

GAIT BALANCE REHABILITATION APPARATUS

RELATED APPLICATION

[0001] This application claims the benefit of priority to the Chinese patent application no. 202310914364X filed July 24, 2023, the contents of which are hereby incorporated herein by reference in their entirety for all purposes.

TECHNICAL FIELD

[0002] The present disclosure relates to an apparatus to aid rehabilitative therapy and, in particular, to aid rehabilitation patients in regaining walking balance or gait balance.

BACKGROUND

[0003] The ability to balance is a fundamental motor skill and a prerequisite for maintaining a variety of postural and mobility activities. Balance has a critical impact on a person's ability to independently handle various tasks in daily life.

[0004] Conventional balance rehabilitation methods can be generally categorized into postural balance training and gait training. Appropriate training can improve a patient's gait, as well as help the patient make progress in static balance and dynamic balance. Gait balance is complex and dynamic, requiring multiple limbs to move simultaneously to achieve overall balance. Conventional gait rehabilitation motorized apparatus, such as treadmill-based devices, are generally only suitable for indoor environments and require a large space and fixed mounting in order to observe the patient's gait when the patient is walking.

SUMMARY

[0005] In one aspect, the present disclosure provides a gait balance rehabilitation apparatus. The gait balance rehabilitation apparatus includes a base, a frame, and a slidable member. The frame is fixedly disposed on the base and extends from the base for a length along a longitudinal direction. The slidable member is engaged with the frame and displaceable relative to the frame in the longitudinal direction or in a counter-longitudinal direction opposing the longitudinal direction. The gait

balance rehabilitation apparatus may include a seat having a rear section pivotably coupled with the slidable member and a mid-section pivotably coupled with the frame.

[0006] The gait balance rehabilitation apparatus may include a braking mechanism. The braking mechanism may include a plurality of linkages and a corresponding plurality of rotary joints. The plurality of linkages and the corresponding plurality of rotary joints may be alternately coupled to one another, forming a closed ring structure. The slidable member may serve as one of the plurality of linkages. Four of the six rotary joints are lockable rotary joints. Selected ones of the rotary joints may be lockable rotary joints that are configured to lock an angular displacement between two of the linkages coupled to the respective one of the lockable rotary joints.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Various embodiments of the present disclosure will be described with reference to the following figures:

FIG. 1 is a schematic perspective view of a gait balance rehabilitation apparatus according to some embodiments of the present disclosure;

FIG. 2 is a schematic perspective view of a gait balance rehabilitation apparatus according to some other embodiments;

FIG. 3 is a schematic perspective view of a braking mechanism in one state;

FIG. 4 is a schematic perspective view of the braking mechanism of FIG. 3 in another state;

FIG. 5 is a partially enlarged side view of a safety harness attached to support member;

FIG. 6 is a schematic side view of a rotary joint;

FIG. 7 is a schematic exploded view of the rotary joint of FIG. 6;

FIG. 8 is a schematic side view illustrating an exoskeleton device according to some embodiments of the present disclosure;

FIG. 9 is a schematic perspective view illustrating the gait balance rehabilitation apparatus in an unfolded-seat mode;

FIG. 10 is a schematic perspective view illustrating the gait balance rehabilitation apparatus in a folded-seat mode;

FIG. 11 is a schematic diagram showing a seat movement;

FIG. 12 is a schematic diagram showing another seat movement;

FIG. 13 is a schematic perspective view of a drive system according to some embodiments of the present disclosure;

FIG. 14 is a schematic perspective view of the drive system according to some embodiments; and

FIG. 15 is a schematic perspective view of the drive system according to some other embodiments of the present disclosure.

DETAILED DESCRIPTION

[0008] The following detailed description is made with reference to the accompanying drawings, showing details and embodiments of the present disclosure for the purposes of illustration and to aid understanding, and not to be limiting. Features that are described in the context of an embodiment may correspondingly be applicable to the same or similar features in the other embodiments, even if not explicitly described in these other embodiments. Additions and/or combinations and/or alternatives as described for a feature in the context of an embodiment may correspondingly be applicable to the same or similar feature in the other embodiments.

[0009] As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items.

[0010] The word “exemplary” is used herein to mean “serving as an example, instance, or illustration.” Any embodiment described herein as “exemplary” is not necessarily to be construed as preferred or advantageous over other embodiments.

[0011] As used herein, the singular ‘a’ and ‘an’ may be construed as including the plural “one or more” unless apparent from the context to be otherwise.

[0012] The terms “about” and “approximately” as applied to a stated numeric value encompasses the exact value and a reasonable variance as will be understood by one of ordinary skill in the art, and the terms “generally” and

“substantially” are to be understood in a comparable manner, unless otherwise specified.

[0013] Some processes may be described in terms of steps merely to aid understanding and/or for convenient reference. The delineation between one step and another step may be described as such merely for convenient reference in the present disclosure. It will be understood that in actual implementation there may not be a clear division or transition from one step to another subsequent step. There may be a certain amount of overlap among the steps and/or more than one step may occur or be performed concurrently in time, etc.

