

LOWER LIMB EXERCISE ASSIST DEVICE

TECHNICAL FIELD

[0001]

The present invention relates to a lower limb exercise assist device, and more
5 particularly to a continuous passive motion (CPM) lower limb exercise assist device.

BACKGROUND ART

[0002]

Continuous passive motion (CPM) lower limb exercise assist devices primarily for
assisting the knee bending exercise have been previously proposed. See Patent Documents 1
10 and 2, for instance. One of the previously proposed CPM lower limb exercise assist devices
includes a base, a pair of left and right sliders provided on the base so as to be capable of
reciprocating in parallel with each other in the fore and aft direction on a single plane, a drive
unit for driving the left and right sliders in the fore and aft direction in a reciprocating manner,
and a pair of foot support members attached to the respective sliders and each provided with a
15 heel stop that prevents at least a rearward movement of a user's foot placed on the
corresponding foot support member, each foot support member being pivotable around a
laterally and horizontally extending axial line passing through a part corresponding to the heel
stop or the ankle joint of the user's foot placed on the foot support member.

PRIOR ART DOCUMENT(S)

20 PATENT DOCUMENT(S)

[0003]

Patent Document 1: JP5475838B

Patent Document 2: JP5509396B

SUMMARY OF THE INVENTION

25 TASK TO BE ACCOMPLISHED BY THE INVENTION

[0004]

According to this previously proposed lower limb exercise assist device, since the drive source for reciprocating the sliders in the fore and aft direction is an electric motor, it is necessary to convert the rotational output of the electric motor to the reciprocating linear motion of the sliders, and this requires a relatively complex mechanism. As a result, an increase in cost and weight is inevitable.

[0005]

A primary object of the present invention is to simplify the structure of a lower limb exercise assist device, and achieve a reduction in cost and weight.

10 MEANS TO ACCOMPLISH THE TASK

[0006]

A lower limb exercise assist device according to the present invention comprises a base (12); a rotatable body (14) provided on the base (12) so as to be rotatable around a vertical axis; a left foot recess (20) and a right foot recess (22) formed on an upper surface of the rotatable body (14) in a mutually spaced apart relationship and each having an open upper end, each recess including a rear wall (20B, 22B) for preventing a rearward movement of a heel of a user, an inner wall (20D, 22D) for preventing an inward movement of a foot of the user, and an outer wall (20E, 22E) for preventing an outward movement of the foot of the user; and a drive unit (30) that is provided to the base (12) and rotatively reciprocates the rotatable body (14) by a prescribed angle.

[0007]

This arrangement eliminates a need for a mechanism for converting the rotational output of the electric motor (30) to the reciprocating motion of the sliders so that the structure is simplified, and a reduction in cost and weight can be achieved.

25 [0008]

In the lower limb exercise assist device according to the present invention, the left foot recess (20) and the right foot recess (22) may be on a diametric line passing through the rotational center of the rotatable body (14), and symmetric to each other.

[0009]

5 Thereby, the flexing motions of the knee joints of the left leg and the right leg can be effected in an even manner.

[0010]

In the lower limb exercise assist device according to the present invention, the outer wall of each recess (20, 22) may be lower on a toe side (21B, 23B) than on a heel side (21A, 10 23A).

[0011]

Thereby, each recess is formed with a low resistance region (24, 26) that allows a toe of the user's foot in the foot support to be moved outward (abduction) so that the user's toe is prevented from being turned excessively inward (adduction) as the recess moves along an 15 arcuate path, and an excessive twisting of the knee joint can be avoided.

EFFECT OF THE INVENTION

[0012]

The lower limb exercise assist device according to the present invention does not require a mechanism for converting the rotational output of the electric motor to the 20 reciprocating motion of the sliders so that the structure is simplified, and a reduction in cost and weight can be achieved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

Figure 1 is a plan view showing a lower limb exercise assist device according to an 25 embodiment of the present invention;

Figure 2 is a perspective view of the lower limb exercise assist device;

Figure 3 is a sectional view taken along line III-III of Figure 1;

Figure 4 is a plan view showing a mode of operation of the lower limb exercise assist device;

5 Figure 5 is a fragmentary perspective view showing a lower limb exercise assist device according to an alternate embodiment of the present invention; and

Figure 6 is a fragmentary perspective view of the lower limb exercise assist device of the alternate embodiment (with a rotatable body mounting plate removed).

