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

(11) **EP 2 649 976 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
28.09.2016 Bulletin 2016/39

(21) Application number: **12757662.7**

(22) Date of filing: **14.03.2012**

(51) Int Cl.:
A61H 3/00 *(2006.01)* ***A63B 21/005*** *(2006.01)*
A63B 23/04 *(2006.01)* ***A63B 23/08*** *(2006.01)*
A63B 24/00 *(2006.01)* ***A61H 1/02*** *(2006.01)*
A63B 71/00 *(2006.01)* ***A63B 69/00*** *(2006.01)*
A63B 21/00 *(2006.01)* ***A63B 22/00*** *(2006.01)*
A63B 21/068 *(2006.01)* ***A63B 23/035*** *(2006.01)*

(86) International application number:
PCT/JP2012/001792

(87) International publication number:
WO 2012/124328 (20.09.2012 Gazette 2012/38)

(54) **DEVICE FOR ASSISTING JOINT EXERCISE**

VORRICHTUNG ZUR UNTERSTÜTZUNG VON GELENKÜBUNGEN

DISPOSITIF D'ASSISTANCE D'EXERCICE ARTICULAIRE

(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: **16.03.2011 JP 2011057470**

(43) Date of publication of application:
16.10.2013 Bulletin 2013/42

(73) Proprietors:
- **Kyushu University,
National University Corporation
Fukuoka-shi, Fukuoka 812-8581 (JP)**
- **Sumitomo Riko Company Limited
Komaki, Aichi (JP)**

(72) Inventors:
- **YAMAMOTO, Motoji
Fukuoka-shi
Fukuoka 812-8581 (JP)**
- **TAKASUGI, Shinichiro
Fukuoka-shi
Fukuoka 812-8581 (JP)**
- **SATO, Masanori
Fukuoka-shi
Fukuoka 812-8581 (JP)**
- **HASHIMOTO, Kazunobu
Komaki-shi
Aichi 485-8550 (JP)**

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

(56) References cited:
JP-A- 2011 036 375
JP-B2- 4 345 025
JP-B2- 4 424 269
JP-B2- 4 582 523
JP-B2- 4 582 523
JP-B2- 4 848 260
US-A1- 2006 135 903

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

EP 2 649 976 B1

Printed by Jouve, 75001 PARIS (FR)

Description

TECHNICAL FIELD

[0001] The present invention relates to a device for assisting joint exercise which, when a user is bending and extending his joints, exerts on the user an assist force which makes it possible to realize bending and extending, or exerts a load (resist force) for efficiently strengthening the muscle strength required for bending and extending.

BACKGROUND ART

[0002] From the past, to support movement such as walking or the like for physically disabled persons who have lost muscle strength or for elderly persons whose muscle strength has diminished, wearable type movement assistance devices like that shown in Japanese Patent No. 4200492 (Patent Document 1) have been proposed.

[0003] However, the wearable type movement assistance device noted in Patent Document 1 is a so-called exoskeleton type assistance device, and by a hard exoskeleton arm arranged at the side of the user's body being driven by a motor at the joint sections, the arm, leg or the like of the user wearing the exoskeleton arm moves together with the exoskeleton arm.

[0004] However, with assistive devices using this kind of hard exoskeleton, it was necessary to accurately measure the physical build of the user (thigh and lower leg length and the like) and to precisely adjust the length of the exoskeleton arm, and when this adjustment was not done appropriately, excessive force could be applied to the joints during exercise, which could lead to a very dangerous situation. Also, the work of putting on and taking off the exoskeleton type assistance device is not easy for a user who requires assistance to move, and a great deal of effort and time is required to put it on and take it off. Because of that, it was difficult to wear and use for everyday purposes with the goal of supplementing reduced muscle strength to make movement easier. In fact, when using an assistance device having a large exoskeleton, it is virtually impossible for the user to move in resistance to the drive force of the exoskeleton with his own muscle strength, and there was absolutely no consideration taken for using this kind of assistance device for walking training or the like with the goal of efficient strengthening of muscle strength. Also, to control the movement of the assistance device, it is necessary to perform measurement of the surface electromyography, so there was also the problem of the user having to wear numerous surface electrodes (normally 18).

[0005] In Japanese Unexamined Patent Publication No. 2010-110464 (Patent Document 2), proposed is a walking assistance device with a relatively simple and light structure. However, with this kind of structure of Patent Document 2 as well, a hard exoskeleton (arm) that extends along the side surface of the thigh is required, so there were cases when device simplification and lightening were still not sufficient.

BACKGROUND ART DOCUMENTS

PATENT DOCUMENTS

[0006]

Patent Document 1: Japanese Patent No. 4200492
Patent Document 2: Japanese Unexamined Patent Publication No. 2010-110464

[0007] US-A1-2006/0135903 discloses a knee brace divided into anterior and posterior halves. The knee brace includes a proximal member and a distal member. The brace further including at least one substantially inelastic cross strap adjustable in length and connected to the proximal and distal members. The at least one cross strap has first and second portions which intersect at an intersection point located between the proximal and distal members. The intersection point is defined at a location posterior of the frontal plane of the brace.

SUMMARY OF THE INVENTION

PROBLEM THE INVENTION ATTEMPTS TO SOLVE

[0008] The problem relates to preventing application of excessive load to user's joints by a device, and suppressing undesirable deformation of the assist force transmission section due to it's elasticity in order to assure shape stability of the device.

MEANS FOR SOLVING THE PROBLEM

[0009] Specifically, a first mode of the present invention is a device according to claim 1.

[0010] With this kind of device for assisting joint exercise noted in the first mode, by the assist force transmission section having flexibility and allowing deformation, the user can put on and take this off more easily than with a device for assisting joint exercise having a hard exoskeleton. Because of that, when movement is difficult due to a decrease in muscle strength or the like due to aging or disability, with a simple task for putting on and taking off the device for assisting joint exercise, it is possible to realize performing of a target movement using the force obtained from the device for assisting joint exercise as an assist force, and efficient strengthening of the muscle strength necessary for a target movement with the force obtained from the device for assisting joint exercise as a load. As a result, it is possible to prevent on an everyday basis the restriction of activities in the elderly or the like due to locomotive syndrome (musculoskeletal system syndrome) due to movement disorders, and it is also possible to perform high efficiency muscle strength strengthening training even during daily activities. Thus, it is possible to quickly eliminate temporary muscle strength decreases and the like due to various injuries or illnesses and bed rest.

[0011] Furthermore, by the assist force transmission section being flexible, it is less likely for the user to be given a sense of being restrained, and the wearing comfort is improved. Because of that, the physical and mental burden on the user due to wearing of the device for assisting joint exercise is reduced, and it becomes possible to wear it continuously over a long period.

[0012] Also, by having at least a portion of the assist force transmission section be able to elastically deform in the tensile force acting direction, the tensile force exerted by the drive source is eased by the elasticity of the assist force transmission section between the first mounting section and the second mounting section. Because of that, it is possible to have the assisting force act with a buffering effect so as not to apply an excessive load on the user's joints or the like.

[0013] By having assisting force exerted on the leg, bending and extending is assisted for at least one of the hip joint or the knee joint. Because of that, for example, it is possible to realize easing of leg exercise or strengthening of leg muscle strength by an assisting force (assist force) that supplements insufficient muscle strength necessary for bending and extending the joints, or an assisting force (resist force) acting as a resistive load on the muscle strength necessary for bending and extending the joints.

[0014] By having the tensile force by the drive source transmitted with sufficient buffering, it is possible to suppress the load on the user's joints and the like. Also, by suppressing deformation in the width direction orthogonal to the tensile force acting direction, selective transmission of force is realized, and it is also possible to improve shape stability and durability.

[0015] A second mode of the present invention is the device for assisting joint exercise according to the first mode, further comprising a sensor for detecting bending and extending of the user's joint, and a control device arranged for controlling the drive source based on detection results of the sensor.

[0016] With the second mode, the assisting force is automatically controlled based on the sensor detection results, so it is possible to obtain suitable assistance at a suitable time without requiring a troublesome operation such as a switch operation or the like.

[0017] A third mode of the present invention is the device for assisting joint exercise according to the second mode, wherein the sensor can detect bending and extending of the user's joint based on force exerted on the sensor in accordance with the bending and extending of the user's joint.

[0018] With the third mode, since bending and extending of the joints is detected based on the force exerted on the sensor, high precision detection is possible, and it is possible to efficiently assist user's movement.

[0019] A fourth mode of the present invention is the device for assisting joint exercise according to the third mode, wherein the sensor includes at least one of a capacitance type sensor and a resistance change type sensor.

[0020] With the fourth mode, by using the capacitance type sensor, it is possible to detect the force exerted on the sensor with high precision, and possible to suitably assist movement. Furthermore, the decrease in detection precision is small even when force is repeatedly input, and since the reproducibility of the detection results are good, durability is improved. Yet further, with the capacitance type sensor, the variation range of the detection precision in relation to temperature change is small, and it is easy to correct the detection precision by adjusting the initial value in relation to temperature change. Therefore, even when the temperature change is large, stable detection is realized.

[0021] Meanwhile, if the resistance change type sensor is used, the resistance value changes sharply in relation to the force exerted on the sensor, so it is possible to have control with little time delay, making it possible to realize movement assistance with suitable timing. Furthermore, the resistance change type sensor can do detection across a broad range from cases when the force acting on the sensor is small to cases when it is large, so it is possible to obtain effective detection results both in cases when the bending of the joints is small and in cases when it is large.

[0022] A fifth mode of the present invention is the device for assisting joint exercise according to any one of the first through fourth modes, wherein the assist force transmission section is in a band form that extends in a force transmission direction.

[0023] With the fifth mode, by having the assist force transmission section be in band form, the mass of the assist force transmission section is small, and it is possible to make the device for assisting joint exercise lighter. As a result, an improvement in the ease of wearing and a decrease in the burden due to wearing are realized, so it is possible to obtain a device for assisting joint exercise that is easier to handle.

[0024] Also, by having the assist force transmission section be thin, it is easy to allow bending in the thickness direction, so by the assist force transmission section deforming according to the surface shape of the user's body, the sense of the device as a foreign object is reduced, and the wearing comfort is increased. Furthermore, if the assist force transmission section is thin, when clothing is worn after putting on the device for assisting joint exercise, bumps in the clothing due to the assist force transmission section do not occur easily, and because the device for assisting joint exercise is prevented from standing out, it is easier to make daily use of it for everyday activities.

[0025] A sixth mode of the present invention is the device for assisting joint exercise according to any one of the first through fifth modes, wherein the assist force transmission section is provided as an integral unit with a main unit in clothing form, and by wearing the main unit, the assist force transmission section is arranged across the user's joint.

[0026] With the sixth mode, by having the assist force transmission section provided as an integral unit with the main unit in clothing form, wearing and arranging in a designated position of the assist force transmission section can be completed easily by putting the main unit on in the same manner as clothing. Because of that, even for an elderly or disabled person with decreased muscle strength, it is easy to use for daily life, and it is also possible to effectively obtain movement assistance with the goal of appropriately transmitting tensile force by the drive source.

[0027] A seventh mode of the present invention is the device for assisting joint exercise according to any one of the first through sixth modes, wherein the first mounting section is attached to at least one of a thigh and the knee joint of the user while the second mounting section is attached to a lower back of the user so that the assist force transmission section is arranged across the hip joint.

[0028] With the seventh mode, the tensile force by the drive source acts as an assist force for reinforcing the muscle strength needed for bending and extending the hip joint, or as resist force for effectively strengthening the muscle strength of the muscles surrounding the hip joint or the like, so walking movement that involves hip joint bending and extending exercise and the like is assisted by the device for assisting joint exercise.

[0029] An eighth mode of the present invention is the device for assisting joint exercise according to any one of the first through seventh modes, wherein the drive source is attached to the second mounting section.