[0014] As used herein, the term “concurrent”, or “concurrently”, is used loosely to refer to two or more occurrences (or events) that at least partially overlap in time. The occurrences may or may not start at the same time instant and/or end at the same time instant.

[0015] Terms such as “first” and “second” are used in the description and claims only for the sake of brevity and clarity, and do not necessarily imply a priority or order, unless required by the context.

[0016] For the sake of brevity, reference may be made to a front side of the frame 300 (where an assisted user may be positioned when using the rehabilitation apparatus) and the rear side that is on another side of the frame of the gait balance rehabilitation apparatus. The terms “forward” and “backward” may be similarly understood with reference to the frame.

[0017] FIG. 1 is a schematic structural diagram of a gait balance rehabilitation apparatus 100 according to embodiments of the present disclosure. The term “gait balance rehabilitation apparatus” as used herein may be interchangeably used with the terms “rehabilitation apparatus” or “balance training apparatus”.

[0018] The rehabilitation apparatus 100 includes a base 200 and a frame 300 disposed on the base 200. The frame 300 extends generally in a longitudinal direction 101. For the sake of brevity, a direction opposite to the longitudinal direction 101 is referred to herein as a counter-longitudinal direction 102.

[0019] The rehabilitation apparatus 100 includes a braking mechanism 400. The braking mechanism 400 as a whole may be displaced relative to the frame 300,

including moving relative to the frame 300 in a direction parallel or substantially parallel to the longitudinal direction 101.

[0020] The rehabilitation apparatus 100 may include a moveable handle system 500 and a fixed handle 590.

[0021] The fixed handle 590 may be provided at a rear side of the frame 300. The fixed handle 590 may be secured at a longitudinal distance (height) from the base 200, so as to allow an assisting user (e.g., a healthcare worker) to hold the fixed handle 590 and push the rehabilitation apparatus 100 conveniently.

[0022] The handle system 500 may be configured to move longitudinally (e.g., up or down) relative to the frame 300 and/or laterally (e.g., forward or backward) relative to the frame, with the movement of the handle system following the braking mechanism 400. The handle system 500 includes a handle 512 (or a pair of handles 512) located in front of the frame 300. The handle 512 (or handles 512) are disposed to be held by the assisted user (e.g., a patient). The braking mechanism 400 may be connected to the handle system 500 with the braking mechanism 400 configured to arrest movement of the handle system 500.

[0023] The rehabilitation apparatus 100 includes a seat system 600. The seat system 600 is configured to allow the assisted user to stand up or sit down in place (without the need to step away or step towards the seat) while using the rehabilitation apparatus 100, without taking his/her hands off the handle 512. The user may sit facing a forward direction 103 on the seat 620 of the seat system 600, or walk or stand between a pair of bars 510. The rehabilitation apparatus 100 may be equipped with one or a pair of exoskeleton devices 800.

[0024] In some embodiments, the rehabilitation apparatus 100 includes a base 200 that is mobile to enable the assisted user to acquire/re-acquire gait balancing skills by walking on the ground (as opposed to walking "in place" on a moving treadmill). The rehabilitation apparatus 100 may include a chassis connected to the base 200. The chassis may be configured as a rear-wheel drive chassis. In some embodiments, the chassis includes rear wheels 212, 222 and front wheels 214, 224. The rear wheels 212, 222 may be disposed parallel to each other on the base 200 such that the rehabilitation apparatus 100 may be movable in the forward direction 103 or a rearward direction 104 (opposite to the forward direction 103).

[0025] A first base element 213 and a second base element 223 may extend from either side of the base 200. The first base element 213 may extend from one side of the base 200 in a first axial direction 110 and provide a first front wheel 214 at an end thereof. The second base element 223 may extend from another side of the base 200 in a second axial direction 120 and provide a second front wheel 224 at an end thereof.

[0026] The rehabilitation apparatus 100 may include footrest 215, 225 pivotably connected to the first base element 213 and the second base element 223, respectively. The footrest 215, 225 may be folded and tucked up against the front wheels 214, 224 when not needed.

[0027] In some application scenarios, the first axial direction 110 defined by the first base element 223 and the second axial direction 120 defined by the second base element 223 may be adjusted accordingly (e.g., cases where greater stability is required, uneven ground, obstacles in the vicinity, spatial needs of the user, etc.). In some embodiments, the first base element 213 is pivotably connected (217) to a first actuator 216 secured to the base 200 such that the first base element 223 can be rotated 111 relative to the forward direction 103. In some embodiments, the second base element 223 is pivotably connected (227) to a second actuator 226 secured to the base 200 such that the second base element 223 can be rotated 121 relative to the forward direction 103. In some embodiments, the first actuator 216 and the second actuator 226 include, but are not limited to, a piston actuator. The piston actuator may include a cylinder secured to the base 200 and a piston rod that slidable relative to the cylinder. The first base element 213 and the second base element 223 may each be pivotably connected to a corresponding piston rod.