EMBODIMENT(S) FOR CARRYING OUT THE INVENTION

10 [0014]

A lower limb exercise assist device according to an embodiment of the present invention is described in the following with reference to Figures 1 to 4.

[0015]

15 The lower limb exercise assist device 10 is provided with a disk shaped base 12 configured to be placed on a floor and a disk shaped rotatable body 14 provided on the base 12 so as to be rotatable around a vertical axis.

[0016]

20 The lower surface of the rotatable body 14 is formed with an annular guide rail 16 which is concentric with the rotational center of the rotatable body 14. The guide rail 16 protrudes downward from the lower surface of the rotatable body 14 and also serves as a reinforcing rib of the rotatable body 14. A plurality of metallic balls 18 are rotatably interposed between the base 12 and the guide rail 16 so as to rotatably support the rotatable body 14 relative to the base 12.

[0017]

25 A left foot recess 20 and a right foot recess 22 are formed on the upper surface of the

rotatable body 14 at positions separated from each other in the lateral direction. The distance between the left foot recess 20 and the right foot recess 22 in the lateral direction is substantially equal to the between the right foot and left foot of the user in a normal posture. This distance as measured between the center points of the left foot recess 20 and the right foot recess 22 may be about 340 mm to 400 mm.

[0018]

More specifically, the left foot recess 20 and the right foot recess 22 are provided on a diametrical line passing through the rotational center of the rotatable body 14 and symmetrically to each other. Each recess 20, 22 consists of a substantially rectangular depression in plan view with an open upper end, and is provided with a planar bottom wall 20A, 22A for placing a sole of the user's foot, a rear wall 20B, 22B extending from the rear edge of the bottom wall 20A, 22A to prevent a rearward movement of the user's foot, a front wall 20C, 22C extending from the front edge of the bottom wall 20A, 22A to allow the sole of the user's foot to be rested upon, an inner wall 20D, 22D extending from the inner edge of the bottom wall 20A, 22A to prevent an inward movement of the user's foot, and an outer wall 20E, 22E extending from the outer edge of the bottom wall 20A, 22A to prevent an outward movement of the user's foot.

[0019]

Each rear wall 20B, 22B is slanted in the fore and aft direction, and the inclination angle with respect to the bottom wall 20A, 22A may be about 25 to 45 degrees. Each front wall 20C, 22C is slanted in the fore and aft direction, and the inclination angle with respect to the bottom wall 20A, 22A may be about 45 degrees to 75 degrees. Each inner wall 20D, 22D extends substantially upright from the bottom wall 20A, 22A, and the inclination angle with respect to the bottom wall 20A, 22A may be about 75 to 90 degrees. Similarly, each outer wall 20E, 22E extends substantially upright from the bottom wall 20A, 22A, and the inclination angle with respect to the bottom wall 20A, 22A may be about 75 to 90 degrees.

[0020]

The outer wall 20E, 22E of each recess 20, 22 is lower on a toe side part 21B, 23B than on a heel side part 21A, 23B. Each front wall 20C, 22C is equal in height to the toe side part 21B, 23B of the outer wall 20E, 22E. As a result, the outer side of the front part and the front end of each recess 20, 22 is lower than the rear part (general surface) of the recess 20, 22 so that the outer side of the front part and the front end of each recess 20, 22 form a low resistance region 24, 26 for an outward movement of the toe of the user's foot.

[0021]

An electric motor 30 is attached to the base 12. A drive pulley 34 is attached to the output shaft 32 of the electric motor 30. A driven pulley 36 is attached to a center shaft 28 of the rotatable body 14. An endless transmission belt 38 is passed around the drive pulley 34 and the driven pulley 36. As a result, the rotatable body 14 is rotationally driven around the center thereof by the electric motor 30. In the illustrated embodiment, the drive pulley 34 and the driven pulley 36 are toothed, and the transmission belt 38 consists of a toothed belt (cogged belt) configured to mesh with the drive pulley 34 and the driven pulley 36.

[0022]

A controller 40 is provided on the base 12. The controller 40 includes a motor driver that rotatively reciprocates the electric motor 30 by a prescribed rotational angle and at a prescribed rotational speed. The controller 40 may be configured for wireless communication such as infrared communication and Bluetooth, and turns on and off the power, and varies the rotational angle and the rotational speed by receiving a command from an external hand-held controller (not shown in the drawings). The power source of the lower limb exercise assist device 10 may be a utility electric power supply or a rechargeable internal battery.

