

A MOBILE DYNAMIC BODY WEIGHT SUPPORT DEVICE

RELATED APPLICATION

[0001] This application claims the benefit of priority to the Chinese patent application no. 202410081353.2 filed January 19, 2024, the contents of which are hereby incorporated herein by reference in their entirety for all purposes.

TECHNICAL FIELD

[0002] The present disclosure relates to a device for rehabilitation training, and more particularly a mobile dynamic body weight support device.

BACKGROUND

[0003] Conventional rehabilitation training devices are not adaptable to the varying physical states and rehabilitation progress of different patients. For example, conventional weight support devices are only capable of providing a constant force weight support. However, in an ideal rehabilitation treatment, as the patient progressively recovers, the weight support should be appropriately reduced to gradually decrease the patient's dependence on external weight support. Over-reliance on external weight support may prevent the patient's muscles from receiving the necessary exercise, potentially hindering full recovery and the patient's ability to stand or walk independently.

[0004] On the other hand, if the weight support provided is insufficient, the rehabilitation training can be too difficult for the patients, which can create psychological barriers for patients. Some patients may even give up on rehabilitation.

[0005] Besides providing appropriate weight support at different stages of the rehabilitation process based on individual patient conditions, weight support devices should be able to prevent falls during the rehabilitation training.

SUMMARY

[0006] To address shortcomings of the state of the art, the present disclosure describes a mobile dynamic body weight support device. According to some

embodiments, the mobile dynamic body weight support device includes: a frame, two support arms, and an assembly corresponding to each of the two support arms. The frame includes: a transverse bar; the two support arms being coupled to the transverse bar, the two support arms extending parallel to one another; The assembly includes: a wheel, a hinge, a rope; and a pulley system. The wheel is coupled to a base of the frame. The hinge includes a first support plate and a second support plate, the first support plate being coupled to the respective one of the two support arms to form a cantilevered hinge. The pulley system includes: a first set of pulleys, a second set of pulleys, and a third set of pulleys. The first set of pulleys is coupled to the transverse bar. The second set of pulleys is coupled with the second support plate. The third set of pulleys is coupled with the second support plate. The rope passes sequentially through the first set of pulleys, the second set of pulleys, and the third set of pulleys. An end of the rope extends beyond the third set of pulleys, a direction of the rope being changed by the second set of pulleys.

[0007] The assembly may further include: a second angle encoder, the second angle encoder being coupled to the second support plate, wherein the second angle encoder is disposed adjacent to the third set of pulleys to sense a second offset angle of the rope.

[0008] The wheel may include a drive wheel, in which the second angle encoder is configured to generate a second signal to the drive wheel responsive to the second offset angle.

[0009] The assembly may further include: a first angle encoder, the first angle encoder being coupled to the second support plate, in which the first angle encoder is disposed adjacent to the second set of pulleys to sense a first offset angle of the rope, and in which the first angle encoder is configured to generate a first signal to the drive wheel responsive to the first offset angle.

[0010] The first angle encoder may be configured to calculate an angular offset between two ropes corresponding to the two support arms, in which the first angle encoder is configured to send the first signal to the drive wheel in response to the angular offset.

[0011] A differential movement between two of the drive wheel may be dependent on the first signal, each of the drive wheel corresponding to a respective one of the two support arms.

[0012] An actuation of the drive wheel may be responsive to a detection of a parallel offset angle of the rope with respect to the frame.

[0013] The rope may be coupled to a respective shoulder strap of a harness, in which the drive wheels may be configured to be driven independently of one another to position a user in the harness in a center position relative to the frame.

[0014] The mobile dynamic body weight support device may further include: a motor and a braking device. The motor is coupled to the frame. The rope is coupled to the main shaft of the motor, a length of the rope from the second set of pulleys to the end of the rope being determined by a rotation of the main shaft. The braking device may be coupled to the frame, in which in a power-off state the braking device is configured to prevent or to stop a rotating motion of the main shaft.

[0015] The braking device may include: a brake pin (or braking pin) and a sprocket fixedly coupled with the main shaft. The sprocket has a plurality of teeth. Adjacent ones of the plurality of teeth are spaced apart to define a corresponding plurality of gaps between the plurality of teeth. The brake pin may be coupled with an electromagnet of the braking device. The braking device may be configured to lock the main shaft in response to either a power failure or an emergency braking signal, the brake pin being configured to be inserted into one of the plurality of gaps to lock the main shaft.

[0016] The wheel may further include a compression spring, the compression spring being provided with a preload.

[0017] The mobile dynamic body weight support device may further include a harness. The harness may include two shoulder straps. Each of the two shoulder straps may be coupled with the end of the corresponding rope.