[0028] As used herein, the term "footprint" or "covered area" refers to the area of ground covered by the rehabilitation apparatus 100. The footprint 150 of the rehabilitation apparatus 100 may also be defined by the base 200, the first base element 213, and the second base element 223. The footprint 150 may be further defined by the wheels 212, 214, 222, 224 of the rehabilitation apparatus 100. For example, the footprint 150 of the rehabilitation apparatus 100 may be defined by the size and shape of the area covered by the rehabilitation apparatus 100 in a plane perpendicular to the longitudinal direction 101.

[0029] According to some embodiments, the rehabilitation apparatus 100 includes base 200 with base elements that can be rotatably displaced to correspondingly adjust the footprint. FIG. 1 illustrates an example of base elements 203 (e.g., a first base element 213 and a second base element 223) disposed approximately parallel to each other. FIG. 2 illustrates an example of the same rehabilitation apparatus 100 with base elements 203 swung out laterally to form a non-parallel configuration. As shown, depending on the application, the rehabilitation apparatus 100 may expand the footprint 150 or contract the footprint 150 by controlling the magnitude and direction of the relative rotation of the base elements 203 (clockwise or counterclockwise direction) to the base 200.

[0030] For example, if the space available is narrow, the rehabilitation apparatus 100 may be configured to have a smaller footprint 150. In another example, in the case of an assisted user with a less steady gait, the rehabilitation apparatus 100 may be configured to have a larger footprint 150, using the base elements 203 to define a larger and obstacle-free space within which the assisted user may move around safely. Enlarging the footprint 150 of the rehabilitation apparatus 100 can also improve the stability of the rehabilitation apparatus 100, allowing the assisted user to carry out rehabilitation training with a peace of mind. Experiments have confirmed that the embodiments disclosed herein have sufficient stability such that the rehabilitation apparatus 100 is suitable for use as a mobile device to provide more effective gait balance rehabilitation training for the assisted user.

[0031] FIG. 3 and FIG. 4 illustrate a braking mechanism 400 of the rehabilitation apparatus 100. The braking mechanism 400 is connected by a plurality of linkages 440 and a corresponding number of rotary joints 410, 420 to form a closed ring structure 490. A first linkage 441 connects a first rotary joint 411 having a braking function to a third rotary joint 413 having a braking function. A second linkage 442 connects a second rotary joint 412 having the braking function to a fourth rotary joint 414 having the braking function. A third linkage 443 connects a third rotary joint 413 with the braking function to a fifth rotary joint 425 without the braking function. A fourth linkage 444 connects a fourth rotary joint 414 with the braking function to a sixth rotary joint 426 without the braking function. The top of each of the rotary joints 413 and 414 may be configured with a ring-like protrusion which may be

loaded with a resilient member, and the other end of the resilient member is connected to or wrapped around the fixed handle 590. The elasticity or the resistance of the rotary joint is adjustable, e.g., the elasticity or the resistance can be adjusted by switching between different resilient members. This function can be utilized when the user is using the rehabilitation apparatus 100, such as to add training resistance. The function may also be useful for helping the assisted user to recover from losing balance, e.g., by bringing the user back towards a central position of the rehabilitation apparatus.

[0032] Both ends of a support linkage 450 of a support backrest 610 is connected to the fifth rotary joint 425 and the sixth rotary joint 426, respectively. A slidable linkage 430 (which may be coupled to the slidable member 340 or serve as the slidable member 340) connects the first rotary joint 411 and the second rotary joint 412 to form a slot 432 that can slide or be displaced parallel to the longitudinal direction relative to the frame 300. The engagement of the slot 432 (defined in part by the slidable member 436 or the slidable member 340) and the frame 300 define a relative displacement path parallel to the longitudinal direction. In some embodiments, the longitudinal direction is not a strictly vertical direction as the longitudinal direction is defined by the frame 300, e.g., dependent on the shape or orientation of the frame 300.

[0033] The first rotary joint 411, the second rotary joint 412, the third rotary joint 413, and the fourth rotary joint 414 are independently lockable rotary joints 410. Each independently lockable rotary joint 410 can be configured to lock or unlock in response to signals from a controller and/or a sensor, independent of the state of any of the other rotary joints 410, 420 in the braking mechanism 400. Regardless of the absolute or relative position/orientation of the individual linkages 440 at that time, and regardless of the state of the other rotary joints of the braking mechanism 400 at that time, any one of the independently lockable rotary joints 410 can switch between a locked state and an unlocked state at any time. This allows the braking mechanism 400 to rapidly lock the relative distance and/or position between the support linkage 450 and the frame 300 in response to control signals and/or sensing information, such as an instantaneous change of the closed ring structure 490 from a retractable state to a rigid state.