[0030] With the eighth mode, the drive source is supported by the second mounting section attached to the lower back which has smaller movement than the thigh during bending and extending of the hip joint. Accordingly, the drive source is supported stably, and also, the drive source which can easily become relatively heavy is arranged at the lower back which has smaller movement, so inertia or the like acting on the drive source is prevented from becoming a load on the user's leg.

[0031] Also, the first mounting section is attached to the thigh or knee joint, and the second mounting section that supports the drive source is attached to the lower back, so both the first mounting section and the second mounting section are arranged at positions near the hip joint. Because of that, it is possible to shorten the length of the assist force transmission section arranged across the hip joints, advantageously lightening or making more compact the device for assisting joint exercise, and also making it possible to easily put on the device for assisting joint exercise.

[0032] A ninth mode of the present invention is the device for assisting joint exercise according to any one of the first through eighth modes, wherein the tensile force by the drive source acts as an assist force that reinforces force necessary for joint bending and extending exercise.

[0033] With the ninth mode, when there has been a decrease in the muscle strength needed for joint bending and extending exercise, the tensile force by the drive force is transmitted via the assist force transmission band, and by acting as an assist force, supplements the insufficient muscle strength, making it possible to perform the target joint bending and extending exercise. By doing this, for example, when exercise is difficult due to decreased muscle strength in an elderly person or the like, it is possible to supplement the user's movement as needed, and to easily maintain a state for which exercise is possible. As a result, it is possible to prevent limitation of activities due to reduced muscle strength as well as to prevent further reduction of muscle strength, making it possible to prevent worsening of the condition.

[0034] A tenth mode of the present invention is the device for assisting joint exercise according to any one of the first through ninth modes, wherein the tensile force by the drive source acts as a resist force resisting the force necessary for joint bending and extending exercise.

[0035] With the tenth mode, for example, when there is a temporary decrease in the muscle strength needed for joint bending and extending exercise due to injury or illness or the like, the assisting force by the drive source acts as a load (resist force) daringly in the direction resisting the force necessary for the movement. Accordingly, it is possible to efficiently implement rehabilitation in an attempt to recover function by strengthening reduced muscle strength. Also, it is possible to effectively strengthen muscle strength by the action of the resist force, so it is possible to efficiently achieve the goal of preventing a decrease in muscle strength due to insufficient amount of exercise or the like when used by healthy persons.

EFFECT OF THE INVENTION

[0036] With the present invention, by exerting tensile force via the assist force transmission section between the first mounting section and the second mounting section arranged at each side sandwiching the joint, bending and extending of the joint is assisted. Therefore, it is possible to supplement insufficient muscle strength, or to try to efficiently strengthen muscle strength. In fact, the assist force transmission section can be elastically deformed in the acting direction of the tensile force by the drive source, so that the tensile force by the drive source is buffered when exerted on the user. Thus, excess load on the joints is prevented, reducing the burden on the user. Furthermore, by the assist force transmission section having flexibility, attachment and detachment can be done easily as necessary, making it possible to use for long periods because of the excellent wearing comfort.

BRIEF DESCRIPTION OF THE DRAWINGS

[0037]

FIG. 1 is a front view showing a device for assisting joint exercise according to a first embodiment of the present invention.
FIG. 2 is a back view of the device for assisting joint exercise shown in FIG. 1.
FIG. 3 is a perspective view of a capacitance type sensor constituting the device for assisting joint exercise shown in FIG. 1.
FIG. 4 is a drawing showing an internal structure of a drive device with the back view of the device for assisting joint exercise shown in FIG. 2.
FIG. 5 is a front view showing a device for assisting joint exercise according to a second embodiment of the present invention.
FIG. 6 is a back view of the device for assisting joint exercise shown in FIG. 5.
FIG. 7 is a front view showing a device for assisting joint exercise according to a third embodiment of the present invention.
FIG. 8 is a back view of the device for assisting joint exercise shown in FIG. 7.
FIG. 9 is a front view showing a device for assisting joint exercise according to a fourth embodiment of the present invention.
FIG. 10 is a front view showing a device for assisting joint exercise according to another embodiment of the present invention.
FIG. 11 is a back view showing a device for assisting joint exercise according to yet another embodiment of the present invention.

EMBODIMENTS FOR CARRYING OUT THE INVENTION

[0038] Following, we will describe embodiments of the present invention while referring to drawings.

[0039] FIG. 1 and FIG. 2 show a device for assisting joint exercise 10 as a first embodiment of the present invention. The device for assisting joint exercise 10 is for assisting bending and extending of the hip joints, and has a constitution including assist force transmission bands 12, 12 as a pair of assist force transmission sections at left and right extending across the hip joints, and a first mounting section 14 and a second mounting section 16 respectively attached to both end parts of the assist force transmission bands 12, 12 so that the first mounting section 14 is attached to one side and the second mounting section 16 is attached to the other side sandwiching the hip joints. In FIG. 1 and FIG. 2, the device for assisting joint exercise 10 is shown in a state worn by the user, and the outline of the user is shown by a double-dot-dash line. Also, in the description hereafter, the front surface means the surface on the user's abdominal side (front surface), the rear surface means the surface on the user's back side (back surface), and the vertical direction means the vertical direction in FIG. 1, which coincides with the vertical direction. Also, in the description hereafter, "assist force" means the assisting force acting in the direction supplementing the force required for movement, and "resist force" means the assisting force acting in the direction resisting the force required for movement.

[0040] In more detail, the assist force transmission band 12 has a constitution whereby a first traction band 18 and a second traction band 20 which are respectively formed using fabric are connected by a connecting fitting 22 made of metal, and the part constituted by the first traction band 18 and the second traction band 20 is flexibly deformable.

[0041] The first traction band 18 is formed with a thin band shaped fabric which gradually has a narrower width toward one end part side (in FIG. 1, the top side), and in the state with the device for assisting joint exercise 10 worn, is arranged so as to cover the front surface of the user's thighs. Also, the first traction band 18 can be elastically deformed in the lengthwise direction (in FIG. 1, the vertical direction) which is the direction of action of the tensile force by an electric motor 40 described later, and has smaller elasticity and limited deformation in the width direction (in FIG. 1, the horizontal

direction), and also has anisotropy of the deformation volume in relation to input in the lengthwise direction and width direction. The first traction band 18 preferably has elasticity of 0.3 kgf/cm or greater and 0.5 kgf/cm or less in the lengthwise direction.

[0042] Also, a ring shaped connecting fitting 22 is attached to the top end of the first traction band 18, and the first traction band 18 is connected to the second traction band 20 via the connecting fitting 22. The second traction band 20 is a band shape having a generally fixed width dimension, and is formed with fabric using fibers with low stretch properties. The second traction band 20 is connected with the first traction band 18 with the middle part inserted in the connecting fitting 22, thus constituting the assist force transmission band 12. The second traction band 20 does not absolutely have to be an item with suppressed stretch properties, and it is also possible to use an item having the same stretch properties formed using elastic fibers or the like the same as with the first traction band 18.

[0043] Also, the first mounting section 14 is provided underneath the first traction band 18 of the assist force transmission band 12. The first mounting section 14 is a sports supporter band used for protecting knee joints, and is formed with fabric or the like having stretch properties, and is worn wound on the user's knee joint. Also, the first mounting section 14 is formed as an integral unit with the first traction band 18, and the first traction band 18 faces upward extending from the front surface part of the first mounting section 14. A partial through hole 24 is provided on the first mounting section 14, and by the partial through hole 24 being aligned with the user's kneecap, it is made not to obstruct bending and extending of the knee joint.

[0044] Also, both end parts of the second traction band 20 of the assist force transmission band 12 are attached to the second mounting section 16. The second mounting section 16 has a transmission band support belt 26 and a drive device support belt 28 respectively worn on the lower back, with one end part of the second traction band 20 attached to the transmission band support belt 26 and the other end part attached to the drive device support belt 28.

[0045] The transmission band support belt 26 is formed by a band shaped fabric with low stretch properties, and is worn on the lower back of the user by being wound onto the lower back of the user and having both end parts connected using a surface fastener, snap, hook or the like. Also, a pair of guide fittings 30, 30 exhibiting a ring shape are provided on the transmission band support belt 26. In a state with the transmission band support belt 26 worn on the lower back, the guide fittings 30, 30 are arranged at both the left and right sides of the lower back. Then, one end part of the second traction band 20 is attached to the front part of the transmission band support belt 26 using mean such as sewing, adhesion, a snap, hook, surface fastener or the like.

[0046] Furthermore, a pair of capacitance type sensors 32 are attached as the sensor to the transmission band support belt 26. The capacitance type sensor 32 is a flexible capacitance change type sensor which allows elastic deformation as shown for example in Japanese Unexamined Patent Publication No. 2010-43880 and Japanese Unexamined Patent Publication No. 2009-20006, and as shown in FIG. 3, has a constitution by which a pair of electrode films 36a, 36b formed using a conductive, elastic material are provided on both surfaces of a dielectric layer 34 formed using a dielectric elastic material. Also, the capacitance type sensor 32 is attached to the transmission band support belt 26 by one electrode film 36a being fixed to the inner surface of the back part of the transmission band support belt 26.

[0047] Then, in the state with the transmission band support belt 26 worn, the capacitance type sensor 32, with the other electrode film 36b overlapping the user's buttocks, is sandwiched between the buttocks and the transmission band support belt 26. By doing this, the capacitance type sensor 32 detects changes in the acting pressure by bending and extending of the hip joint as changes in the capacitance that accompanies closeness and distance of the pair of electrode films 36a and 36b, and outputs the detection results to a control device 46 of a drive device 38 described later. As shown by the dotted line in FIG 2, the capacitance type sensors 32 are arranged as a left and right pair, and one capacitance type sensor 32 each is overlapped on the left and right buttock. Also, in FIG. 3, the thickness dimension of the dielectric layer 34 and the pair of electrode films 36a and 36b is shown to be more enlarged than the length dimension and the width dimension, but preferably, the dielectric layer 34 as well as the pair of electrode films 36a and 36b have a thin film shape, and can be arranged without giving a sense of discomfort to the buttocks.

[0048] Meanwhile, as shown in FIG. 1 and FIG. 2, the drive device support belt 28, the same as with the transmission band support belt 26, is formed with a band shaped fabric with low stretch properties, and is worn on the lower back of the user by being wound onto the lower back of the user and having both end parts connected using a surface fastener, snap, hook or the like. Also, with the drive device support belt 28, the back surface part extends downward further than the front surface part so as to have a large surface area, and the drive device 38 is fixed at that back surface part.

[0049] As shown in FIG. 4, the drive device 38 has the electric motor 40 as a drive source, a rotation shaft 42 that is rotationally driven by the electric motor 40, a power supply device 44 such as a battery or the like that supplies power to the electric motor 40, and the control device 46 for controlling the electric motor 40 based on the detection results of the capacitance type sensor 32.

[0050] The electric motor 40 is a typical electric motor, and generates rotational drive force of the drive shaft 48 by power being conducted from the power supply device 44. Also, the rotational drive force exerted on the drive shaft 48 of the electric motor 40 is transmitted to the rotation shaft 42 via a speed reducing gear train (not illustrated). The rotation shaft 42 is a circular shaft shaped member supported so as to allow rotation in the circumference direction, and the other

end part of the second traction band 20 is fixed to the outer circumference surface of the rotation shaft 42. By doing this, the other end part of the second traction band 20 is attached to the drive device support belt 28 via the drive device 38, and thus the assist force transmission band 12 is arranged across the hip joints.

[0051] Then, by the rotation shaft 42 being rotated in one circumference direction by the drive force exerted from the drive shaft 48 of the electric motor 40, the second traction band 20 of the assist force transmission band 12 is wound onto the rotation shaft 42. By doing this, the drive force by the electric motor 40 is transmitted in the lengthwise direction of the assist force transmission band 12 (lengthwise direction of the first traction band 18 and the second traction band 20), and is exerted as tensile force between the first mounting section 14 and the second mounting section 16. As is clear from the description above, the assist force transmission band 12 extends in the transmission direction of the drive force of the electric motor 40. Meanwhile, when the rotation shaft 42 is rotated in the other circumference direction by the electric motor 40, winding of the assist force transmission band 12 by the rotation shaft 42 is cancelled, and the tensile force between the first mounting section 14 and the second mounting section 16 is cancelled.