[0018] In operation, the drive wheel may be configured to displace the frame to align the frame with a position of the user, in response to the first signal and/or the second signal.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] The following describes some embodiments of the present application with reference to the accompanying drawings, in which:

[0020] **FIG. 1** is a perspective view of the mobile dynamic body weight support device according to various embodiments;

[0021] **FIG. 2** is a front view of the mobile dynamic body weight support device shown in FIG. 1;

[0022] **FIG. 3** is a rear view of the mobile dynamic body weight support device shown in FIG. 1;

[0023] **FIG. 4** is a side view of the mobile dynamic body weight support device shown in FIG. 1;

[0024] **FIG. 5** is a perspective view of the handrail of the mobile dynamic body weight support device shown in FIG. 1;

[0025] **FIG. 6** is an exploded view of the handrail shown in FIG. 5;

[0026] **FIG. 7A** is a perspective view of the base of the mobile dynamic body weight support device shown in FIG. 1;

[0027] **FIG. 7B** is a perspective view of the base according to another embodiment;

[0028] **FIG. 8** is a perspective view of the motor and braking device;

[0029] **FIG. 9** is an exploded view of the motor and braking device shown in FIG. 8;

[0030] **FIG. 10** is a top view of the motor and braking device shown in FIG. 8;

[0031] **FIG. 11** is a front view of the sprocket;

[0032] **FIG. 12A** and **FIG. 12B** shows two different states of the braking device;

[0033] **FIG. 13** is a top view of the pulley system shown in FIG. 1;

[0034] **FIG. 14** is a perspective view of the pulley system shown in FIG. 13;

[0035] **FIG. 15** is a side view of the pulley system shown in FIG. 13;

[0036] **FIG. 16** a perspective view of the pulley system shown in FIG. 13 from another angle; and

[0037] **FIG. 17** is a schematic diagram of the method for controlling the mobile dynamic body weight support device.

DETAILED DESCRIPTION

[0038] In the description, references to "one embodiment," "another embodiment," or "an embodiment" (or similar terms) mean that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. Thus, the phrases "in one embodiment" or "in an embodiment" or similar expressions appearing in various places throughout this specification do not necessarily all refer to the same embodiment. Furthermore, the described features, structures, or characteristics may be combined in any suitable manner in one or more embodiments. The following description will provide various specific details to assist the reader in gaining a comprehensive understanding of the embodiments. Those skilled in the relevant art will recognize that various embodiments can be practiced without one or more specific details, or by employing other methods, components, materials, etc. In other cases, certain well-known structures, materials, or operations may not be shown or described in detail to avoid confusion.

[0039] 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.

[0040] 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.

[0041] 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.

[0042] For simplicity, in the descriptions herein, the term "front" may refer to the direction the user faces when using the device or the general direction the user is walking towards. The left and right sides can also be understood based on the user's orientation. It is to be understood that the scope of protection of this application is not limited by the position or direction of the user and/or the device.

[0043] **FIG. 1 to FIG. 4** are perspective views of the mobile dynamic body weight support device 100 according to various embodiments of the present application.

For the sake of brevity, in this document, the terms "mobile dynamic body weight support device" and "weight support device" may be used interchangeably.

[0044] The mobile dynamic body weight support device 100 includes a movable frame 110, e.g., the entire mobile dynamic body weight support device 100 is displaceable relative to the ground. The frame may include a transverse bar 120. The frame may include longitudinal rods 130 (including, for example, a first longitudinal rod 131 and a second longitudinal rod 132). The ends of the transverse bar 120 may be respectively coupled and supported by the first longitudinal rod 131 and the second longitudinal rod 132. The structure of the frame 110 may be in the form of a gantry, providing the necessary stability and providing the entire mobile dynamic body weight support device 100 with a sufficient degree of flexibility, making the mobile dynamic body weight support device 100 convenient for use in relatively small indoor spaces.

[0045] The first longitudinal rod 131 and the second longitudinal rod 132 may each be generally rod-shaped or be in other forms. The first longitudinal rod 131 and the second longitudinal rod 132 enable the transverse bar 120 to be positioned higher than the height of most users (e.g., patients or individuals undergoing rehabilitation). As shown in **FIG. 2**, the first longitudinal rod 131 and the second longitudinal rod 132 may be approximately parallel to one another. The first longitudinal rod 131 and the second longitudinal rod 132 are spaced apart by a distance 102 sufficient to allow the user 190 room between the first longitudinal rod 131 and the second longitudinal rod 132 for movement. For instance, in use, the first longitudinal rod 131 may be positioned to the left of the user 190, and the second longitudinal rod 132 may be positioned to the right of the user 190. As illustrated in **FIG. 2**, the distance between the first longitudinal rod 131 and second longitudinal rod 132 allows the user 190 to reach out and grasp the first longitudinal rod 131 and/or the second longitudinal rod 132, while also providing enough space for users who are approaching full recovery to swing their arms and walk comfortably.

[0046] In other embodiments, the distance 102 between the first longitudinal rod 131 and the second longitudinal rod 132 can be adjusted and locked in place. For the sake of brevity, this distance may also be referred to as the "device width" 102.