[0034] FIG. 3 illustrates the braking mechanism 400 in an expanded state, and FIG. 4 illustrates the braking mechanism 400 in a retracted state (the support backrest 610 and some of the members of the braking mechanism 400 have been omitted from FIG. 4 to more clearly illustrate some details). The lateral movement of the first rotary joint 411 and the second rotary joint 412 is limited by the frame 300. This change in the braking mechanism 400 from the expanded state to the retracted state is equivalent to a movement of the support linkage 450 in a rearward direction 104 relative to the frame 300.

[0035] The bars 510 and handles 512 for use by a patient may be disposed on the front side of the frame 300. According to some embodiments, a bar 510 extends from either end of the support linkage 450 in the forward direction 103. A handle 512 may be disposed at a distal end of each bar 510. The patient may hold the handle 512 with his/her forearm resting on the bar 510. A cushion may be disposed on the bar 510 for the forearm to rest upon.

[0036] A proximal end of the support member 520 may be coupled to one of the plurality of linkages other than the slidable member. The support member 520 may extend in a cantilevered manner from a proximal end of the support member 520, in the forward direction. The support member 520 may extend from the support linkage 450 in a direction substantially parallel to the bar 510 or in a direction non-parallel to the longitudinal direction 101. A pair of the support linkage 450 may be coupled to the support members 520 to form a U-shape defining a space in which a person (e.g., the assisted user or another person using a rehabilitation apparatus) may stand, with the support members 520 being at hip-height. The support members 520 may provide attachments for a safety harness 550. Each support members 520 may include a fastener 522 for securing an exoskeleton device.

[0037] FIG. 5 is a partially enlarged view of the support member 520 with the support linkage 450. The handle system 500 and the braking mechanism 400 are connected by the support linkage 450 and can be elevated together relative to the frame 300 by sliding in the longitudinal direction 101 or lowered together relative to the frame 300 by sliding in the counter-longitudinal direction 102. The safety harness 550 may be coupled to the support member 520.

[0038] One end of the support member 520 (e.g., the proximal end of the support member 520) may be pivotably coupled 552 to the support linkage 450, and the support member 520 (and the safety harness 550) may rotate about a transverse axis 553. In some embodiments, the support member 520 is configured with an alignable aperture between the support member 520 and the support linkage, which can be passed through by a positioning pin 557. The positioning pin 557 extends transversely to prohibit or limit the rotation of the support member 520 with respect to the support linkage 450 (i.e., rotation about the transverse axis 553). When there is a need to transfer an assisted user to the rehabilitation apparatus 100, the positioning pin 557 on the side of the support linkage 450 may be removed to permit a larger rotation of the support member 520 and/or the safety harness 550. In some embodiments, the rehabilitation apparatus 100 is configured such that the bar 510 on one side may be removed, the positioning pin 557 on the same side is also removed, and the support member 510 rotated. This makes one side of the rehabilitation apparatus 100 obstacle-free, and the assisted user can move to/from the seat 620 from the side of the rehabilitation apparatus, e.g., along a transverse direction 105 (generally parallel to the ground).

[0039] One or more sensors provided on the rehabilitation apparatus 100 may be selected based on the use of the rehabilitation apparatus 100. In some embodiments, the sensors include force sensor 554 disposed on the support member 520. In some embodiments, the support member 520 may be located below the waist of the assisted user (e.g., a patient), such as on either side of the hips/pelvic region and/or thighs, to support the assisted user. In some embodiments, the safety harness 550 is secured around the pelvic region of the assisted user to protect the assisted user in the event of falling. The force sensors 554 may be configured to monitor the force exerted on the support member 520 to support the assisted user. If the assisted user wearing the safety harness 550 is unable to balance, the weight will cause the support member 520 to rotate, and the force sensor 554 disposed on the support member 520 will send a signal to the controller and/or the lockable rotary joint 410 of the braking mechanism 400 in response to the force sensed. In response to such corresponding signals received by the

lockable rotary joints, the braking mechanism 400 will instantaneously lock at the lockable rotary joints, forming a rigid body to prevent the user from falling.

[0040] FIG. 6 schematically illustrates an example of the lockable rotary joint 410. FIG. 7 is an exploded schematic view of the rotary joint 410 of FIG. 6. The structure 402 may secure the rotary joint 410 to one end of the linkage 440. A housing (which may comprise several housing members 409, 407, 404) of the rotary joint 410 may comprise a planetary gear transmission 408 and a friction member 405/406. A rotary encoder 403 may be configured to monitor rotation of the rotating sub. In some embodiments, the friction members 405/406 can diverge from each other (e.g., spring-loaded) and drive mutual friction through magnetic force to generate braking torque. The planetary gear transmission 408 is configured to enhance the braking torque that can be generated by the rotary joint 410 and to make the locking force of the rotary joint 410 adjustable.

