any change in the muscle strength.

[0025] From the above data, it is found the variable-resistance training machines provide training effects that are somewhat better than or similar to that obtainable with general fixed-resistance training machines or free-weight training, but lower than that obtainable with the isokinetic training machine. What is to be noted is whether the variable-resistance training machine has been designed to meet the human engineering or not. Since there is not supporting material in the relevant literature, and the training items vary from machine to machine, it is still controvertible whether the comparison results are sufficient to represent the training effects. On the other hand, the use of cams to change the action of resistance has the drawbacks of involving complicate manufacturing process, requiring high manufacturing cost, inconvenient for use, etc. Therefore, it is tried by the inventor to develop an improved method of training muscles that meets the human engineering, and a simple, economical, easily erectable, and conveniently operable apparatus for implementing the method, so that the muscles being trained are always under the largest possible and the most optimal stimulus in the whole training process to obtain enhanced strength and avoid unwanted injury.

SUMMARY OF THE INVENTION

[0026] It is a primary object of the present invention to provide a method for enhancing muscle strength through progressive resistance.

[0027] Another object of the present invention is to provide an apparatus for implementing the method of enhancing muscle strength through progressive resistance. The apparatus is simple, economical, easily erectable, and conveniently operable, and may be used with all brands of weight training instruments.

[0028] The method of the present invention is established on the basis of a proven relation between the joint angle and the producible muscle strength thereof. In a preferred embodiment of the apparatus of the present invention, a resistance-varying device is included to convert a fixed-resistance training structure into a variable-resistance training structure to meet the human engineering and the relation between the joint angle and the producible muscle strength, so that the joints being trained are best trained in the optimal manner to increase the training effect and minimize injury possibly occurred during training.

[0029] To achieve the above and other objects, the apparatus of the present invention uses the above-mentioned relation between the elbow joint flexion angle and the producible strength as its basis and includes a resistance transmitting mechanism to transmit progressive resistances provided through a resistance-varying device, so that a trainee's body area being trained is always given the most suitable load when the joint angle at the trained area changes. That is, the original load in the form of a fixed resistance is changed to a load of variable resistance, and the value of the variable resistance corresponds to the relation between the joint angle and the producible muscle strength. Taking the elbow flexion as an example, since the elbow joint produces a relative smaller strength when it is at an initial angle of flexion of 180 degrees, the apparatus of the present invention applies a relative smaller resistance to the trainee; and when the elbow joint is flexed to an angle of 110 degrees, at which a largest possible muscle strength is producible, the apparatus of the present invention applies a largest possible resistance to the trainee. The resistance applied to the trainee by the apparatus of the present invention gradually decreases when the elbow joint angle becomes smaller and produces less muscle strength.

[0030] The resistance-varying device of the present invention is embodied through a plurality of serially connected four-bar linkages, two-bar linkages, or tension cords being pivotally connected to one lateral side of weights of the apparatus with pins. Strength exerted by the trainee at the trained body area is transmitted via a steel cord and many pulleys to pull a top weight upward and sequentially stretch the linkages or tension cords open, so that subsequent weights are pulled upward one by one until the last linkage or tension cord is fully stretched.

[0031] The method and the apparatus of the present invention for enhancing muscle strength use progressively increased resistance force that meets the theoretical requirement established on the curve of relation between the joint angle and the producible strength as well as the human engineering, allowing the trained joint to always have the optimal load.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032] The structure and the technical means adopted by the present invention to achieve the above and other objects can be best understood by referring to the following detailed description of the preferred embodiments and the accompanying drawings, wherein

[0033] **FIG. 1** is a schematic perspective view of a progressive-resistance type muscle-strength training machine according to a preferred embodiment of the present invention;

[0034] **FIG. 2** is an enlarged perspective view of a resistance-varying device adopted in the muscle-strength training machine of **FIG. 1**;

[0035] **FIG. 3** shows another embodiment of the resistance-varying device included in the muscle-strength training machine of the present invention;

[0036] **FIG. 4** shows a further embodiment of the resistance-varying device included in the muscle-strength training machine of the present invention; and

[0037] **FIG. 5** shows a curve of relation between elbow angle and torque, based on which the method and the apparatus of present invention are developed.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0038] Please refer to **FIG. 1** that is a schematic perspective view of an apparatus according to a preferred embodiment of the present invention for enhancing muscle strength through progressive resistance. As shown, the apparatus mainly includes a steel cord **1** preferred made of a rigid transmission member without elasticity which sequentially passing through a first pulley **8**, an intermediate pulley **2**, a second pulley **9**, and a third pulley **10**; a grip **3** connected to a first end of the steel cord **1**; an upper arm rest **5** provided on a body supporting structure of the apparatus to locate above the grip **3** and be adjustable with a movable pin **4**; a group of weights **7** vertically movably stacked on and between two slide rails **11, 12** with a top one of the weights **7** connected to a second end of the steel cord **1**; and a main steel framework **15**, to which related components, such as the second and the third pulleys **9, 10**, of the apparatus of the present invention are fixed.