For example, there may be adjustable and lockable connections between the first longitudinal rod 131 and the transverse bar 120, and/or between the second longitudinal rod 132 and the transverse bar 120, to provide an adjustable device width.

[0047] The mobile dynamic body weight support device 100 may include one or more handrails 140. As shown in **FIG. 5**, the handrails 140 may be elongated in shape. The handrails 140 may be disposed on one side of the user 190, extending laterally and in a forward direction, in a cantilevered manner relative to the longitudinal rods 130.

[0048] **FIG. 6** shows the handrail 140 according to various embodiments. The handrail 140 includes a connection end 142. The connection end 142 may be detachably coupled with the longitudinal rod 130 to form a cantilevered structure. The height of the handrail 140 may be adjustable or adjusted relative to the longitudinal rod 130, e.g., based on the user's height and/or the rehabilitation needs of the user. The detachable coupling between the handrail 140 and the longitudinal rod 130 may be implemented in various ways. As shown in **FIG. 6**, the longitudinal rod 130 may have a plurality of holes 144 which are spaced apart from one another, e.g. vertically, along a vertical direction, or along a longitudinal axis. The handrail 140 may be coupled with any one of the holes 144. For example, the handrail 140 may be alternately coupled with a hole at a more elevated position or at a lower position depending on the user's built or height and/or rehabilitation needs. The connection end 142 of the handrail 140 may be inserted into one of the plurality of multiple holes 144 on the longitudinal rod 130. The longitudinal rod 130 may also include clips 146 positioned on either side of the holes 144. The clips 146 may be elastic or resiliently deformable. When the connection end 142 of the handrail 140 is received by a selected hole 144, the handrail pin 147 at the connection end 142 is also held by the clips 146. The clips 146 and the handrail pin 147 cooperate to lock the handrail 140 in the desired position or height relative to the longitudinal rod 130.

[0049] **FIG. 7A** shows the base 200 of the mobile dynamic body weight support device according to various embodiments. The base 200 may include at least one pair of powered wheels or drive wheels 210. It should be understood that the

following description based on **FIG. 7A** is to aid understanding and is not limiting. For example, in other embodiments, the drive wheel 210 may include wheels with different driving mechanisms, and the non-drive wheel 220 may include other forms of rotatable components.

[0050] According to the examples shown in **FIG. 7A** and **FIG. 7B**, the base 200 may include a first drive wheel 211, a first front caster wheel 222, and a first rear caster wheel 224. The first drive wheel 211, the first front caster wheel 222, and the first rear caster wheel 224 may be disposed at the base of the first longitudinal rod 131. The base 200 may also include a second drive wheel 212, a second front caster wheel 226, and a second rear caster wheel 228. The second drive wheel 212, the second front caster wheel 226, and the second rear caster wheel 228 may be disposed at the base of the second longitudinal rod 132. The drive wheel 210 may have a larger diameter compared to the caster wheel. The drive wheel 210 may include rubber wheel 237. In some examples, the drive wheels 210 and the frame 110 are elastically coupled by a coupling that includes a spring 230. The drive wheel 210 may include a drive assembly 240. The caster wheels (such as the first front caster wheel 222, first rear caster wheel 224, second front caster wheel 226, and second rear caster wheel 228), also referred to as non-drive wheels 220, may include swivel caster wheels and/or omnidirectional wheels that can rotate horizontally up to 360 degrees.

[0051] The mobile dynamic body weight support device 100 may include at least two motors 300. The at least two motors 300 may be coupled to the frame 110. For the sake of brevity, the following will describe an embodiment with two motors as an example, but it should be understood that different embodiments of the mobile dynamic body weight support device may include more than two motors.

[0052] In some examples, the motors 300 include direct-drive motors (also known as brushless motors), each of which is configured to adjust a rotational speed (of the motor output) based on a sensed current. This enables the mobile dynamic body weight support device to have fewer components and be relatively lightweight, making it more suitable for mobility. For example, the entire mobile dynamic body weight support device of the present disclosure may be sufficiently lightweight to be displaced along as the user walks in harness to the mobile dynamic

body weight support, and yet provide adequate stability and support to the user. Each motor is coupled with a braking device 400. Each one of the motors 300 is configured to be braked independently of any other of the motors 300, e.g., the motors may be individually braked. The control of each of the motors 300 (such as starting, accelerating, decelerating, and/or braking) may be operated independently of any of the other motors 300.

[0053] Referring to **FIG. 1** to **FIG. 3**, the motors 300 may be mounted on the transverse bar 120, and more specifically, disposed “behind” or at the rear of the transverse bar 120. The two motors 300 may be placed on either side of the longitudinal axis 101. The motors 300 and their associated braking devices 400 may be arranged symmetrically with respect to the longitudinal axis 101. Each motor 300 is coupled to a pulley system 500 via a rope 700. The distance between the two motors 300 (or between the two ropes 700) may be generally less than the average shoulder width of an adult. In other embodiments, the motors 300 may be located at different places on the frame 110, e.g., above or to the front of the transverse bar 120. In other embodiments, the motors 300 may be disposed at or directly coupled to the longitudinal rods 130.