[0041] FIG. 8 illustrates a side view of the rehabilitation apparatus 100 according to some embodiments. The support member 520 of the rehabilitation apparatus 100 may include a connector 552 disposed at a distal end of the support member 520. The connector 552 is configured to enable attachment of the exoskeleton device 800 thereto. The connector 552 may be configured to be releasably coupleable with the exoskeleton device. For example, a healthcare provider may attach or detach one or a pair of exoskeleton devices 800 to/from the rehabilitation apparatus 100, depending on the needs of the assisted user. The exoskeleton device 800 may include a thigh subassembly 810 for supporting the thighs, and a calf subassembly 820 for supporting the calves. The support that the assisted user requires during gait rehabilitation may vary with the condition or length of the rehabilitation. The same rehabilitation apparatus 100 as disclosed herein may be used by patients with different needs and can provide the required support as a patient's needs vary over time. This can eliminate the need to purchase multiple rehabilitation devices with different levels of support. At the same time, the braking mechanism 400 of the rehabilitation apparatus 100 can also provide an adjustable braking force such that the rehabilitation apparatus 100 can avoid providing excessive support or providing insufficient support.

[0042] It can also be understood from FIG. 8 that the rehabilitation apparatus 100 does not require a suspension frame that is taller than the human body to provide effective support. The tallest portion of the rehabilitation apparatus 100 can be approximately the same height, H1 (relative to the base 200 or the ground) as the waist of a person. The highest height of the braking mechanism 400, which helps provide braking force to prevent the patient from falling, can remain at approximately the same height, H2 (relative to the base 200 or the ground) as the waist of the patient. The rehabilitation apparatus 100 disclosed herein provides a lighter and less space-consuming solution compared to existing suspension types.

[0043] According to some embodiments, the rehabilitation apparatus 100 includes a folded-seat mode 180 (as shown in FIG. 8 and FIG. 10) as well as an unfolded-seat mode 190 (as shown in FIG. 9). The rehabilitation apparatus 100 may be interchangeable between these two modes. To aid understanding, FIG. 10, FIG. 11, and FIG. 12 provide schematic side views to illustrate the structure and movement of the frame 300, the seat system 600, and the relative structures and movements between the two. FIG. 11 illustrates with dashed lines the direction of the movement of the seat as the seat changes between the folded-seat mode and unfolded-seat mode. In some embodiments, the folded-seat mode 180 may be characterized by the longitudinal direction 101 being parallel to a first plane defined by the seat 620 being fully folded. In some embodiments, the unfolded-seat mode 190 may be characterized by the longitudinal direction 101 being normal to a second plane defined by the seat 620 being fully unfolded.

[0044] As shown in FIG. 11, the seat 620, the slidable member 340, the swivel element 324, and the slide groove component 320 form a quadrilateral structure. A rear section (345) of the seat 620 (e.g., one end of the seat 620 nearer the frame) is pivotably coupled to the slidable member 340. A mid-section (325) of the seat 620 is pivotably coupled to an outer end of the swivel element 324. The slide groove component 320 defines a groove 322 that extends parallel to the longitudinal direction. An inner end of the swivel element 324 is pivotably and slidably engaged with the groove 322 such that the inner end of the swivel element 324 can also be moved along the groove 322. The slidable member 340 and the slide groove member 320 define one side of a quadrilateral structure. According to embodiments

of the rehabilitation apparatus 100 disclosed herein, the rehabilitation apparatus 100 may also be configured such that, in response to the seat 620 being loaded with the weight of a human body, e.g., when the seat 620 is fully unfolded as shown in FIG. 12, the braking mechanism 400 enters or remains in a locked state. It will be appreciated by those skilled in the art that the weight of a person sitting on the seat 620 is such that the protective slidable member 340 will only slide downwardly and not (in the absence of deliberate actuation) upwardly against the force of gravity. In other words, the seat 620 is more stable with someone sitting on it.

[0045] The rehabilitation apparatus 100 includes an elevation device 700 to allow the slidable member 340 to slide relative to the frame 300 in the longitudinal direction 101 or in a counter-longitudinal direction 102 opposite the longitudinal direction. In some embodiments, the elevation device 700 may include a manual mode that allows a user (e.g., a patient, a healthcare professional, etc.) to manually move the slidable member 340 to adjust the height of the slidable member 340 relative to the base. In some embodiments, the elevation device 700 may include a motorized mode. In some embodiments, the handle system 500 and the seat system 600 can move independently of each other. In some embodiments, the handle system 500, the slidable member 340, and the seat system 600 mutually influence or drive each other's movement. To aid understanding, FIG. 13 and FIG. 14 illustrate a motorized elevation device 700 that includes a linear drive pushing and guiding the elevation device 700 along its track. However, it can be understood that a person skilled in the art can make substitutions or modifications within the scope of the present technical solution without inventing laborious solutions. As shown in FIG. 15, the elevation device 700 can include a longitudinally disposed column 302 in place of the track shown in FIG. 14. For example, the guiding assembly of the elevation device 700 can include a linkage mechanism, a rail structure, a guide wheel, a belt drive device, a gear drive device, a linear actuator device, a rack and pinion device, a tension cable device, and so on. The elevation device 700 can include one or more driving mechanism 710, which can include electric actuators, pneumatic actuators, hydraulic actuators, and the like. The driving mechanism 710 may be partially secured to the base 200 or the frame 300, such that the slidable member 340 can slide relative to the frame 300 in the

longitudinal direction 101 or in a counter-longitudinal direction 102 opposite the longitudinal direction. In some embodiments, the elevation device 700 may directly drive the slidable member 340. In yet another embodiment, the elevation device 700 is configured to directly drive the handle system 500 and indirectly drive the slidable member 340.