[0052] Also, control of the electric motor 40 is executed by the presence or absence of power conduction to the electric motor 40 from the power supply device 44 and the conductivity direction (rotation direction of the drive shaft 48) being controlled by the control device 46. The control device 46 is equipped with a CPU, RAM, ROM or the like, and based on the capacitance type sensor 32 detection results (output signals), it detects hip joint bending exercise and extending exercise by the user, and controls power conduction to the electric motor 40 according to the detected hip joint exercise. By doing this, the tensile force exerted between the first mounting section 14 and the second mounting section 16 based on the drive force of the electric motor 40 is adjusted by the control device 46. With this embodiment, the control device 46 identifies the walking movement stage (e.g. the stage of bending the hip joint and carrying the back leg to the front, or the stage of extending the hip joint and kicking the front leg to the ground or the like), and controls the power conduction to the electric motor 40 according to the identified walking movement stage.

[0053] If the device for assisting joint exercise 10 constituted as described above is used, when bending the hip joint, assisting force (assist force) that reinforces the force required for the hip joint's bending exercise is exerted, and the movement accompanied with hip joint bending and extending is assisted. Specifically, when the control device 46 identifies that the user is trying to bend the hip joint based on the detection results of the capacitance type sensor 32, power is conducted to the electric motor 40 from the power supply device 44, and the rotation shaft 42 is rotated in one circumference direction. By doing this, the second traction band 20 is wound by the rotation shaft 42, and the substantial length of the second traction band 20 becomes shorter, so the connecting fitting 22 externally fitted around the middle part of the second traction band 20 is pulled toward the second mounting section 16 side (top side) and displaced. Then, tensile force is exerted on the first mounting section 14 through the first traction band 18 attached to the connecting fitting 22, and the first mounting section 14 worn on the knee joint is pulled toward the second mounting section 16 side worn on the lower back. As a result, assist force acts so as to pull the knee joint to the lower back side in resistance to gravity, and assists the hip joint bending exercise. Based on the detected value of the capacitance type sensor 32, if the control device 46 adjusts the rotation volume of the rotation shaft 42 (power conduction time to the electric motor 40), just enough assist force is provided for the movement the user is trying to perform.

[0054] Meanwhile, when the control device 46 identifies that the user is trying to extend the hip joint based on the detection results of the capacitance type sensor 32, power is conducted to the electric motor 40 from the power supply device 44 and the rotation shaft 42 is rotated in the other circumference direction. By doing this, the winding of the second traction band 20 by the rotation shaft 42 is cancelled, and the substantial length of the second traction band 20 becomes longer, so the connecting fitting 22 externally fitted around the middle part of the second traction band 20 is displaced to the direction separating from the second mounting section 16 (bottom side) by its own weight or the like. Then, the tensile force exerted on the first mounting section 14 through the first traction band 18 attached to the connecting fitting 22 is cancelled, and the first mounting section 14 separates from the second mounting section 16 based on gravitational action or the like. As a result, the hip joint extending exercise being obstructed by the device for assisting joint exercise 10 is prevented.

[0055] In this way, if the device for assisting joint exercise 10 is worn, a part of the force required when bending the hip joint is supplemented by the force generated by the electric motor 40, so for example when doing the movement of carrying the back leg to the front by bending the hip joint when walking, it is possible to perform the goal movement with small muscle strength. Therefore, using the device for assisting joint exercise 10, even when sufficient muscle strength is not available for performing movement by the user due to being elderly or disabled, it is possible to smoothly perform the target movement, and it becomes possible to prevent restriction of activities by the user.

[0056] Also, the first traction band 18 of the assist force transmission band 12, which is provided on the path for transmitting the generated drive force of the electric motor 40 as an assist force to the user's leg, can be elastically deformed in the force transmission direction. By doing this, the generated force of the electric motor 40 is exerted on the user's leg after being eased by the elastic deformation of the first traction band 18. Because of that, compared to when the generated drive force of the electric motor 40 is transmitted directly, the load on the user's joints and the like is reduced, and it is possible to prevent the problem of muscle pain and the like. In particular with this embodiment, the

assist force exerted on the user's leg is 2 kgf to 5 kgf which is a relatively small force, and rather than forcibly causing movement, it is always based on the concept of supplementing insufficient muscle strength required for movement. Therefore, it is possible to perform the necessary assistance without placing a burden on the user's body.

[0057] In fact, with this embodiment, the elasticity in the force transmission direction of the first traction band 18 is set between 0.3 kgf and 0.5 kgf. By doing this, the generated drive force of the electric motor 40 is sufficiently buffered, and it is possible to avoid excess loads acting on the user's leg. At the same time, effective assist force in an amount that allows sufficient realization of movement by the user is transmitted to the leg of the user, and it is possible to effectively assist movement.

[0058] Furthermore, the first traction band 18 has deformation limited in the direction roughly orthogonal to the force transmission direction. Thus, the first mounting section 14 formed as an integral unit with the first traction band 18 is restrained from stretching in the circumference direction (diameter expansion deformation or diameter reduction deformation), and the shape stability is increased. By doing this, during acting of the tensile force by the electric motor 40, the first mounting section 14 is held without coming off from the knee joint, and the assist force is transmitted effectively to the leg.

[0059] Also, the assist force by the device for assisting joint exercise 10 is exhibited when doing hip joint bending exercise, whereas it is canceled when doing hip joint extending exercise. By doing this, if the device for assisting joint exercise 10 is worn, while it assists hip joint bending exercise which requires exercise in resistance to gravity in a standing state, with hip joint extending exercise which is assisted by the action of gravity in a standing state, there is no acting of the assist force as a resist force, but instead smooth movement is realized. Therefore, even with walking movement performing repeated hip joint bending and extending or the like, there is no obstruction of the movement, and it is possible to provide the necessary assist force at appropriate times and to give appropriate assistance for movement.

[0060] With the device for assisting joint exercise 10 of this embodiment, this kind of switching of assistance according to the user movement state is executed automatically by the control device 46 based on the detection results of the capacitance type sensor 32. Because of that, the user is able to obtain suitable assistance at a suitable time without requiring manual control by the user of the timing at which assist force is given, of the size of the assist force or the like.

[0061] In fact, by using the capacitance type sensor 32 as the sensor, it is possible to obtain high precision detection results. Because of that, for example, if the assist force size or the like is adjusted based on the detection results, more appropriate assistance is possible. Furthermore, with the capacitance type sensor 32, the reduction in detection precision in relation to temperature change is small, and correction in relation to temperature change is easy, so it is possible to stably obtain correct detection results even when the temperature change is big. In addition, with the capacitance type sensor 32, since the detection precision decrease in relation to repeated input is small, it is possible to ensure sufficient durability, and daily use with everyday activities or the like can be realized.

[0062] Also, the assist force transmission section of this embodiment is made to be the assist force transmission band 12 formed of a band shaped thin cloth. Accordingly, it has sufficient flexibility, and compared to a device for assisting joint exercise having a hard exoskeleton, it is possible to put it on and take it off easily. Specifically, when the user wears the hard exoskeleton, the user has to adjust the joint bending angle to match the shape of the exoskeleton, and there are many cases when putting it on is difficult when sitting. However, with the device for assisting joint exercise 10 of this embodiment, the assist force transmission band 12 that connects the first mounting section 14 and the second mounting section 16 bends as needed. Therefore, if the assist force transmission band 12 is made sufficiently long, regardless of the degree of the bending angle of the user's joint, it is possible to attach the first mounting section 14 and the second mounting section 16 at respectively suitable positions. In fact, by the assist force transmission band 12 being flexible, for example, it is possible to respectively put on the first mounting section 14 and the second mounting section 16 in a seated posture with the hip joint bent. Thus, it is possible to do the work of putting on and taking off the item from a position of ease.

[0063] Furthermore, by using the assist force transmission band 12 formed with a thin, band shaped cloth, the device for assisting joint exercise 10 is light, and it can be easily handled even by elderly persons or the like for whom muscle strength has decreased. In fact, with this embodiment, since both the first mounting section 14 and the second mounting section 16 are also made of cloth, the overall device for assisting joint exercise 10 is lighter, and there are further improvements in handling including the task of putting on and taking off the device and the like.

[0064] Yet further, by having the assist force transmission band 12 made of thin cloth, in the state when worn, the assist force transmission band 12 curves easily in the thickness direction along the shape of the user's body surface. Because of that, with the device for assisting joint exercise 10, a good sense of wearing comfort is realized. Also, when worn with clothing over the device for assisting joint exercise 10, it is possible to prevent the assist force transmission band 12 from having dents and bumps occur which would make the device stand out, so it can be used easily for everyday activities. With this embodiment, both the first mounting section 14 and the second mounting section 16 are also thin. Therefore, by avoiding an odd visual appearance when wearing with clothing over the device for assisting joint exercise 10, it is easy to use this on a daily basis.

[0065] Also, by having the first mounting section 14 attached to the knee joint, and the second mounting section 16

attached to the lower back, it is possible to efficiently exert assist force on the leg while preventing making the length of the assist force transmission band 12 longer than necessary, as well as making the device for assisting joint exercise 10 smaller. Perhaps this is because when the separation distance from the hip joint (the fulcrum during swinging of the thigh) to the first mounting section 14 (the action point) is larger, the tensile force acts efficiently on the first mounting section 14. In fact, by providing the drive device 38 on the lower back for which there is little exercise volume during walking, it is possible to prevent the drive device 38 from obstructing the walking movement.

[0066] FIG. 5 and FIG. 6 show a device for assisting joint exercise 50 as a second embodiment of the present invention. The device for assisting joint exercise 50 is constituted including the assist force transmission band 12 and the assist force transmission band 52 as the assist force transmission section, and the first mounting section 14 and the second mounting section 16 provided at both ends of that. With the description hereafter, for substantially the same members and parts as those of the first embodiment, we will give the same code number and omit an explanation.

[0067] In more detail, the assist force transmission band 52 is constituted including a third traction band 54 and a fourth traction band 56, and these are arranged across the hip joint on the user's back surface side, connecting the first mounting section 14 and the second mounting section 16.

[0068] The third traction band 54 extends upward from the top end of the back surface side of the first mounting section 14, with the bottom end fixed on the first mounting section 14, and the top end fixed to the connecting fitting 22. The third traction band 54 is formed as a separate item from the first mounting section 14 and connected by a means such as a seam or the like, and it is possible to realize both of the required performance of the third traction band 54 and the required performance of the first mounting section 14 at a high level. Also, the third traction band 54 has a gradually narrower width facing upward, and has a shape that allows deformation of the thigh muscle or the like when bending and extending the hip joint. Besides, the third traction band 54 is also elastically deformable in the lengthwise direction (in FIG. 6, the vertical direction) which is the action direction of the tensile force by the electric motor 40 of the drive device 38.

[0069] Also, the fourth traction band 56 is inserted through the connecting fitting 22 attached to the third traction band 54. The same as the second traction band 20, the fourth traction band 56 is in a thin band form having a generally constant width dimension, and is formed using fibers which do not stretch easily, so elastic deformation is restricted. With this fourth traction band 56, while the middle part is inserted through the connecting fitting 22, one end part is fixed by a means such as a seam or the like to the transmission band support belt 26, and the other end part is fixed to the rotation shaft 42 of the drive device 38. By doing this, the third traction band 54 is connected to the middle part of the fourth traction band 56, and the first mounting section 14 and the second mounting section 16 are connected to each other by the third and fourth traction bands 54 and 56.