[0054] **FIG. 8** to **FIG. 10** illustrate one of the motors 300 (e.g., the first motor 301) and the braking device 400 configured to brake the motor 300. Another motor (e.g., the second motor 302) may be similarly configured, and will not be described in detail for the sake of brevity. A main shaft 310 of the motor 300 may be substantially horizontally disposed. For example, the main shaft 310 of the motor 300 may be generally or approximately parallel to the transverse bar 120 and form a right angle or an approximately perpendicular angle (90 degrees or approximately 90 degrees) with respect to the longitudinal rods 130 (such as the first longitudinal rod 131 and the second longitudinal rod 132).

[0055] The mobile dynamic body weight support device 100 may also include a braking device 400 corresponding to each of the motors 300. The braking device 400 may include an electromagnetic brake actuator 430, a braking pin 420, and a sprocket 410. The electromagnetic brake actuator 430 may be disposed proximal to or beside the far end of the motor's main shaft 310. The braking pin 420 may be disposed on a moving component of the electromagnetic actuator, enabling the

braking pin 420 to be displaced in response to the electromagnetic brake actuator 430 operating.

[0056] The sprocket 410 may be fixedly coupled to the main shaft 310 with the sprocket 410 being rotatable by or along with the main shaft 310. For example, the sprocket 410 may include two similar or substantially similar semi-circular sprocket components. Referring to **FIG. 11**, the sprocket 410 may be assembled around the main shaft 310 of the motor 300. The sprocket 410 may define an arcuate inner edge 411 and an outer edge 413. The inner edge 411 of the sprocket 410 and the main shaft 310 may be configured with complementary shapes, enabling the sprocket 410 to be closely coupled with the main shaft 310. The outer edge 413 of the sprocket 410 is equipped with teeth 416 and multiple gaps 414 between the teeth 416. The spacing between the teeth 416 is set to be slightly larger than the diameter of the braking pin 420, allowing the braking pin 420 to pass between two adjacent teeth 416. The spacing between the teeth 416 may be also referred to as the gaps 414 or in terms of teeth pitch.

[0057] To better illustrate the components, **FIG. 12A** and **FIG. 12B** show only a portion of **FIG. 10**. The electromagnetic brake actuator 430 may be configured to drive a displacement of the braking pin 420 in response to a braking signal. The braking pin 420 may be displaced from a non-locking state (as shown in **FIG. 12A**) to a locking state (as shown in **FIG. 12B**). The displacement of the braking pin 420 may involve a linear movement as the braking pin 420 transitions between the non-locking and locking states. The braking pin 420 may be described as extending linearly and/or displacing to a braking position, moving into the gap 414 between two adjacent teeth 416 of the sprocket 410. With the braking pin 420 being constrained to a linear displacement along its own axis 103, when the braking pin 420 is positioned between the teeth 416, the teeth 416 are immediately locked, thereby stopping or preventing any rotational motion of the sprocket 410. Consequently, any rotation of the sprocket 410, which is fixedly coupled with the main shaft 310, is also prevented or stopped, and correspondingly, rotation of the main shaft 310 is prevented or stopped. The braking device 400 may also include a collar 424 that is coupled with the braking pin 420. The collar 424 may be disposed to prevent excessive displacement of the braking pin 420.

[0058] In some embodiments, the braking pin 420 may include a spring 440. As shown in **FIG. 12A** and **FIG. 12B**, this spring 440 keeps the braking pin 420 between two teeth 416 in the locked state. The braking device 400 may be configured so that, when power is supplied to the braking device 400, the braking pin 420 retracts from between the teeth 416, enabling the main shaft 310 of the motor 300 to rotate. In other words, in a default state, the braking pin 420 may be maintained in the locked position between the teeth 416 by the action of the spring 440, providing maximum support to the user. This ensures effective support and safety for the user in case of equipment malfunction or power interruption.

[0059] The mobile dynamic body weight support device 100 includes a frame 110, which includes two support arms 150 (e.g., first support arm 151 and second support arm 152) that are coupled with and extend forward from the transverse bar 120. Each support arm 150 extends from the transverse bar 120 at approximately a right angle (e.g., about 90 degrees). The mobile dynamic body weight support device 100 includes two pulley systems 500 (e.g., first pulley system 501 and second pulley system 502). For the sake of brevity, **FIG. 13** through **FIG. 16** show one of the support arms 150 and its associated pulley system 500 (e.g., the first pulley system 501). It should be understood that the other support arm and its associated pulley system (e.g., the second pulley system) have a similar setup and are not elaborated here for the sake of brevity. Additionally, it should be understood that **FIG. 13** to **FIG. 16** illustrate just one non-limiting example among various embodiments of the present disclosure. To aid understanding, a frame 110 may be described as including two assemblies, each one of the assemblies corresponding to one support arm 150. For example, an assembly may include a hinge 600, a rope 700, a pulley system 500, a first angle encoder 810, a second angle encoder 820, and wheels 210/220 (the wheels being located at the base 200 of one of the longitudinal rods 130), among other elements.