[0046] FIG. 13 and FIG. 14 illustrate that the seat 620 in the folded mode can be further elevated parallel to the frame 300, e.g., with the assistance of the elevation device. The elevation device 700 is configured such that the slidable member 340 can be driven to slide in the longitudinal direction 101 or in a counter-longitudinal direction 102 (opposite to the longitudinal direction 101) with respect to the track 360 fixed to the frame 300. FIG. 15 illustrates another embodiment of the elevation device 700. The slidable member 340 is driven to slide in the longitudinal direction 101, raising the handle system 500 as well, while the seat 620 is rotated and folded-up. The patient can stand up from a seated position on the seat 620 with the help of the raised handle system 500. At the same time, the seat 620 is automatically folded-up to give the patient more space for gait balance rehabilitation training.

[0047] When the slidable member 340 is driven to slide in the counter-longitudinal direction 102, the patient holding the handle system 500 naturally bends his or her legs to sit down as the handle system 500 is lowered. At this point, the seat 620 also lowers accordingly, with alignment in the direction of the patient's bent legs, the seat 620 automatically rotates and unfolds. The rehabilitation apparatus 100 may also be configured such that, in response to the patient manually pushing the handle system 500 downward, or in response to the handle system 500 being driven downward by an actuator, the seat 620 unfolds and prepares the seat for the patient. It will be understood that in outdoor or mobility device application scenarios, the patient no longer needs to prepare an additional stool or chair. The patient can sit down and rest whenever he or she is tired.

[0048] Various embodiments of the gait balance rehabilitation apparatus 100 proposed herein have been described. For example, the gait balance rehabilitation apparatus 100 includes a base 200, a frame 300, and a slidable member 340. The frame 300 is fixedly disposed on the base 200 and extends from the base 200 for a length along a longitudinal direction. The slidable member 340 is slidably engaged

with the frame 300 and displaceable relative to the frame 300 in the longitudinal direction 101 or in a counter-longitudinal direction 102 opposing the longitudinal direction. The gait balance rehabilitation apparatus 100 may include a seat 620 having a rear section pivotably coupled with the slidable member 340 and a mid-section pivotably coupled with the frame 300.

[0049] The gait balance rehabilitation apparatus 100 may include a braking mechanism 400. The braking mechanism 400 may include a plurality of linkages and a corresponding plurality of rotary joints. The plurality of linkages and the corresponding plurality of rotary joints may be alternately coupled to one another, forming a closed ring structure 490. The slidable member 340 may serve as one of the plurality of linkages.

[0050] The gait balance rehabilitation apparatus 100 may include a handle system 500. The handle system 500 may be slidably coupled to the frame 300 via the braking mechanism 400.

[0051] The seat 620 may be rotatable in a direction of rotation that is dependent on a displacement of the slidable member 340 relative to the frame 300.

[0052] A first displacement of the slidable member 340 in the longitudinal direction may enable the seat 620 to rotatably fold.

[0053] A second displacement of the slidable member 340 in the counter-longitudinal direction enables the seat 620 to rotatably unfold.

[0054] The gait balance rehabilitation apparatus 100 may be convertible from an unfolded-seat mode to a folded-seat mode in response to the slidable member 340 being displaced in the longitudinal direction.

[0055] The gait balance rehabilitation apparatus 100 may be convertible from the a folded-seat mode to an unfolded-seat mode in response to the slidable member 340 being displaced in the counter-longitudinal direction.

[0056] The folded-seat mode may be characterized by the longitudinal direction being parallel to a first plane defined by the seat 620 being fully folded.

[0057] The unfolded-seat mode may be characterized by the longitudinal direction being normal to a second plane defined by the seat 620 being fully unfolded.

[0058] The gait balance rehabilitation apparatus 100 may include a slide groove component 320. The slide groove component 320 may form a part of the frame 300. The slide groove component 320 may define a groove 322 extending along the longitudinal direction.

[0059] The gait balance rehabilitation apparatus 100 may include a swivel element 324. A first end of the swivel element 324 may be in slidable engagement with the groove 322. A second end of the swivel element 324 may be pivotably coupled with the mid-section of the seat 620. The rear section may be confined to displace along the groove 322. The rear section may be pivotably coupled with the slidable member 340.