[0023]

When using the lower limb exercise assist device 10, the user is seated on a chair, and

places his or her feet in the respective recesses 20 and 22 such that the heel of each foot is positioned in the vicinity of the corner part between the bottom wall 20A and the rear wall 20B. When the power supply is turned on, the electric motor 30 starts angularly reciprocating the rotatable body 14 by a commanded rotational angle and at a commanded rotational speed.

5 [0024]

As shown in Figure 4(A), in a neutral position, the rotatable body 14 assumes a rotational position where the left foot recess 20 and the right foot recess 22 are positioned on a straight line extending in the lateral direction, and squarely face the user. The rotatable body 14 can be angularly reciprocated between a right angular position where the rotatable body 14 has
10 turned by angle θ_a from the neutral position in clockwise direction as shown in Figure 4(B), and a left angular position where the rotatable body 14 has turned by angle θ_b from the neutral position in counterclockwise direction as shown in Figure 4(C).

[0025]

As a result, the left and right feet are moved back and forth substantially in the fore
15 and aft direction in an alternating manner, and the knee joints of the user are repeatedly flexed in a passive manner. The rotational angles θ_a and θ_b of the rotatable body 14 may be equal to each other, and may be about 25 degrees to 45 degrees. The circumferential speed of the rotatable body 14 may be about 20 to 40 mm / sec at the laterally central points of the left foot recess 20 and the right foot recess 22.

20 [0026]

Since the mechanism for converting the rotational output of the electric motor 30 into the linear reciprocating motion of the sliders is not required for the lower limb exercise assist device 10, the structure is simplified and a reduction in cost and weight can be achieved.

[0027]

25 The arrangement for restraining the user's feet that is required for effecting the passive

flexing movement of the knee joints consists of a pair of recesses 20 and 22 provided in the rotatable body 14 or a pair of recesses integrally formed in the rotatable body 14 for placing the user's feet therein. This arrangement is so simple that a significant reduction in the cost and weight of the lower limb exercise assist device 10 can be achieved.

5 [0028]

Each foot of the user placed in the left foot recess 20 or the right foot recess 22 moves along an arcuate locus owing to the rotation of the rotatable body 14.

[0029]

Owing to this arcuate movement, the rightward or clockwise rotation of the rotatable
10 body 14 causes an abducting movement of the right foot and an adducting movement of the left foot as shown in Figure 4(B). Similarly, the leftward or counterclockwise rotation of the rotatable body 14 causes an adducting movement of the right foot and an abducting movement of the left foot as shown in Figure 4(C).

[0030]

15 Anatomically, a human knee joint has a greater tolerance for an abducting movement of the foot than for an adducting movement of the foot, and an adducting movement causes a relatively greater stress on the knee joint.

[0031]

The lower limb exercise assist device 10 is provided with a low resistance region 24,
20 26. Therefore, when an adducting movement is caused to the user's foot, the toe of the user's foot is allowed to move through the low resistance region 24, 26 so that an excessive inward movement of the toe (adduction) is avoided. As the knee joint is more tolerant for the abducting movement of the foot, a low resistance region is not required to be provided on the inner side of the recess 20, 22.

25 [0032]

Thus, even when the left foot recess 20 and the right foot recess 22 are moved along arcuate loci by the rotation of the rotatable body 14, a passive knee joint flexing exercise can be performed without causing any undue strain on the knee joints similarly as in the case where the user's feet are linearly moved. In particular, the flexing movement of the knee joints can be performed evenly when the left foot recess 20 and the right foot recess 22 are disposed on a diametric line passing through the rotational center of the rotatable body 14 and symmetrically to each other about the center of the rotatable body 14.

[0033]

An alternate embodiment of the lower limb exercise assist device according to the present invention is described in the following with reference to Figure 5 and Figure 6.

[0034]

In this embodiment, an electric motor 52 is mounted on the base mounting plate 50 fixedly attached to the base 12. A worm 56 is attached to an output shaft 54 of the electric motor 52. A worm wheel 60 is rotatably supported by the base mounting plate 50 via a shaft 58. The worm wheel 60 meshes with the worm 56. An integral assembly of a large diameter gear 64 and a small diameter gear 66 is rotatably supported by the base mounting plate 50 via a shaft 62. The large diameter gear 64 meshes with the worm wheel 60.