[0070] Then, the rotation shaft 42 is rotated to one circumference direction side by the drive force of the electric motor 40 so that the fourth traction band 56 is wound on the rotation shaft 42. Consequently, tensile force is exerted between the first mounting section 14 and the second mounting section 16 through the third and fourth traction bands 54 and 56. Meanwhile, by the rotation shaft 42 rotating to the other circumference direction side, the winding of the fourth traction band 56 by the rotation shaft 42 is cancelled, so the aforementioned tensile force is cancelled. The electric motor 40 for exerting tensile force on the fourth traction band 56 may be provided separately from the electric motor 40 for exerting tensile force on the second traction band 20, or alternatively, it is also possible to have tensile force by a common electric motor 40 selectively exerted on either one of the second traction band 20 or the fourth traction band 56.

[0071] Then, when the user bends the hip joint, tensile force in the direction that pulls the first mounting section 14 toward the second mounting section 16 side is exerted through the third and fourth traction bands 54 and 56. Accordingly, assisting force (resist force) acting in the direction resisting in relation to the force necessary for the hip joint bending exercise is exerted on the leg. By doing this, the drive force of the electric motor 40 acts as a load (resistance) to the hip joint bending exercise, so it efficiently strengthens the muscle strength necessary for movement accompanied with hip joint exercise such as walking movement or the like. Furthermore, when extending the hip joint, the tensile force exerted between the first mounting section 14 and the second mounting section 16 through the third and fourth traction bands 54 and 56 is cancelled, and acting of the tensile force as an assist force is prevented. By doing this, strengthening of the muscle strength of the muscles around the hip joint and the like is efficiently realized. If control is done so that tensile force exerted on the first mounting section 14 through the first and second traction bands 18 and 20 is canceled when the hip joint is bent, and acts when the hip joint is extended, it is possible to add a load in relation to the exercise of extending the hip joint. It is possible to more effectively realize strengthening of the muscle strength thereby.

[0072] Meanwhile, if the tensile force action and cancellation control is reversed, it is also possible to effectively obtain assisting force (assist force) for aiding movement. Specifically, in addition to giving assist force by the first and second traction bands 18 and 20 shown in the first embodiment, the tensile force exerted on the first mounting section 14 through the third and fourth traction bands 54 and 56 is cancelled when doing bending exercise of the hip joint, while being acted when doing extending exercise of the hip joint. By so doing, assist force is exerted through the first and second traction bands 18 and 20 for hip joint bending exercise, and assist force is exerted through the third and fourth traction bands 54 and 56 for hip joint extending exercise.

[0073] In other words, with the device for assisting joint exercise 50, it is possible to selectively use, according to user's needs, function as an assisting device for aiding movement such as walking or the like, or function as an assisting device for efficiently strengthening muscle strength of the muscles around the hip joints during rehabilitation or the like. In fact, with the device for assisting joint exercise 50, assisting force is exerted not only for hip joint bending exercise but also for extending exercises, so user movement is more effectively assisted.

[0074] Also, with the device for assisting joint exercise 50, the third and fourth traction bands 54 and 56 are provided so as to exhibit assisting force even for hip joint extending exercise. Accordingly, when the device for assisting joint exercise 50 is put on in a seated state, after putting it on, it is also possible to start the movement assistance by the device while still in the seated posture, and to assist the standing up movement.

[0075] Also, FIG. 7 and FIG 8 show a device for assisting joint exercise 60 as a third embodiment of the present invention. This device for assisting joint exercise 60 has a main unit 62 exhibiting a pants (leggings) shape which adheres tightly to the body surface covering from the lower back to below the knees. This main unit 62 is formed with fabric that has excellent stretch properties that allow elastic deformation according to the user's body shape, and deforms according to the user's body shape or the like.

[0076] Also, an assist force transmission section 64 is provided on the main unit 62. The assist force transmission section 64 is a thin band shaped fabric, and is equipped integrally with a first traction section 66 extending vertically so as to cover the front surface of the thigh, and a second traction section 68 extending diagonally upward branching left and right at a designated angle from the top end of the first traction section 66. Also, both the first traction section 66 and the second traction section 68 of the assist force transmission section 64 are allowed elastic deformation in the lengthwise direction (in FIG. 7, the vertical direction) which is the action direction of tensile force by the electric motor 40 of the drive device 38, while being restricted from elastic deformation in the width direction. This assist force transmission section 64 is provided integrally during weaving and formed as an integral unit with the main unit 62.

[0077] Also, a first mounting section 70 is provided below the first traction section 66 of the assist force transmission section 64. The first mounting section 70 is generally ring shaped, and is worn so as to generally cover across the entire circumference of the knee joint. Also, the first mounting section 70 uses the same fabric as the first traction section 66, and is provided as an integral unit with the main unit 62 and the first traction section 66. Thus, the first mounting section 70 is restricted from elastic deformation in the circumference direction, so displacement from the knee joint is suppressed. Also, with the first mounting section 70, the part that covers the front surface of the knee joint is interwoven as an integral unit with the main unit 62, and the parts that cover the back surface from the side surface of the knee joints extend in respective band forms separating from the main unit 62 at the left and right side surface parts. Besides, surface fasteners (not illustrated) are provided on the left and right pair of band shaped parts of the first mounting section 70 separating from the main unit 62 at the left and right side surface parts. Then, by pulling those band shaped parts in the circumference direction and tightening the knee joint when necessary and connecting to each other by the surface fasteners, the first mounting section 70 is aligned to the knee joint. A part formed by a material that has excellent stretch properties the same as the main unit 62 is provided on the front surface center part of the first mounting section 70. By arranging that part so as to cover the kneecap, restriction of the knee joint is prevented.

[0078] Also, with the second traction section 68 of the assist force transmission section 64, the end part extending to the inside branching laterally is held tightened by the drive device support belt 28. Meanwhile, the side extending to the outside branching laterally is separated from the main unit 62 at the side of the lower back so the end part forms a band shape, and is fixed to the rotation shaft 42 of the drive device 38. Though not shown in the drawing, the drive device 38 of this embodiment is equipped with one electric motor 40 for which the rotation direction of the drive shaft 48 is controlled by the control device 46. The rotation shafts 42 and 42 connected one each to the left and right assist force transmission sections 64 and 64 are rotated by the one electric motor 40. Also, with this embodiment, the left side assist force transmission section 64 is inserted from the back surface side in the drive device 38 and fixed to the rotation shaft 42, while the right side assist force transmission section 64 is inserted from between the drive device support belt 28 and the drive device 38, and fixed to the rotation shaft 42. Based on the above, with the assist force transmission section 64, the bottom end part is attached to the first mounting section 14, and the top end part is attached to the drive device support belt 28 as the second mounting section, and arranged across the hip joints.

[0079] With the device for assisting joint exercise 60 constituted in this way, the same as with the device for assisting joint exercise 10 shown in the first embodiment, tensile force is exerted between the first mounting section 70 and the second mounting section 16 through the assist force transmission section 64, and it is possible to assist hip joint exercise including walking.

[0080] In fact, the device for assisting joint exercise 60 has the assist force transmission section 64 interwoven to be provided as an integral unit with the pants shaped main unit 62, so it is possible to easily put it on and take it off with a simple action the same as with pants. Furthermore, simply by correctly putting on the main unit 62, the assist force transmission section 64 is arranged at an accurate position, and it is possible to efficiently obtain assisting force. In addition, even when worn under clothing, the problem of bumps and dents arising and causing bulkiness does not occur easily, so other people are not given a strange visual impression easily. Moreover, it is possible to avoid problems of

the movement of the user being restricted and the freedom of choice of clothing being small.

[0081] When using the device for assisting joint exercise of the present invention for assisting joint movement of the upper half of the body, it is also possible to provide the assist force transmission section as an integral unit with a shirt form main unit in the same manner as with this embodiment. In other words, the main unit in clothing form worn so as to cover the joints can be prepared according to the joint for which movement is to be assisted.

[0082] FIG. 9 shows a device for assisting joint exercise 80 as a fourth embodiment of the present invention. The device for assisting joint exercise 80 has a constitution by which an assist force transmission band 82 as the assist force transmission section connects the first mounting section 14 and the second mounting section 16.

[0083] The assist force transmission band 82 is constituted including a first traction band 84, a second traction band 86, and a third traction band 88. The first through third traction bands 84, 86, and 88 are respectively formed with thin band shaped fabric extending at a generally fixed width dimension. The first and second traction bands 84 and 86 are made to be elastically deformable in the lengthwise direction (in FIG. 9, the vertical direction) which is the action direction of the tensile force by the electric motor 40 of the drive device 38, while the third traction band 88 has elastic deformation restricted in the lengthwise direction. Also, an adjustable fitting 90 is provided on the second traction band 86, and this makes it possible to easily adjust the length of the second traction band 86 according to physical build.

[0084] Then, the top end of the first traction band 84 and the bottom end of the second traction band 86 are respectively attached to a ring shaped first connecting fitting 92, and the first traction band 84 and the second traction band 86 are connected via the first connecting fitting 92. Furthermore, the top end of the second traction band 86 is attached to a ring shaped second connecting fitting 94, and the third traction band 88 is inserted through the second connecting fitting 94, so that the top end of the second traction band 86 and the middle part of the third traction band 88 are connected via the second connecting fitting 94. It is possible to fix the first and second traction bands 84 and 86 to the first and second connecting fittings 92 and 94 so they can't be removed, but it is preferable to attach them using a hook, snap, surface fastener or the like so they are removable. With this embodiment, they are attached in a removable state using a snap 96.

[0085] Also, the bottom end of the first traction band 84 is attached to the top end of the front surface part of the first mounting section 14. The attachment of the first traction band 84 to the first mounting section 14 can be fixing by sewing or adhesion, but it is preferable to attach it so as to be detachable using a hook, snap, surface fastener or the like.

[0086] Furthermore, with the third traction band 88, one of the end parts extends circling around to the back part from the side part of the lower back, and is fixed to the rotation shaft 42 of the drive device 38 shown in FIG. 4. Meanwhile, the other end part of the third traction band 88 is attached to the drive device support belt 28 of the second mounting section 16 at the front of the lower back. In more detail, a hook fitting 98 is attached to the other end part of the third traction band 88, and that is attached in a state that is detachable to a ring shaped or half ring shaped attachment fitting 100 provided on the front surface part of the drive device support belt 28. A plurality of the attachment fittings 100 are provided aligned in the circumference direction on the drive device support belt 28, and by suitably selecting from among that plurality the attachment fitting 100 for attaching the hook fitting 98, it is possible to adjust the length of the third traction band 88.

[0087] By the description above, with the device for assisting joint exercise 80, the first mounting section 14 and the second mounting section 16 are connected by the assist force transmission band 82 constituted by the first through third traction bands 84, 86, and 88. With this arrangement, tensile force is exerted between the first mounting section 14 and the second mounting section 16 through the assist force transmission band 82. Then, the same as with the first embodiment, when doing hip joint bending and extending exercise, assist force is exerted using tensile force, which assists walking.

[0088] Also, with this embodiment, the assist force transmission band 82 is constituted by the first through third traction bands 84, 86, and 88, and they are respectively connected by the connecting fittings 92 and 94. Because of that, in cases such as when any of the first through third traction bands 84, 86, and 88 are damaged, it is possible to remove and replace just the damaged part from the connecting fittings 92 and 94, so maintainability is excellent.

[0089] Also, if replaced with an item for which the lengths of the first to third traction bands 84, 86, and 88 are different according to the physical build of the user (thigh length and the like), it is possible for users with a wide range of physical builds to use this. Therefore, it is possible to also handle cases such as when a large number of unidentified users are using them in a rehabilitation center of a hospital or the like, for example. Furthermore, since a plurality of attachment fittings 100 are provided aligned laterally, by changing the attachment position of the hook fittings 98, it is possible to change the vertical direction length of the assist force transmission band 82. Thus, it is possible to easily perform adjustments according to differences in physical build. In addition, since an adjustable fitting 90 is provided on the second traction band 86, it is possible to easily adjust the length of the assist force transmission band 82 by adjusting the length of the second traction band 86.