[0060] Referring to **FIG. 13** to **FIG. 16**, the mobile dynamic body weight support device 100 may include a first set of pulleys 510 being disposed between the first motor 301 and the first support arm 151. The first set of pulley 510 may include two or more pulleys. Each pulley of the first set of pulleys 510 may be fixedly mounted above/on the transverse bar 120. The rope 700 may extend in a forward direction

from the main shaft 310 of the first motor 301, pass between the two pulleys of the first set of pulleys 510, and continue to extend generally in the forward direction. The first set of pulleys 510 enables the rope 700 to extend from the motor 300 (e.g., located behind the transverse bar 120) to the support arm 150 (e.g., disposed to the front of the transverse bar 120).

[0061] In the first pulley system 501, the rope 700 extends from the first set of pulleys 510, extend in the forward direction, and extend generally horizontally to the second set of pulleys 520. The rope 700 changes direction through the second set of pulleys 520, shifting from a generally horizontal orientation to a generally vertical (downward) orientation. The rope 700 may extend vertically downward from the second set of pulleys 520 to the third set of pulleys 530, and continue downward from the third set of pulleys 530. An end of the rope 700 is configured to connect with one of the two shoulders straps 194 of the harness 192 (refer to **FIG. 2**), such as the first shoulder or the left shoulder.

[0062] As shown, the mobile dynamic body weight support device 100 includes a hinge 600 (e.g., a first hinge 601, a second hinge 602) or a pair of foldable leaves. The first support arm 151 and the second support arm 152 respectively support the first hinge 601 and the second hinge 602. The first hinge 601 includes a first support plate 610 and a second support plate 620, which are rotatable relative to each other. The first support plate 610 may be coupled to the first support arm 151. For example, the first support plate 610 may be fixedly coupled to the first support arm 151, with its cross-section generally parallel to the first support arm 151. The second support plate 620 may be arranged to form a relative right angle (i.e., approximately 90 degrees) with the first support plate 610. The second set of pulleys 520 and the third set of pulleys 530 may be respectively mounted on the second support plate 620. The second support plate 620 typically remains in a vertical orientation due to its own weight.

[0063] The mobile dynamic body weight support device 100 also includes a first angle encoder 810. The first angle encoder 810 may be coupled to or mounted on the first support arm 151. For example, the first angle encoder 810 may be supported by a first bracket 815. The first bracket 815 may be fixedly coupled to the first support arm 151. The shape and size of the first bracket 815 may be

determined according to the first angle encoder 810 and the first support plate 610. The first angle encoder 810 is configured to generate or provide a first signal in response to and/or corresponding to a first offset angle, in which the first offset angle corresponds to a relative rotation between the second support plate 620 and the first support plate 610. The first offset angle may be generated by the first angle encoder 810 in response to an angular displacement of the rope.

[0064] The second support plate 620 may be formed from a single integral component or from multiple components connected together. The second support plate 620 may include a strip section 630. At least a part of the third set of pulleys 530 may be formed by a plurality of pulleys, at least some of which may be disposed and/or distributed on the strip section 630. In some embodiments, the third set of pulleys 530 may include at least one pair of third pulleys 533 and a fourth pulley 534. The rotation axis of the fourth pulley 534 is perpendicular or substantially perpendicular (e.g., approximately 90 degrees) to the rotation axis of each of the third pulleys 533. The rope 700 passes between the third pulleys 533, and then between the strip section 630 and fourth pulley 534, so that this segment of the rope 700 is maintained parallel or approximately parallel to the strip section 630 (or to the second support plate 620).

[0065] As shown, in some embodiments, the third set of pulleys 530 includes a pair of third pulleys 533, a fourth pulley 534, and a pair of fifth pulleys 535. The rotation axis of the fourth pulley 534 is perpendicular or substantially perpendicular (e.g., approximately 90 degrees) to the rotation axis of the third pulleys 533. The rotation axis of each of the fifth pulleys 535 may be perpendicular or substantially perpendicular to the rotation axis of the fourth pulley 534. The rotation axis of the fifth pulleys 535 is approximately parallel to the rotation axis of the third pulleys 533. The fifth pulleys 535 and the third pulleys 533 ensure that the rope 700 passes between the pair of the third pulleys 533, and then between the fourth pulley 534 and the strip section 630, making this segment of the rope 700 parallel or approximately parallel to the strip section 630 (or to the second support plate 620).