[0035]

A guide plate 70 fitted with a plurality of guide pins 68 is mounted on the base mounting plate 50. A rotatable body mounting plate 72 is fixedly attached to the bottom surface of the rotatable body 14 (see Figure 2). The rotatable body mounting plate 72 is formed with arcuate slots 74 slidably receiving the corresponding guide pin 68 so that the rotatable body 14 can angularly reciprocate relative to the base 12 around the central axis of the rotatable body 14 within a range permitted by the length of the arcuate slots 74, or in other words, within a prescribed rotational angle range.

[0036]

A sector gear 78 is fixed to the rotatable body mounting plate 72 via a plurality of mounting pins 76. The sector gear 78 is disposed concentrically with the central axis (rotational center) of the rotatable body 14, and meshes with the small diameter gear 66.

5 [0037]

According to this arrangement, the rotation of the electric motor 52 is transmitted to the worm wheel 60 via the worm 56. The rotation of the worm wheel 60 is transmitted to the sector gear 78 via the large diameter gear 64 and the small diameter gear 66 at a reduced rotational speed. As a result, when the electric motor 52 cyclically and angularly reciprocates,
10 the rotatable body 14 angularly reciprocates around the central axis thereof with respect to the base 12 by a prescribed rotational angle and at a prescribed rotational speed.

[0038]

The worm 56, the worm wheel 60, the large diameter gear 64, the small diameter gear 66, and the sector gear 78 may be made of plastic material so as to form a gear transmission
15 mechanism that is capable of a highly quiet operation.

[0039]

Although the present invention has been described in terms of preferred embodiments thereof, it is obvious to a person skilled in the art that various alterations and modifications are possible without departing from the scope of the present invention. For example, the shapes of
20 the base 12 and the rotatable body 14 are not limited to the disk shape, and can be modified to any other shapes. The rotational driving mechanism for the rotatable body 14 is not limited to those based on the belt type transmission mechanism and the gear mechanism, but may also be based on the direct drive system using a chain type transmission mechanism or a direct transmission system using an electric motor coaxially arranged with the center shaft 28 . In
25 addition, all of the constituent elements described in the above embodiment are not necessarily

indispensable, and can be appropriately selected as long as they do not depart from the gist of the present invention.

[0040]

The contents of the original Japanese patent application (Japanese Patent Application
5 No. 2015-98900 filed on May 14, 2015) on which the Paris Convention priority claim is made for the present application are incorporated in this application by reference.

GLOSSARY OF TERMS

[0041]

	10	lower limb exercise assist device	12	base
10	14	rotatable body	16	guide rail
	18	ball	20	left foot recess
	20A	bottom wall	20B	rear wall
	20C	front wall	20D	inner wall
	20E	outer wall	22	right foot recess
15	22A	bottom wall	22B	rear wall
	22C	front wall	22D	inner wall
	22E	outer wall	24	low resistance region
	26	low resistance region	28	center shaft
	30	electric motor	32	output shaft
20	34	drive pulley	36	driven pulley
	38	transmission belt	40	controller
	50	base mounting plate	52	electric motor
	54	output shaft	56	worm
	58	shaft	60	worm wheel
25	62	shaft	64	large diameter gear

66 small diameter gear

70 guide plate

74 slot

78 sector gear

68 guide pin

72 rotatable body mounting plate

76 mounting pin

CLAIMS

1. A lower limb exercise assist device, comprising:
a base;
a rotatable body provided on the base so as to be rotatable around a vertical axis;
5 a left foot recess and a right foot recess formed on an upper surface of the rotatable body in a mutually spaced apart relationship and each having an open upper end, each recess including a rear wall for preventing a rearward movement of a heel of a user, an inner wall for preventing an inward movement of a foot of the user, and an outer wall for preventing an outward movement of the foot of the user; and
10 a drive unit that is provided to the base and rotatively reciprocates the rotatable body by a prescribed angle.
2. The lower limb exercise assist device according to claim 1, wherein the left foot recess and the right foot recess are on a diametric line passing through the rotational center of the
15 rotatable body, and symmetric to each other.
3. The lower limb exercise assist device according to claim 1 or 2, wherein the outer wall of each recess is lower on a toe side than on a heel side.