[0060] The handle system 500 may be displaceable in the longitudinal direction to cause the slidable member 340 to move in a longitudinal direction relative to the frame 300 and to cause the seat 620 to rotatably fold. The handle system 500 displacing in the counter-longitudinal direction may cause the slidable member 340 to move in the counter-longitudinal direction relative to the frame 300 and cause the seat 620 to rotatably unfold.

[0061] The handle system 500 may be configured to be manually displaceable to enable the slidable member 340 to slide relative to the frame 300 alternately in the longitudinal direction or the counter-longitudinal direction.

[0062] The gait balance rehabilitation apparatus 100 may further include a driving mechanism coupled to the slidable member 340 and configured to drive the slidable member 340 to slide relative to the frame 300.

[0063] The braking mechanism 400 may include six rotary joints and six linkages, the six rotary joints and the six linkages being alternately coupled with one another to form a closed ring structure 490, in which four of the six rotary joints are lockable rotary joints 410.

[0064] Each one of the lockable rotary joints 410 may be configured to lock an angular displacement between two of the six linkages coupled to the respective one of the lockable rotary joints 410 in response to a signal received from a sensor 554. The sensor 554 may be configured to sense a force.

[0065] The gait balance rehabilitation apparatus 100 may further include a connecting member serving as one of the linkages other than the slidable member

340. The connecting member may extend to the handle system 500 and be coupleable with a safety harness 550.

[0066] The gait balance rehabilitation apparatus 100 may further include: a first base element 213 and a second base element 223. The first base element may extend in a first axial direction. The second base element may extend in a second axial direction. The first base element and the second base element may extend from different ends of the base 200. The first base element and the second base element may each be pivotably coupled to the base 200 to define an adjustable footprint area 150 therebetween.

[0067] The gait balance rehabilitation apparatus 100 may further include a first front wheel coupled to the first base element, a second front wheel coupled to the second base element, and two rear wheels coupled to the base 200. The first front wheel, the second front wheel, and the two rear wheels may form a rear wheel drive chassis.

[0068] The gait balance rehabilitation apparatus 100 further may include a first footrest 215 and a second footrest 225. The first footrest may be pivotably coupled to the first base element, and configured to be rotatably folded relative to the first base element. The second footrest may be pivotably coupled to the second base element, and configured to be rotatably folded relative to second base element.

[0069] The gait balance rehabilitation apparatus 100 may further include a support member 520 and a connector disposed at a distal end of the support member 520. A proximal end of the support member may be coupled to one of the plurality of linkages other than the slidable member 340. The support member may be cantilevered from the proximal end in a forward direction perpendicular to the longitudinal direction. The connector may be releasably coupleable with an exoskeleton device 800.

[0070] According to various embodiments, the rehabilitation apparatus for gait balance rehabilitation includes a mobile base 200 and a frame 300 fixedly disposed thereon. The apparatus may include a seat and a braking mechanism. A braking mechanism 400 includes a plurality of linkages 440 and a corresponding plurality of rotary joints 410. The plurality of linkages 440 and the corresponding plurality of rotary joints 410 are alternately coupled to one another, forming a closed ring

structure 490. A rotary joint 410 may be a lockable rotary joint configured to lock an angular displacement between corresponding two of the linkages 440 coupled to the rotary joint. A slidable member serving as one of the plurality of linkages is displaceable relative to the frame in the longitudinal direction or in a counter-longitudinal direction. The apparatus may include a handle system operable in tandem with the slidable member. The seat may be rotatable in a direction dependent on a displacement of the slidable member relative to the frame.

[0071] All examples described herein, whether of apparatus, methods, materials, or products, are presented for the purpose of illustration and to aid understanding, and are not intended to be limiting or exhaustive. Modifications not involving inventive effort may be made by one of ordinary skill in the art without departing from the scope of the claimed invention.

CLAIMS

1. A gait balance rehabilitation apparatus, comprising:
 - a base;
 - a frame, the frame being fixedly disposed on the base, the frame extending from the base for a length along a longitudinal direction;
 - a slidable member, the slidable member being slidably engaged with the frame, the slidable member being displaceable relative to the frame in the longitudinal direction or in a counter-longitudinal direction opposing the longitudinal direction; and
 - a seat, the seat having a first end pivotably coupled with the slidable member, wherein the seat includes a mid-section pivotably coupled with the frame.
2. The gait balance rehabilitation apparatus as recited in claim 1, further comprising:
 - a braking mechanism, the braking mechanism including a plurality of linkages and a corresponding plurality of rotary joints, the plurality of linkages and the corresponding plurality of rotary joints being alternately coupled to one another and forming a closed ring structure, the slidable member serving as one of the plurality of linkages; and
 - a handle system, the handle system being slidingly coupled to the frame via the braking mechanism.
3. The gait balance rehabilitation apparatus as recited in any one of claim 1 or claim 2, characterized in the seat is rotatable in a direction of rotation, the direction of rotation being dependent on a displacement of the slidable member relative to the frame.
4. The gait balance rehabilitation apparatus as recited in any one of claims 1 to 3, characterized in that a first displacement of the slidable member in the longitudinal direction enables the seat to rotatably fold.