[0090] Above, we gave a detailed description of embodiments of the present invention, but the present invention is not limited by those specific descriptions. For example, with the embodiments noted above, the first mounting section for using the device for assisting joint exercise for hip joint exercise assistance is attached to the knee joint. However,

it will suffice for the first mounting section to be provided on the opposite side to the second mounting section across the lower back, and when the second mounting section is worn on the lower back, it is possible to obtain generally the same effect even by the first mounting section being attached to the thigh. Naturally, if the first mounting attachment position is too close to the hip joint, it is difficult for the assist force to act effectively, so when the first mounting section is attached to the thigh, it is preferable to attach it to a position near the knee joint.

[0091] Also, the arrangement position of the drive device is not limited to being on the lower back. For example, when assisting bending and extending exercise of the shoulder joint, by providing the drive device on the user's back, it is possible to make the device for assisting joint exercise more compact by shortening the assist force transmission path without obstructing user's movement.

[0092] Also, as a sensor for detecting user's movement, this is not limited to being a capacitance type sensor. For example, it is also possible to use a resistance change type sensor that detects user's movement based on changes in the resistance value by action of a force. If this kind of resistance change type sensor is used, because it is possible to do measurement using DC voltage, simplifying the measuring circuit is easy, and realizing smaller size and lower costs is easy. In fact, since the resistance value changes sharply even with the action of a small force, it is possible to detect over a wide range, from tiny exercise to big exercise of the joints. As the resistance change type sensor, for example, an item having flexibility like that shown in Japanese Unexamined Patent Publication No. 2008-69313 can be suitably used. It is also possible to use a combination of a plurality of different types of sensors with different structures and detection methods, such as using the capacitance type sensor and resistance change type sensor in combination or the like.

[0093] Also, the sensor arrangement positions shown in the embodiments noted above are simply examples, and as long as it is possible to detect user's movement, the arrangement mode is not particularly limited. In specific terms, for example as with a device for assisting joint exercise 110 shown in FIG 10, a capacitance type sensor 112 is arranged on the back surface of the first traction band 18 (surface overlaid on the thigh). By so doing, it is also possible to detect the gripping pressure between the first traction band 18 and the thigh, which comes with deformation of the thigh muscle when bending the hip joint, as a change in capacitance. Furthermore, for example as with the device for assisting joint exercise 120 shown in FIG. 11, if the capacitance type sensor 122 that expands from the user's buttocks toward the thigh is used, it is possible to more directly detect bending and extending of the hip joint. In this case, with the device for assisting joint exercise 120, in addition to the assist force transmission band 12 as well as the first and second mounting sections 14 and 16 shown in the first embodiment, the structure includes a pants (leggings) shaped sensor holding suit 124 equipped with a capacitance type sensor 122. Then, the assist force transmission band 12 as well as the first and second mounting sections 14 and 16 are put on after putting on the sensor holding suit 124. The capacitance type sensors 112 and 122 shown in FIG. 10 and FIG. 11 also have the basic structure that is the same as that of the capacitance type sensor 32 shown in the embodiment, so their explanation will be omitted here. Furthermore, it is also possible to use a combination of the capacitance type sensor 112 and the capacitance type sensor 122, making it possible to more precisely detect movement.

[0094] Also, with the embodiments noted above, to effectively assist bending and extending of the hip joint, the assist force transmission section is provided at least at the front surface side. However, for example in a case of assisting bending and extending of the knee joint or the like, it is also possible to provide the assist force transmission section only on the back side. In other words, the assist force transmission section is acceptable as long as it is suitably arranged considering the mobility of the joints and the like.

[0095] Also, the assist force transmission section is not limited to being an item having flexibleness (flexibility) for the entire object, but can also have a hard part formed of metal, plastic or the like as long as it is only partial. Furthermore, it is possible to have the entire assist force transmission section be elastically deformable in the force transmission direction, or alternatively to have the assist force transmission section allow partial elastic deformation in the force transmission direction.

[0096] Also, the transmission band support belt 26 and the drive device support belt 28 do not absolutely have to be provided independently. For example, there can also be cases of the end part of the assist force transmission band 12 being fixed to the front part of the drive device support belt 28, and simultaneously equipping a function with the drive device support belt 28 as the transmission band support belt. Also, the assist force transmission band 12 does not have to be formed as a separate item in relation to the transmission band support belt 26. It is also possible to provide the second traction band 20 of the assist force transmission band 12 as an integral unit so as to extend from the front part of the transmission band support belt 26. As is clear from the description above, when the drive device support belt 28 has a function as the transmission band support belt, the assist force transmission band 12 can be formed as an integral unit with the drive device support belt 28.

[0097] Also, with the embodiments noted above, the device for assisting joint exercise for assisting hip joint bending and extending exercise is shown, but the device for assisting joint exercise of the present invention can also be used for assisting bending and extending exercise of joints other than the hip joint, such as the knee joint, shoulder joint, elbow joint and the like.

KEY TO SYMBOLS

[0098]

10, 50, 60, 80, 110, 120:	Device for assisting joint exercise
12, 52, 82:	Assist force transmission band (assist force transmission section)
14, 70:	First mounting section
16:	Second mounting section
32, 112, 122:	Capacitance type sensor
40:	Electric motor (drive source)
46:	Control device
62:	Main unit
64:	Assist force transmission section

Claims

1. A device for assisting joint exercise (10, 50, 60, 80, 110, 120) comprising:

a flexible assist force transmission section (12, 52, 64, 82);
a first mounting section (14, 70) and a second mounting section (16), which are provided at both end portions of the assist force transmission section (12, 52, 64, 82), the first mounting section (14, 70) adapted to be mounted on one site and the second mounting section (16) adapted to be mounted on another site sandwiching a user's joint so that the assist force transmission section (12, 52, 64, 82) is arranged across at least one of a hip joint and a knee joint of a user; and
a drive source (40) that exerts tensile force between the first mounting section (14, 70) and the second mounting section (16) through the assist force transmission section (12, 52, 64, 82),

wherein at least a portion of the assist force transmission section (12, 52, 64, 82) is elastically deformable in an acting direction of the tensile force by the drive source (40), and
characterised in that the portion of the assist force transmission section (12, 52, 64, 82) which is elastically deformable is an item for which, compared to elasticity in the acting direction of the tensile force by the drive source (40), elasticity in a direction orthogonal to that is smaller.

2. The device for assisting joint exercise (10, 50, 60, 80, 110, 120) according to claim 1, wherein the first mounting section (14, 70) is suitable to be attached to at least one of a thigh and the knee joint of the user while the second mounting section (16) is suitable to be attached to a lower back of the user so that the assist force transmission section (12, 52, 64, 82) is arranged across the hip joint.

3. The device for assisting joint exercise (10, 50, 60, 80, 110, 120) according to claim 1 or 2, wherein the portion of the assist force transmission section (12, 52, 64, 82) which is elastically deformable has the elasticity of 0.3 kgf/cm or greater and 0.5 kgf/cm or less in the acting direction of the tensile force by the drive source (40).

4. The device for assisting joint exercise (10, 50, 80, 110, 120) according to any one of claims 1-3, wherein the assist force transmission section (12, 52, 82) comprises: a band-shaped first traction band (18, 84) extending from the first mounting section (14, 70); a band-shaped second traction band (20, 86) extending from the second mounting section (16); and a connecting fitting (22, 92) connecting the first and second traction bands (18, 84, 20, 86) with each other.

5. The device for assisting joint exercise (10, 50, 110, 120) according to claim 4, wherein the first mounting section (14) is worn wound on the knee joint of the user and the second mounting section (16) is worn wound on the lower back of the user;
wherein the first traction band (18) is elastically deformable in a lengthwise direction which is the acting direction of the tensile force, while extending from the first mounting section (14) and being arranged so as to cover a front surface of the thigh of the user;
wherein the connecting fitting (22) is attached to a top end of the first traction band (18); and
wherein a lengthwise middle part of the second traction band (20) is inserted in the connecting fitting (22) while both lengthwise end parts of the second traction band (20) are attached to the second mounting section (16) so that the

assist force transmission section (12, 52) including the first traction band (18) and the second traction band (20) is arranged across the hip joint of the user, and an assisting force exerted involving elastic deformation of the assist force transmission section (12, 52) assists bending and extending of the hip joint.

6. The device for assisting joint exercise (60) according to any one of claims 1-3, wherein the assist force transmission section (64) is provided as an integral unit with a main unit (62) in clothing form, and by wearing the main unit (62), the assist force transmission section (64) is arranged across the user's joint.

7. The device for assisting joint exercise (10, 50, 60, 80, 110, 120) according to any one of claims 1-6, further comprising: a sensor (32, 112, 122) that can detect bending and extending of the user's joint based on force exerted on the sensor (32, 112, 122) in accordance with the bending and extending of the user's joint, the sensor (32, 112, 122) including at least one of a capacitance type sensor (32, 112, 122) and a resistance change type sensor; and a control device (46) arranged for controlling the drive source (40) based on detection results of the sensor (32, 112, 122).

8. The device for assisting joint exercise (10, 50, 60, 80, 110, 120) according to any one of claims 1-7, wherein the assist force transmission section (12, 52, 64, 82) is in a band form that extends in a force transmission direction.

9. The device for assisting joint exercise (10, 50, 60, 80, 110, 120) according to any one of claims 1-8, wherein the drive source (40) is attached to the second mounting section (16).

10. The device for assisting joint exercise (10, 50, 60, 80, 110, 120) according to any one of claims 1-9, wherein the tensile force by the drive source (40) acts as an assist force that reinforces force necessary for joint bending and extending exercise.

11. The device for assisting joint exercise (10, 50, 60, 80, 110, 120) according to any one of claims 1-10, wherein the tensile force by the drive source (40) acts as a resist force resisting the force necessary for joint bending and extending exercise.

Patentansprüche

1. Eine Vorrichtung zur Unterstützung von Gelenkübungen (10, 50, 60, 80, 110, 120), die Folgendes umfasst:

einen flexibler Hilfskraft-Übertragungsabschnitt (12, 52, 64, 82);
einen ersten Montageabschnitt (14, 70) und einen zweiten Montageabschnitt (16), die an beiden Endbereichen des Hilfskraft-Übertragungsabschnitts (12, 52, 64, 82) bereitgestellt werden, wobei der erste Montageabschnitt (14, 70) dazu angepasst ist, an einem Ort (*site*) montiert zu werden und wobei der zweite Montageabschnitt (16) dazu angepasst ist, an einem anderen Ort montiert zu werden, was zu einem Einzwängen eines Gelenks des Benutzers führt, sodass der Hilfskraft-Übertragungsabschnitt (12, 52, 64, 82) quer über mindestens einen der Folgenden angeordnet ist: einem Hüftgelenk und einem Kniegelenk eines Benutzers; und
eine Antriebsquelle (40), die durch den Hilfskraft-Übertragungsabschnitt (12, 52, 64, 82) eine Zugkraft zwischen dem ersten Montageabschnitt (14, 70) und dem zweiten Montageabschnitt (16) ausübt,

wobei mindestens ein Teil des Hilfskraft-Übertragungsabschnitts (12, 52, 64, 82) in einer Wirkrichtung der Zugkraft von der Antriebsquelle (40) elastisch verformbar ist, und
dadurch gekennzeichnet, dass
der elastisch verformbare Teil des Hilfskraft-Übertragungsabschnitts (12, 52, 64, 82) ein Element ist, für das die Elastizität, im Vergleich zur Elastizität in Wirkrichtung der Zugkraft von der Antriebsquelle (40), in einer Richtung, die zu dieser orthogonal ist, geringer ist.