[0039] The group of vertically stacked weights **7** is provided at one lateral side with a resistance-varying device. A first embodiment of the resistance-varying device **14** is shown in **FIG. 2** that is an enlarged perspective view of the group of vertically stacked weights **7** of **FIG. 1**. In this embodiment, the resistance-varying device **14** includes three sets of four-bar linkages. **FIG. 3** shows a second embodiment of the resistance-varying device **14A** that includes three sets of two-bar linkages, and **FIG. 4** shows a third embodiment of the resistance-varying device **14B** that includes a plurality of tension cords.

[0040] A trainee (not shown) may sit or lie on the body supporting structure of the apparatus in a suitable position and hold the grip **3** to pull the steel cord **1**. The first pulley **8**, the intermediate pulley **2**, and the second and the third pulleys **9, 10** enable the force exerted by the trainee to transmit via the steel cord **1** to pull the weights **7**. The four-bar or two-bar linkages or the tension cords of the resistance-varying device **14**, **14**A or **14**B provided at the lateral side of the stacked weights **7** are sequentially stretched open to generate progressively increased resistance to the force exerted by the trainee. The trainee's muscle strength is therefore enhanced through the progressive resistance provided by the resistance-varying device **14**, **14**A or **14**B.

[**0041**] In the apparatus of the present invention, the steel cord **1** that transmits the resistance from the weights **7** and the resistance-varying device **14**, **14**A or **14**B to the trainee's body areas to be strengthened; the weights **7** that constitute a source of resistance; the first, the second, and the third pulleys **8**, **9**, **10**, and the intermediate pulley **2** that change directions in which the resistance is transmitted via the steel cord **1**; and a connecting device that is connected to the steel cord **1** to transfer the resistance to the trainee's torso and limbs to be trained together constitute a resistance transmission mechanism. The resistance-varying device **14**, **14**A or **14**B connected to the weights **7** of the resistance transmission mechanism of the apparatus of the present invention is embodied based on the above-mentioned curve of relation Between joint angle and producible muscle strength. That is, when the trainee's joint is at an angle to exert a relatively larger strength, the resistance-varying device enables the apparatus of the present invention to provide a relatively larger resistance to the trainee's trained limbs. Similarly, when the trainee's joint is at an angle to exert only a relatively smaller strength, the resistance-varying device enables the apparatus of the present invention to provide a relatively smaller resistance to the trainee's trained limbs.

[**0042**] The training apparatus of the present invention is particularly different from the general isotonic training machine in the provision of the resistance-varying device. The resistance-varying device **14**, **14**A, or **14**B is formed from a plurality of mutually connected four-bar linkages, two-bar linkages, or tension cords. The four-bar linkages, the two-bar linkages, or the tension cords are connected to the weights **7** by means of pins. When the steel cord **1** is pulled to lift the top one of the group of the stacked weights **7**, the first four-bar linkage, the first two-bar linkage, or the first tension cord in the resistance-varying device **14**, **14**A, or **14**B, respectively, connecting the top weight **7** to the second weight **7** is stretched open and finally pulls the second weight **7** upward. In the course of pulling the steel cord **1** to sequentially stretch open the four-bar linkages, the two-bar linkages, or the tension cords until a corresponding lower weight **7** is finally pulled upward, the resistance provided by the weights **7** to the trainee is progressively increased. As mentioned above, the resistance-varying device **14**, **14**A, or **14**B is embodied based on the previously described curve of relation between joint angle and producible muscle strength. It is known from theoretical deduction and physical experiments that the strength that is producible at a joint has absolute relation with the angle of the joint at that time. Thus, the resistance-varying device **14**, **14**A, or **14**B should be designed in consistence with the curve of relation between joint angle and producible muscle strength for the four-bar or two-bar linkages or the tension cords to increase and convert the fixed resistance provided by the group of stacked weights **7** and transmitted via the steel cord **1** into a variable resistance meeting the human engineering. As a result, the resistance-varying device meeting the human engineering may always convert any load of resistance to be borne by the trainee into a resistance compatible with a strength that can be exerted by the trainee's muscles, and may also train the muscles to exert the largest possible strength against the resistance to obtain doubled effect in the training.

[**0043**] According to the above-described training method and apparatus for enhancing muscles through progressive resistance, the weights **7**, which are usually made of a metal material, play the role of transmitting the resistance source of the muscle training apparatus. The weights **7** are caused to smoothly move up and down along the two slide rails **11**, **12** by pulling and releasing the steel cord **1**, respectively. The provision of pulleys **2**, **8**, **9**, and **10** enables change of directions in which the steel cord **1** extends.