[0066] In other words, the first set of pulleys 510 may be disposed or provided on the transverse bar 120. The second set of pulleys 520 may be coupled with the second support plate 620. The rope 700 sequentially passes through the first set of

pulleys 510 and then the second set of pulleys 520, extending out from the second set of pulleys with its end suspended below the second set of pulleys 520. The second set of pulleys 520 changes the direction of the rope 700. The first angle encoder 810 is coupled with the second support plate 620 and positioned adjacent to the second set of pulleys 520 to sense the first offset angle of the rope 700. In some embodiments, optionally, the pulley system also includes a third set of pulleys 530. The third set of pulleys 530 may be coupled with the second support plate 620. The rope 700 sequentially passes through the first set of pulleys 510, the second set of pulleys 520, and then the third set of pulleys 530, before extending out from the third set of pulleys 530. The end of the rope 700 is suspended below the third set of pulleys 530.

[0067] The mobile dynamic body weight support device 100 includes a second angle encoder 820. The second angle encoder 820 may be disposed on or coupled to the first support arm 151. For instance, the second angle encoder 820 may be supported by a second bracket 817. The second bracket 817 may be fixedly coupled to the second support plate 620. The shape and size of the second bracket 817 may be determined according to the second angle encoder 820 or the second support plate 620. The second angle encoder 820 is configured to generate or provide a second signal corresponding to a second offset angle. The second offset angle corresponds to a relative rotation between the strip section 630 and the second support plate 620. The second signal may be generated in response to a relative rotation between the strip section 630 and the second support plate 620. The second signal may be generated by the second angle encoder in response to an angular displacement of the rope.

[0068] The mobile dynamic body weight support device 100 may also include a battery 180 or other power supply equipment (refer to **FIG. 1**). The battery 180 may be coupled to the frame 110. For example, the battery 180 may be disposed in a battery bracket which is in turn coupled to one of the longitudinal rods 130. Optionally, another of the longitudinal rods 130 may be equipped with a counterweight, so that the overall center of gravity of the frame 110 is approximately located at the (geometric) center of the frame 110, to avoid providing uneven training on the left side and to the right side of the user.

[0069] In use, the user 190 may wear a harness 192. The harness 192 may be equipped with two shoulder straps 194, which are each connected to the corresponding end of the respective rope (the ends of the ropes 700). For example, the left shoulder strap 195 may be coupled to the end of the left rope 701, and the right shoulder strap 197 may be coupled to the end of the right rope 702. In use for rehabilitative training, the ropes 700 may remain taut, providing an upward force that reduces the weight to be supported by the user. If the electromagnetic brake actuator 430 of the braking device 400 is in an operational mode, the braking pin 420 is retracted from between the teeth of the sprocket 410, allowing the motor's main shaft 310 to rotate. The mobile dynamic body weight support device 100 provides support through the left shoulder strap 195 and the right shoulder strap 197, with the corresponding motors 300 (301/302) and braking devices 400 (401/402) being independently adjustable.

[0070] The output of the motor 300 controls the rotation speed and direction of the main shaft 310. This output may be adjusted based on the user's height and weight to help provide adequate support for at least a part of the user's own weight. Throughout the rehabilitation training process, healthcare personnel can adjust the motor's output using the controller 372. The amount of support can thus be adapted according to the user's current weight and rehabilitation progress. This allows the user 190 to gradually experience and adapt to different levels of resistance caused by their own body weight, and to progressively learn to stand and walk independently under controlled conditions. In some embodiments, the mobile dynamic body weight support device 100 may include one or more controllers 372 and/or brake resistors 374, 238 to control the operation of the motor 300 and the drive wheels 210. The controllers 372 and brake resistors 374, 238 may be coupled to the frame 110.

[0071] The pulley system 500 includes guiding pulleys and angle encoders. The rope 700 first passes through the first set of pulleys 510 and then changes direction as it passes through the second set of pulleys 520. The second set of pulleys 520 is coupled with hinges 600. The first angle encoder 810 and the second angle encoder 820 are coupled to the hinges 600. The second angle encoder 820 may be positioned adjacent to the third set of pulleys 530 to sense a forward/ backward

displacement angle of the rope 700. The first angle encoder 810 is located on one side of the guide set of pulleys (i.e., the second set of pulleys 520) to sense the left and right (relative to the user 190 or the frame 110) (sideways) displacement or tilting of the rope 700. The end of the rope 700 is connected to the harness 192. In other words, the end of the rope 700 in the mobile dynamic body weight support device 100 with the harness 192 are respectively coupled with the two shoulder straps 194 of the harness 192. Preferably, the end of the rope 700 are configured to securely connect with the shoulder straps 194 of the harness 192.

[0072] When the user 190 walks forward, the end of the rope 700 also moves forward. At this moment, the second angle encoder 820 can read or sense the second angular displacement or angular offset of the rope 700 relative to the longitudinal direction. The second angle encoder 820 can be configured to calculate the corresponding walking speed based on the second angular offset and send a second signal to the drive wheels 210 at the base. In response to the second signal, the drive wheels 210 drive forward at a controllable and appropriate speed, enabling the frame 110 to automatically follow the user's movement. In other words, the second angle encoder 820 can be set up to send a second signal to the relevant drive wheels 210 in response to the second angular offset.