5. The gait balance rehabilitation apparatus as recited in any one of claims 1 to 4, characterized in that a second displacement of the slidable member in the counter-longitudinal direction enables the seat to rotatably unfold.
6. The gait balance rehabilitation apparatus as recited in any one of claims 1 to 5, characterized in that the gait balance rehabilitation apparatus is convertible from an unfolded-seat mode to a folded-seat mode in response to the slidable member being displaced in the longitudinal direction.
7. The gait balance rehabilitation apparatus as recited in any one of claims 1 to 5, characterized in that the gait balance rehabilitation apparatus is convertible from a folded-seat mode to an unfolded-seat mode in response to the slidable member being displaced in the counter-longitudinal direction.
8. The gait balance rehabilitation apparatus as recited in claim 6 or claim 7, wherein the folded-seat mode is characterized by the longitudinal direction being parallel to a first plane defined by the seat being fully folded.
9. The gait balance rehabilitation apparatus as recited in any one of claims 6 to 8, wherein the unfolded-seat mode is characterized by the longitudinal direction being normal to a second plane defined by the seat being fully unfolded.
10. The gait balance rehabilitation apparatus as recited in any one of claims 2 to 9, further comprising:
- a slide groove component, the slide groove component forming a part of the frame, the slide groove component defining a groove, the groove extending along the longitudinal direction; and
 - a swivel element, a first end of the swivel element being in slidable engagement with the groove, a second end of the swivel element being pivotably coupled with a mid-section of the seat, the first end being confined to displace along the groove,

wherein a rear section of the seat is pivotably coupled with the slidable member.

11. The gait balance rehabilitation apparatus as recited in any one of claims 2 to 10,

wherein the handle system displacing in the longitudinal direction causes the slidable member to move in a longitudinal direction relative to the frame and causes the seat to rotatably fold, and

wherein the handle system displacing in the counter-longitudinal direction causes the slidable member to move in the counter-longitudinal direction relative to the frame and causes the seat to rotatably unfold.

12. The gait balance rehabilitation apparatus as recited in claim 10 or claim 11, characterized in that the handle system is configured to be manually displaceable to enable the slidable member to slide relative to the frame alternately in the longitudinal direction or the counter-longitudinal direction.

13. The gait balance rehabilitation apparatus as recited in any one of claims 10 to 12, further comprising a driving mechanism, the driving mechanism being coupled to the slidable member and configured to drive the slidable member to slide relative to the frame.

14. The gait balance rehabilitation apparatus as recited in any one of claims 2 to 13, wherein the braking mechanism comprises six rotary joints and six linkages, the six rotary joints and the six linkages being alternately coupled with one another to form a closed ring structure, wherein four of the six rotary joints are lockable joints.

15. The gait balance rehabilitation apparatus according to claim 14, wherein each one of the lockable rotary joints is configured to lock an angular displacement between two of the six linkages coupled to the respective one of the lockable joints in response to a signal received from a sensor.

16. The gait balance rehabilitation apparatus as recited in claim 14, further comprising: a connecting member, the connecting member serving as one of the linkages other than the slidable member, wherein the connecting member extends to the handle system and is coupleable with a safety harness.

17. The gait balance rehabilitation apparatus as recited in any one of claims 2 to 16, further comprising:

- a first base element, the first base element extending in a first axial direction;
and

- a second base element, the second base element extending in a second axial direction, the first base element and the second base element extending from different ends of the base,

- wherein the first base element and the second base element are each pivotably coupled to the base to define an adjustable footprint area therebetween.

18. The gait balance rehabilitation apparatus as recited in claim 17, further comprising:

- a first front wheel, the first front wheel being coupled to the first base element;
- a second front wheel, the second front wheel being coupled to the second base element; and

- two rear wheels, two rear wheels being coupled to the base, wherein the first front wheel, the second front wheel, and the two rear wheels form a rear wheel drive chassis.

19. The gait balance rehabilitation apparatus as recited in claim 17 or claim 18, further comprising:

- a first footrest, the first footrest being pivotably coupled to the first base element, the first footrest being configured to be rotatably folded relative to the first base element; and

a second footrest, the second footrest being pivotably coupled to the second base element, the second footrest being configured to be rotatably folded relative to second base element.

20. The gait balance rehabilitation apparatus as recited in any one of claims 2 to 19, further comprising:

a support member, a proximal end of the support member being coupled to one of the plurality of linkages other than the slidable member, the support member being cantilevered from the proximal end in a forward direction perpendicular to the longitudinal direction; and
a connector, the connector being disposed at a distal end of the support member, wherein the connector is releasably coupleable with an exoskeleton device.