[**0044**] To use the apparatus for enhancing muscle strength through progressive resistance shown in **FIG. 1, a** user, that is, the trainee, may first adjust the upper arm rest **5** to a vertical position suitable for his or her height and then lay his or her upper arm or arms on the rest **5**. The grip **3** is then adjusted to a position corresponding to a length of the trainee's forearm. At the beginning of training, combinations of different numbers of weights **7** may be properly selected according to the training plan to achieve an intended training effect. To obtain an enhanced training effect, an increased number of packaged trainings, an increased number of repetitions of trainings, and an increased duration of trainings may be performed on the apparatus of the present invention. Since the resistance-varying device **14**, **14**A, or **14**B in the resistance transmission mechanism of the apparatus of the present invention meets the human engineering, the trainee's muscles would not encounter an overlarge resistance when they are exerting force and can therefore avoid unwanted injury of the muscles.

[**0045**] The present invention has been described with some preferred embodiments thereof and it is understood that many changes and modifications in the described embodiments can be carried out without departing from the scope and the spirit of the invention as defined by the appended claims.

What is claimed is:

1. A method for training muscle strength through progressive resistance exercise, comprising the steps of preparing a resistance transmission mechanism having a resistance-varying device adapted to change a load of said mechanism, and designing said resistance-varying device based on a curve of relation between joint angle and producible muscle strength to generate resistance variations on said resistance transmission mechanism, so that said resistance transmission mechanism provides different magnitudes of resistance relative to different magnitudes of strength producible by muscles at different joint angles.

2. The method for training muscle strength through progressive resistance exercise as claimed in claim 1, wherein said resistance-varying device comprises a plurality of linkages that are sequentially stretched open when being subjected to a pull.

3. The method for training muscle strength through progressive resistance exercise as claimed in claim 1, wherein said resistance-varying device comprises a plurality of tension cords that are sequentially stretched open when being subjected to a pull.

4. The method for training muscle strength through progressive resistance exercise as claimed in claim 1, wherein said resistance transmission mechanism includes a resistance source consisting of a plurality of vertically stacked weights made of a metal material.

5. The method for training muscle strength through progressive resistance exercise as claimed in claim 4, wherein said metal weights are in a number that can be freely selected to provide different resistance for training muscle strength.

6. An apparatus for training muscle strength through progressive resistance exercise, comprising:

a resistance transmission mechanism including a plurality of weights that constitute a source of resistance; a steel cord that has an end connected to said weights and transmits a resistance provided by said weights to a trainee's body areas to be trained; a group of pulleys that are connected to said steel cord to change directions in which the resistance is transmitted via said steel cord; and a connecting device that is connected to another end of said steel cord and transfers the resistance transmitted via said steel cord to the trainee's body areas to be trained; and

a resistance-varying device being provided at one lateral side of said resistance source of said resistance transmission mechanism, and being designed in accordance with a curve of relation between joint angle and producible muscle strength in order to change a load of said resistance transmission mechanism according to different magnitudes of strength producible by muscles at different joint angles.

7. The apparatus for training muscle strength through progressive resistance exercise as claimed in claim 6, wherein said resistance-varying device comprises a plurality of linkages that are sequentially stretched open when said resistance source is subjected to a force and moved upward.

8. The apparatus for training muscle strength through progressive resistance exercise as claimed in claim 6, wherein said resistance-varying device comprises a plurality of tension cords that are sequentially stretched open when said resistance source is subjected to a force and moved upward.

9. The apparatus for training muscle strength through progressive resistance exercise as claimed in claim 6, wherein said plurality of weights are vertically stacked, and are in a number that can be freely selected to provide different resistance for training muscle strength.

10. The apparatus for training muscle strength through progressive resistance exercise as claimed in claim 6, wherein said steel cord is a rigid transmission member without elasticity.

11. The apparatus for training muscle strength through progressive resistance exercise as claimed in claim 6, wherein said resistance transmission mechanism is provided on a main steel framework, and includes slide rails to define a path along which said weights are moved upward and downward.

12. The apparatus for training muscle strength through progressive resistance exercise as claimed in claim 11, wherein said resistance transmission mechanism further includes a body supporting structure for a trainee to sit or lie thereon.

13. The apparatus for training muscle strength through progressive resistance exercise as claimed in claim 6, wherein said connecting device of said resistance transmission mechanism includes a grip at where the trainee holds to exert strength, and an upper arm rest on which the trainee's upper arms are positioned.

14. The apparatus for training muscle strength through progressive resistance exercise as claimed in claim 7, wherein said linkages of said resistance-varying device are four-bar linkages.

15. The apparatus for training muscle strength through progressive resistance exercise as claimed in claim 7, wherein said linkages of said resistance-varying device are two-bar linkages.

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