[0073] Generally, patients who need rehabilitation training to relearn walking do not have sufficient strength to support their entire body weight. If these patients also need to exert extra force to move the frame, it can be very challenging for them. Many rehabilitation training programs, therefore, use fixed-position (non-movable) training equipment. However, walking on a treadmill is different from walking on the ground, offering different experiences and outcomes.

[0074] Owing to the automatic following feature described in the embodiments of this document, the user (patient) 190 does not need to exert extra effort to move the frame 110, allowing them to focus on learning to walk according to their own rehabilitative goals and needs. Additionally, healthcare personnel (such as physical therapists) assisting the user (patient) 190 do not need to help push the frame 110, allowing them to focus on the user 190 undergoing rehabilitation training.

[0075] If the user 190 turns while walking or if there is asymmetry in their body posture, the offset angles of the two ropes 700 can also be sent to the base's drive

wheels 210 via the angle encoders 810/820. For example, in response to different offset angles of the two ropes 700, the two drive wheels 210 at the base 200 can perform differential movement. For instance, the first drive wheel 211 and the second drive wheel 212 may provide different rotational angles or rotational speeds. In other words, the differential between the two drive wheels 210 can be adjusted accordingly based on the first/second signals.

[0076] The angular offset of the two ropes 700 (on both sides) can also be used for an anti-collision function of the frame 110 which automatically avoids collisions between the user 190 and the frame 110. Generally, patients in rehabilitation often cannot maintain a nearly straight walking path. In some embodiments, the first angle encoder 810 may be configured to detect a parallel offset angle of the user 190 relative to the door frame (frame 110). For example, based on the parallel offset angle of the two ropes 700 (i.e., left rope 701 and right rope 702) relative to the frame 110, it can be determined whether the user 190 is approximately centered within or relative to the frame 110. For instance, based on the angular offset between the two ropes 700 (i.e., left rope 701 and right rope 702), the controller 372 may be configured to calculate the difference (if any) in the length of the ropes 700 (e.g., the left rope and right rope 701, 702) and determine whether the user 190 is approximately centered within the frame 110. If it is detected that the user 190 is too close to any of the longitudinal rod 130 (e.g., closer than a safety threshold), the left drive wheel and the right drive wheel 210 will be operated at different rotational speeds and/or directions of movement, causing the frame 110 to automatically move the user 190 to be approximately centered within the frame 110, maintaining an appropriate distance between the longitudinal rods 130 and the user 190. For example, the first angle encoder 810 may be configured to calculate the first offset angle of the two ropes 700 (701, 702) and send a first signal to the relevant drive wheels 210 in response to the first offset angle. The first angle encoder 810 can also be configured to send a first signal to the relevant drive wheels 210 in response to the first offset angle. For instance, the mobile dynamic body weight support device 100 may be configured so that, in response to detecting that the user 190 is closer to the first longitudinal rod 131, the second drive wheel 212 at the base of the second longitudinal rod 132 will displace more than the first drive wheel 211 at

the base of the first longitudinal rod 131. Conversely, if the user 190 is detected to be closer to the second longitudinal rod 132, the first drive wheel 211 at the base of the first longitudinal rod 131 will displace more than the second drive wheel 212 at the base of the second longitudinal rod 132. The frame automatically adjusts its position to prevent the user from colliding with the mobile dynamic body weight support device 100. This means that the user does not need to move purely to avoid collision with the mobile dynamic body weight support device 100, allowing for safer forward walking rehabilitation training.

[0077] The mobile dynamic body weight support device 100 can also include a function to prevent the user 190 from falling. If the user 190 feels unwell during the rehabilitation training, the user (patient) 190 or healthcare personnel can press the emergency stop switch 376. This switch 376 can be positioned on the handrails 140, longitudinal rods 130, or other easily accessible locations. In response to an emergency stop signal (generated in response to the emergency stop switch being activated), the braking device 400 may be configured to immediately halt the rotation of the motor's main shaft 310. All the motors 300 and the drive wheels 210 may be caused to stop operating in response to the emergency stop signal, causing the mobile dynamic body weight support device 100 to power off and cease operation. In other words, the length of the rope 700 from the second set of pulleys 520 to the end of the rope 700 depends on a state of the main shaft 310. In a power-off state, any rotation of the main shaft 310 is prevented, which in turn prevents changes in the length of the rope 700.

[0078] The following describes a strategy to prevent the user (patient) 190 from falling. The braking device 400 is configured such that when powered, the braking pin 420 is retracted and does not contact the sprocket 410 (brake disc). In the event of a power outage, the core of the electromagnet in the braking device 400 pops out or is displaced outward. The braking pin 420 is fixedly connected to the core, and the braking pin 420 is also pushed out when the core pops out. Once pushed out, the braking pin 420 will be inserted into one of the evenly distributed gaps 414 on the sprocket 410, locking the sprocket 410 and preventing further rotation of the sprocket. In other words, the braking pin 420 may be coupled with the electromagnet of the braking device 400. The braking device 400 may be

configured so that in response to either a power outage or an emergency stop signal, the braking pin 420 displaces and inserts itself into one of the gaps 414, causing the main shaft 310 to stop rotating. The sprocket 410 stops rotating, which halts the motor 300 and ceases the motor's output. The user 190 will remain at the current suspended height, thereby reducing the risk of falling.