2. Die Vorrichtung zur Unterstützung von Gelenkübungen (10, 50, 60, 80, 110, 120) nach Anspruch 1, wobei der erste Montageabschnitt (14, 70) dazu geeignet ist, an mindesten einen der Folgenden befestigt zu werden: an einen Oberschenkel und an ein Kniegelenk des Benutzers während der zweite Montageabschnitt (16) dazu geeignet ist, am unteren Rückenbereich des Benutzers montiert zu werden, sodass der Hilfskraft-Übertragungsabschnitt (12, 52, 64, 82) quer über dem Hüftgelenk angeordnet ist.

3. Die Vorrichtung zur Unterstützung von Gelenkübungen (10, 50, 60, 80, 110, 120) nach Anspruch 1 oder 2, wobei

der Teil des Hilfskraft-Übertragungsabschnitts (12, 52, 64, 82), der elastisch deformierbar ist, eine Elastizität von 0,3 kgf/cm oder mehr aufweist und 0,5 kgf/cm oder weniger in Wirkrichtung der Zugkraft von der Antriebsquelle (40).

4. Die Vorrichtung zur Unterstützung von Gelenkübungen (10, 50, 80, 110, 120) nach irgendeinem der Ansprüche 1 bis 3, wobei der Hilfskraft-Übertragungsabschnitt (12, 52, 82) Folgendes umfasst: ein bandförmiges erstes Zug-Band (18, 84), das vom ersten Montageabschnitt (14, 70) ausgeht; ein bandförmiges zweites Zug-Band (20, 86), das vom zweiten Montageabschnitt (16) ausgeht; und einen Verbindungsbeschlag (22, 92), der das erste und das zweite Zug-Band (18, 84, 20, 86) miteinander verbindet.

5. Vorrichtung zur Unterstützung von Gelenkübungen (10, 50, 110, 120) nach Anspruch 4, wobei der erste Montageabschnitt (14) auf dem Benutzer-Kniegelenk gewickelt getragen wird, und wobei der zweite Montageabschnitt (16) auf dem unteren Rückenbereich des Benutzers gewickelt getragen wird;
wobei das erste Zug-Band (18) in einer Längsrichtung elastisch verformbar ist, die der Wirkrichtung der Zugkraft entspricht, während es sich vom ersten Montageabschnitt (14) ausgeht und derart angeordnet ist, dass es eine vordere Oberfläche des Oberschenkels des Benutzers bedeckt;
wobei der Verbindungsbeschlag (22) an einem oberen Ende des ersten Zug-Bandes (18) befestigt ist; und
wobei ein in Längsrichtung mittleres Stück des zweiten Zug-Bandes (20) in den Verbindungsbeschlag (22) eingefügt wird, während beide in Längsrichtung endseitige Stücke des zweiten Zug-Bandes (20) am zweiten Montageabschnitt (16) befestigt werden, sodass der Hilfskraft-Übertragungsabschnitt (12, 52), der das erste Zug-Band (18) und das zweite Zug-Band (20) enthält, quer über dem Hüftgelenk des Benutzers angeordnet ist, und sodass eine Hilfskraft, die unter Einbeziehung der elastischen Verformung des Hilfskraft-Übertragungsabschnitts (12, 52) ausgeübt wird, die das Biegen und Strecken des Hüftgelenks unterstützt.

6. Die Vorrichtung zur Unterstützung von Gelenkübungen (60) nach irgendeinem der Ansprüche 1 bis 3, wobei der Hilfskraft-Übertragungsabschnitt (64) als integrale Einheit mit einer Haupteinheit (62) in Form von Kleidung bereitgestellt wird, und wobei der Hilfskraft-Übertragungsabschnitt (64), durch das Tragen der Haupteinheit (62), quer über dem Gelenk des Benutzers angeordnet ist.

7. Die Vorrichtung zur Unterstützung von Gelenkübungen (10, 50, 60, 80, 110, 120) nach irgendeinem der Ansprüche 1 bis 6, die des Weiteren Folgendes umfasst: einen Sensor (32, 112, 122), der ein Biegen und Strecken des Benutzergelenks aufgrund einer auf den Sensor (32, 112, 122) ausgeübten, dem Biegen und Strecken des Benutzergelenks gemäßen Kraft erfassen kann, wobei der Sensor (32, 112, 122) mindestens einen der Folgenden beinhaltet: einen kapazitiven Sensor (32, 112, 122) und einen Widerstandsänderungs-Sensor; und eine Steuervorrichtung (46), die zur Steuerung der Antriebsquelle (40) aufgrund der Erfassungsergebnisse des Sensors (32, 112, 122) angeordnet wird.

8. Die Vorrichtung zur Unterstützung von Gelenkübungen (10, 50, 60, 80, 110, 120) nach irgendeinem der Ansprüche 1 bis 7, wobei der Hilfskraft-Übertragungsabschnitt (12, 52, 64, 82) eine Bandform aufweist, die in Richtung einer Kraftübertragung verläuft.

9. Die Vorrichtung zur Unterstützung von Gelenkübungen (10, 50, 60, 80, 110, 120) nach irgendeinem der Ansprüche 1 bis 8, wobei die Antriebsquelle (40) an den zweiten Montageabschnitt (16) befestigt wird.

10. Die Vorrichtung zur Unterstützung von Gelenkübungen (10, 50, 60, 80, 110, 120) nach irgendeinem der Ansprüche 1 bis 9, wobei die Zugkraft von der Antriebsquelle (40) als Hilfskraft wirkt, die die Kraft verstärkt, die für Biege- und Streck-Übungen des Benutzergelenks notwendig ist.

11. Die Vorrichtung zur Unterstützung von Gelenkübungen (10, 50, 60, 80, 110, 120) nach irgendeinem der Ansprüche 1 bis 10, wobei die Zugkraft von der Antriebsquelle (40) als Widerstandskraft wirkt, die der Kraft widersteht, die für Biege- und Streck-Übungen des Benutzergelenks notwendig ist.

Revendications

1. Un dispositif d'assistance à l'exercice d'articulation (10, 50, 60, 80, 110, 120), comprenant:

une section flexible d'assistance à la transmission de force (12, 52, 64, 82) ;
une première section de montage (14, 70) et une deuxième section de montage (16), qui sont fournies aux

deux portions terminales de la section d'assistance à la transmission de force (12, 52, 64, 82), la première section de montage (14, 70) étant adaptée pour être montée dans un site et la deuxième section de montage (16) étant adaptée pour être montée dans un autre site, prenant en sandwich une articulation d'utilisateur de manière que la section d'assistance à la transmission de force (12, 52, 64, 82) soit disposée à travers au moins une des suivantes: une articulation de la hanche et une articulation du genou d'un utilisateur ; et
une source d'entraînement (40) qui exerce une force de traction ou encore de tension entre la première section de montage (14, 70) et la deuxième section de montage (16) à travers la section d'assistance à la transmission de force (12, 52, 64, 82),

sachant qu'au moins une portion de la section d'assistance à la transmission de force (12, 52, 64, 82) est élastiquement déformable dans une direction d'action de la force de traction par la source d'entraînement (40), et
caractérisé en ce que
la portion de la section d'assistance à la transmission de force (12, 52, 64, 82) qui est élastiquement déformable est un élément pour lequel, par rapport à l'élasticité dans la direction d'action de la force de traction par la source d'entraînement (40), l'élasticité dans une direction orthogonale à celle-ci est moins élevée.

2. Le dispositif d'assistance à l'exercice d'articulation (10, 50, 60, 80, 110, 120) d'après la revendication 1, sachant que la première section de montage (14, 70) est appropriée pour être fixée à un moins un des suivants: une cuisse et l'articulation du genou de l'utilisateur, alors que la deuxième section de montage (16) est appropriée pour être fixée dans la région lombaire de l'utilisateur de manière que la section d'assistance à la transmission de force (12, 52, 64, 82) soit disposée à travers l'articulation de la hanche.

3. Le dispositif d'assistance à l'exercice d'articulation (10, 50, 60, 80, 110, 120) d'après la revendication 1 ou 2, sachant que la section d'assistance à la transmission de force (12, 52, 64, 82) qui est élastiquement déformable présente une élasticité de 0,3 kgf/cm ou plus et 0,5 kgf/cm ou moins dans la direction d'action de la force de traction par la source d'entraînement (40).

4. Le dispositif d'assistance à l'exercice d'articulation (10, 50, 80, 110, 120) d'après une quelconque des revendications de 1 à 3, sachant que la section d'assistance à la transmission de force (12, 52, 82) comprend : une première bande de traction en forme de bande (18, 84) qui s'étend à partir de la première section de montage (14, 70) ; une deuxième bande de traction en forme de bande (20, 86) qui s'étend à partir de la deuxième section de montage (16) ; et une ferrure d'assemblage (22, 92) reliant l'une à l'autre la première et la deuxième bande de traction (18, 84, 20, 86).

5. Le dispositif d'assistance à l'exercice d'articulation (10, 50, 110, 120) d'après la revendication 4, sachant que la première section de montage (14) est portée enroulée sur l'articulation du genou de l'utilisateur et que la deuxième section de montage (16) est portée enroulée sur la région lombaire de l'utilisateur ;
sachant que la première bande de traction (18) est élastiquement déformable dans une direction longitudinale qui est la direction d'action de la force de traction, pendant qu'elle s'étend à partir de la première section de montage (14) et qu'elle est disposée de manière à couvrir une surface frontale de la cuisse de l'utilisateur ;
sachant que la ferrure d'assemblage (22) est attachée à une extrémité supérieure de la première bande de traction (18) ; et
sachant qu'une partie intermédiaire dans le sens longitudinal, de la deuxième bande de traction (20) est insérée dans la ferrure d'assemblage (22) alors que les deux parties terminales dans le sens longitudinal, de la deuxième bande de traction (20) sont attachées à la deuxième section de montage (16) de manière que la section d'assistance à la transmission de force (12, 52) incluant la première bande de traction (18) et la deuxième bande de traction (20) soit disposée à travers l'articulation de la hanche de l'utilisateur, et qu'une force d'assistance qui est exercée impliquant une déformation élastique de la section d'assistance à la transmission de force (12, 52) aide à fléchir et à détendre l'articulation de la hanche.

6. Le dispositif d'assistance à l'exercice d'articulation (60) d'après une quelconque des revendications de 1 à 3, sachant que la section d'assistance à la transmission de force (64) est fournie sous forme d'unité intégrale avec une unité principale (62) sous forme de vêtement et qu'en portant l'unité principale (62), la section d'assistance à la transmission de force (64) est disposée à travers l'articulation de l'utilisateur.

7. Le dispositif d'assistance à l'exercice d'articulation (10, 50, 60, 80, 110, 120) d'après une quelconque des revendications de 1 à 6, comprenant en outre : un capteur (32, 112, 122) qui est en mesure de détecter un fléchissement et une extension de l'articulation de l'utilisateur en se basant sur une force exercée sur le capteur (32, 112, 122) en concordance avec le fléchissement et l'extension de l'articulation de l'utilisateur, le capteur (32, 112, 122) incluant

au moins un des suivants : un capteur de type capacitif (32, 112, 122) et un capteur de type à changement de résistance ; et un dispositif de commande (46) agencé pour commander la source d'entraînement (40) en se basant sur des résultats de détection du capteur (32, 112, 122).

8. Le dispositif d'assistance à l'exercice d'articulation (10, 50, 60, 80, 110, 120) d'après une quelconque des revendications de 1 à 7, sachant que la section d'assistance à la transmission de force (12, 52, 64, 82) est sous forme de bande qui s'étend dans une direction de la transmission de force.

9. Le dispositif d'assistance à l'exercice d'articulation (10, 50, 60, 80, 110, 120) d'après une quelconque des revendications de 1 à 8, sachant que la source d'entraînement (40) est attachée à la deuxième section de montage (16).

10. Le dispositif d'assistance à l'exercice d'articulation (10, 50, 60, 80, 110, 120) d'après une quelconque des revendications de 1 à 9, sachant que la force de traction par la source d'entraînement (40) agit en tant que force d'assistance qui renforce la force nécessaire à l'exercice de fléchissement et d'extension de l'articulation de l'utilisateur.

11. Le dispositif d'assistance à l'exercice d'articulation (10, 50, 60, 80, 110, 120) d'après une quelconque des revendications de 1 à 10, sachant que la force de traction par la source d'entraînement (40) agit en tant que force de résistance qui résiste à la force nécessaire à l'exercice de fléchissement et d'extension de l'articulation.

FIG.1

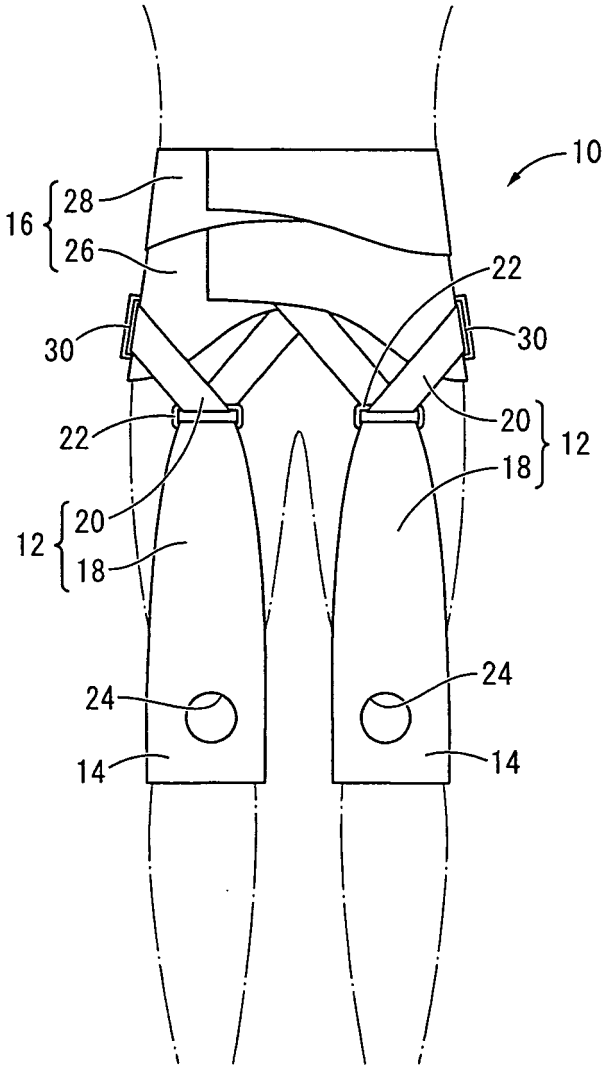


FIG.2

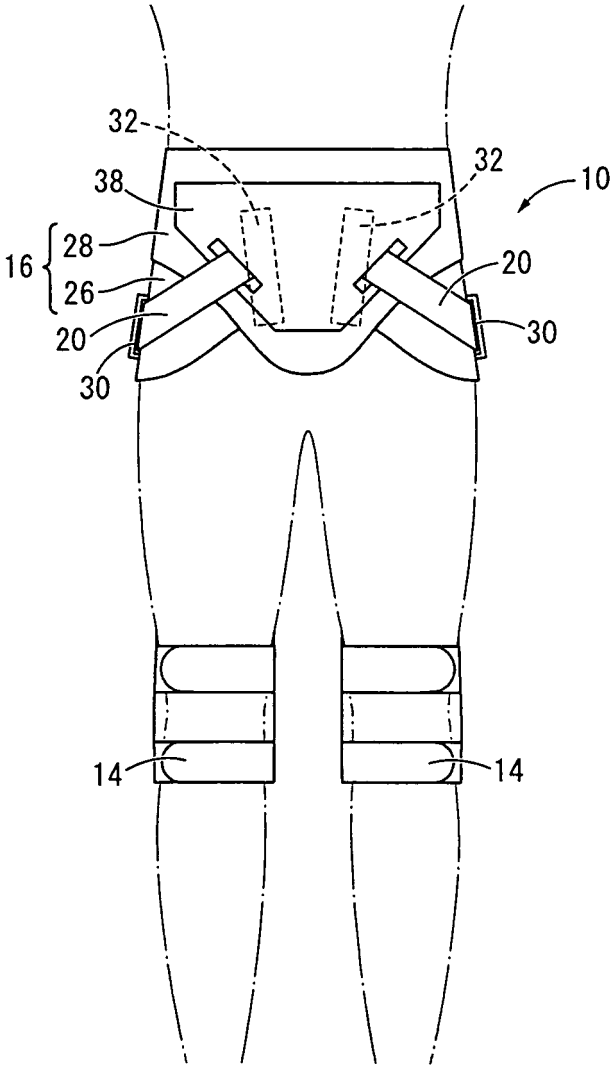


FIG.3

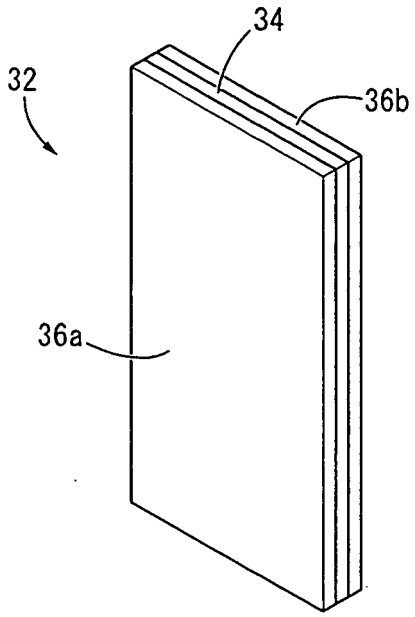


FIG.4

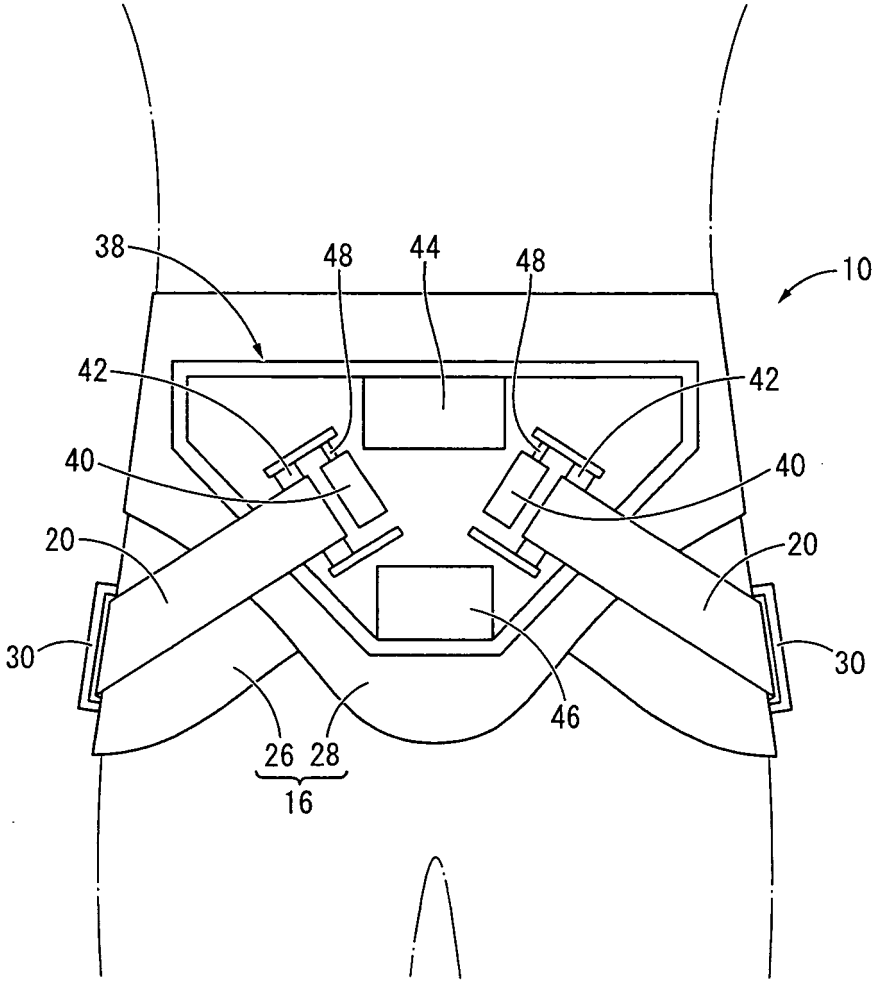


FIG.5

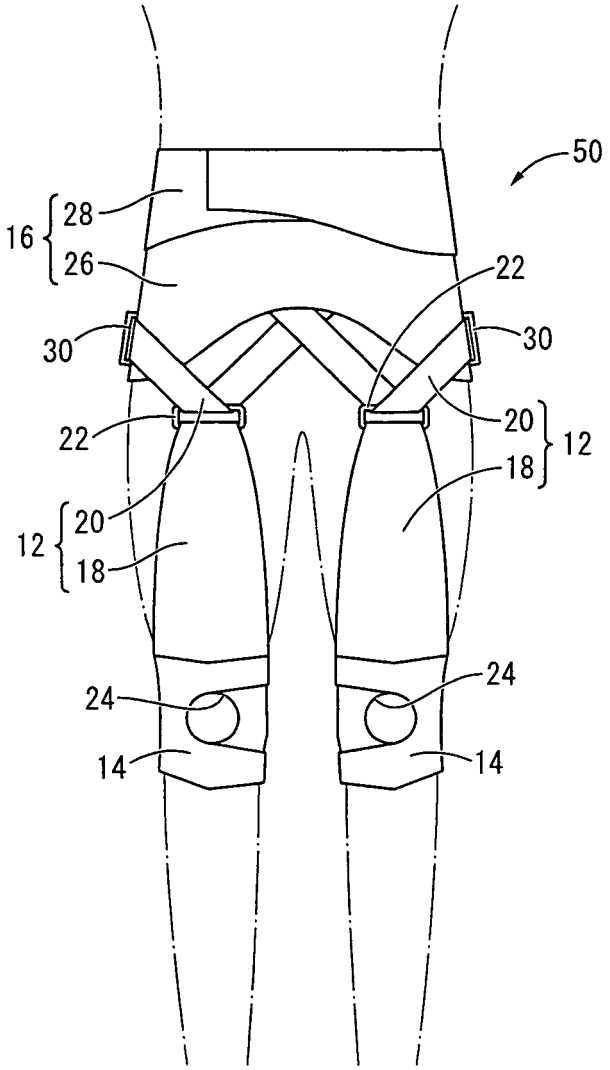


FIG.6

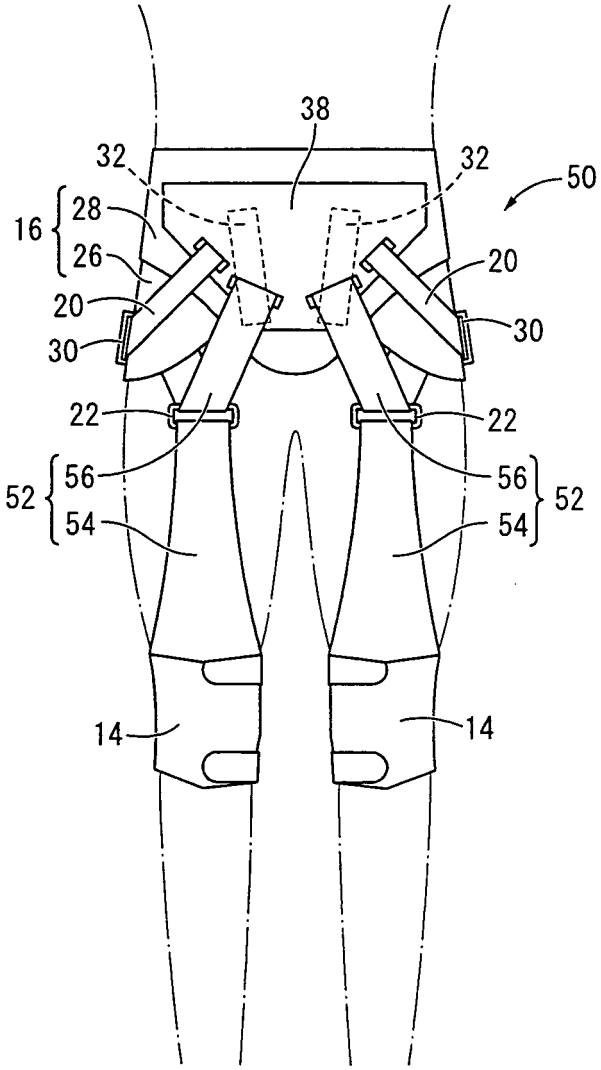


FIG.7

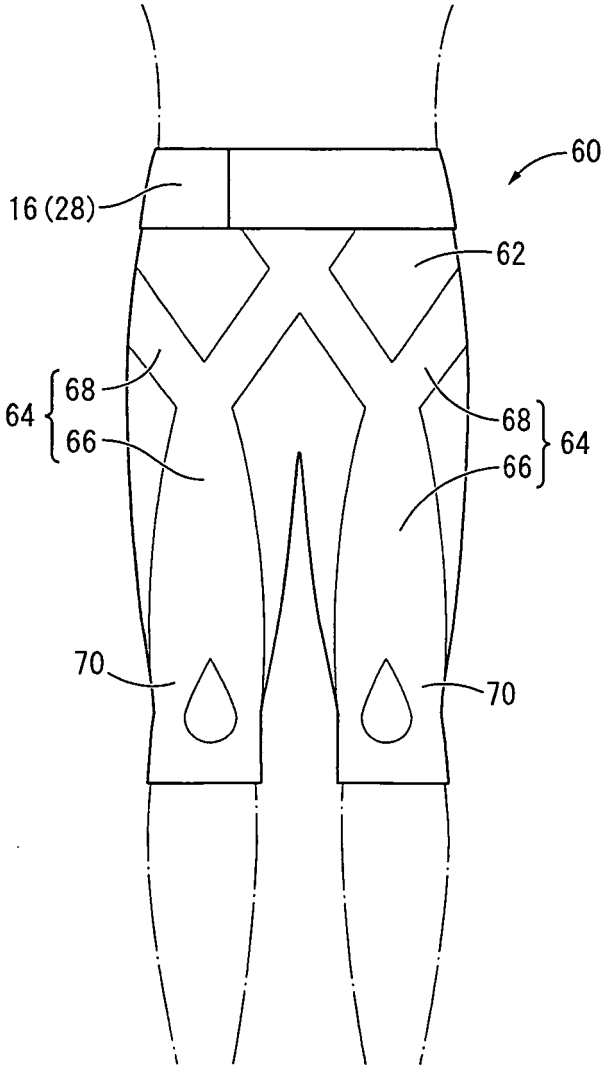


FIG.8

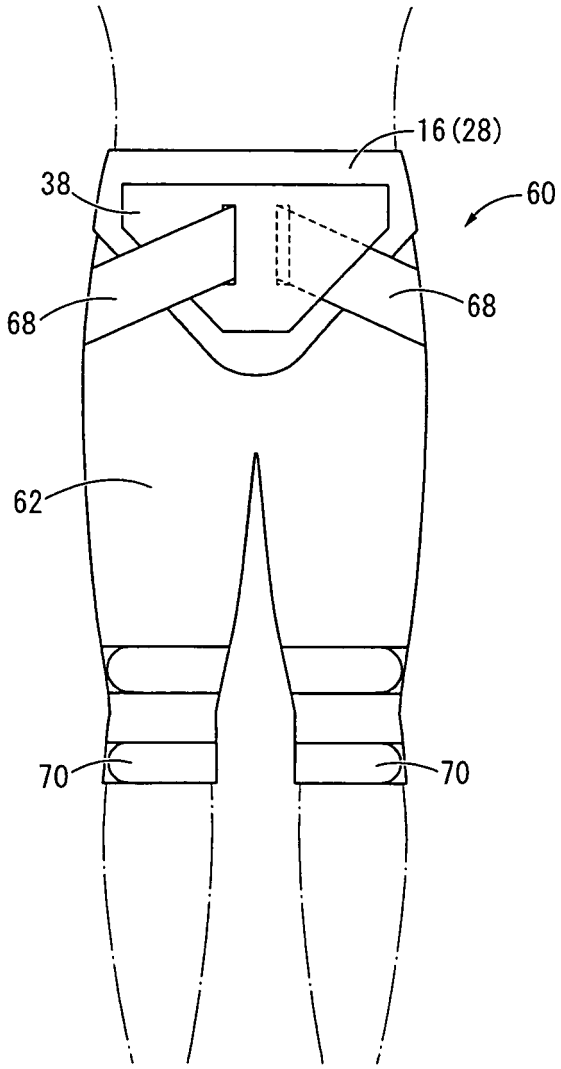


FIG.9

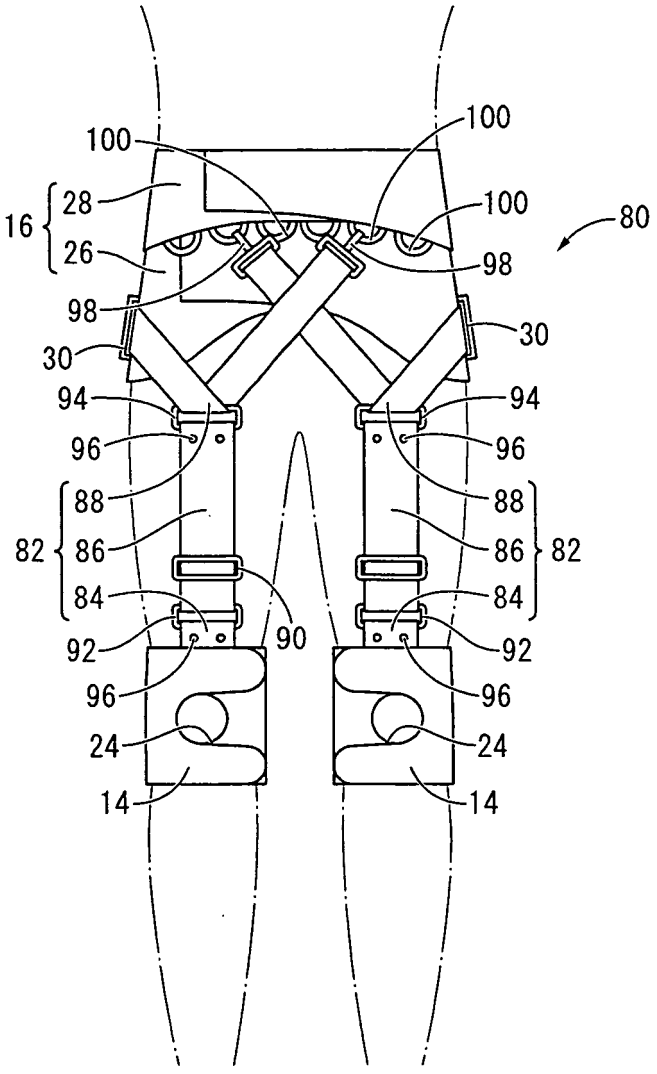

100
100
16
28
26
100
80
98
98
30
30
94
94
96
96
88
82
86
88
86
82
84
84
90
92
92
96
96
24
24
14
14

FIG.10

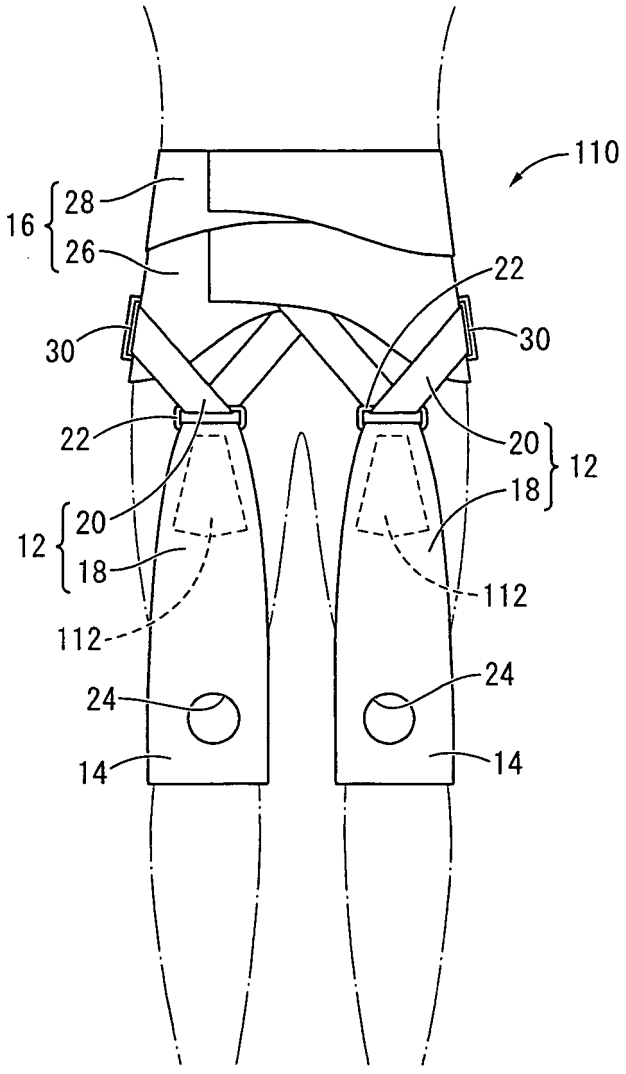
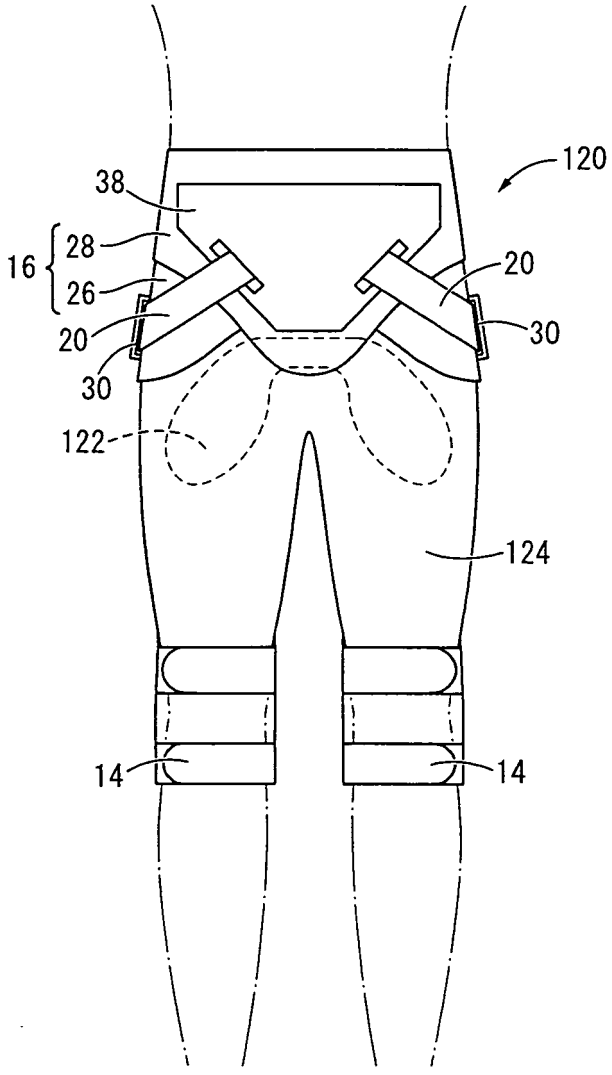


FIG.11



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

- JP 4200492 B **[0002] [0006]**
- JP 2010110464 A **[0005] [0006]**
- US 20060135903 A1 **[0007]**
- JP 2010043880 A **[0046]**
- JP 2009020006 A **[0046]**
- JP 2008069313 A **[0092]**