[0079] According to some embodiments, the base 200 can include a drive assembly 240 and four omnidirectional wheels 220 (also known as universal wheels or caster wheels). The drive assembly 240 provides the driving force for the movement of the mobile dynamic body weight support device 100 (also referred to as "robot" in some applications). The four omnidirectional wheels 220 support the robot's own weight and load, enabling overall planar movement of the robot. The two sets of drive components are arranged symmetrically from left to right. The drive assembly 240 can be connected to the base of the frame 110 via screws. The drive assembly 240 may include a spring-loaded coupling 232, a compression spring 230, a connecting spring mount 234, a link 235, a drive wheel mount 236, and a rubber wheel 237. The preload or pre-tension force of the compression spring 230 ensures that the drive wheels 210 always remain in contact with the ground, preventing the wheels from becoming suspended or slipping when encountering depressions or protrusions. The drive wheels 210 may be disposed at the front part of the base 200, with a centerline of the two drive wheels 210 being in alignment (or substantially in alignment) with a standing position of the user (patient) 190. For example, the standing position of the user (patient) 190 and the respective centerline of the drive wheels may be aligned along a straight line, allowing the robot to rotate around the user's standing position (e.g., turning or rotating in place). In other words, in operation, the mobile dynamic body weight support device 100 is configured such that the drive wheels 210 respond to the first and/or second signals to align the frame 110 with the positions of the two drive wheels 210 and the user 190 in a straight line.

[0080] In another aspect, the present application discloses a dynamic weight support method 900. As schematically shown in **FIG. 17**, the method may include determining and controlling the movement of the mobile dynamic weight support device based on one or more angular offsets of the ropes (Step 902). The method

may further include moving (including rotation) the mobile dynamic weight support device based on the length difference of the left rope and the right rope (Step 904). For example, adjusting the position of the mobile dynamic weight support device until the user (patient) is approximately centered relative to the device. It is understood that the steps 902 and 904 shown in **FIG. 17** can be performed individually or in a different sequence, as needed.

[0081] The foregoing describes various embodiments of a mobile dynamic body weight support device 100 that can monitor various parameters through the angles and lengths of the ropes 700 and deliver feedback signals to components such as the drive wheels 210 and/or braking devices 400. The mobile dynamic body weight support device includes a movable frame 110 that supports a weight support system. The weight support system includes ropes 700 and a pulley system 500 arranged transversely on the frame 110, with each rope 700 and pulley system 500 functioning independently. Each rope 700 has one end connected directly to a drive motor 300 and the other end connected to a load-bearing harness. This harness connects to a right motor and a left motor situated on the respective sides of the mobile dynamic body weight support device. The right motor 301 and left motor 302 operate independently from one another. Each motor 300 is equipped with a corresponding braking device 400, which may include an electromagnetic brake. The braking device 400 is configured to stop or to prevent the rotation of the motor's main shaft 310 in response to an emergency braking signal, to provide additional assurance of safety. The output (e.g., torque) of each motor 300 may be adjusted based on a range of factors, including the user's height, weight, desired level of support, and the respective ropes. The second angle encoder 820 is configured to detect or sense the second offset angle of the ropes 700, such as the forward offset angle, and to determine the user's forward walking motion. The rotational movement of the user may also be determined based on differences in the second offset angles of the ropes. The first angle encoder 810 is configured to detect or to sense the first offset angle, e.g., the lateral offset angle or the parallel offset angle, and to determine the user's lateral alignment relative to the frame 110. The frame 110 is equipped with at least one pair of drive wheels 210, which can be controlled to move the frame 110 in response to signals from the angle encoders. This allows

the frame to follow the user's movement and automatically align or re-align to prevent collisions. Additionally, the coupling of the drive wheels 210 to the base of the frame may be spring-loaded with springs 230. The frame 110 may be mounted on multiple caster wheels 220 for easy movement or mobility. This configuration enables the mobile dynamic body weight support device to dynamically adjust its own position relative to the user (patient) to provide more effective support and to enhance the safety and efficacy of rehabilitation training.

[0082] The above description is intended to aid those skilled in the relevant technical field in understanding the technical solutions and embodiments related to this disclosure and are not intended to be exhaustive or to limit the scope of the present application. It should be understood that the illustrations and descriptions of the examples shown in the figures are for illustrative purposes only and should not be construed as the only possible ways of implementing the proposed technical solution. Furthermore, unless otherwise specified, the components or alternative examples described in one embodiment may also be applicable to other embodiments described herein.

CLAIMS

1. A mobile dynamic body weight support device, comprising:
 - a frame, the frame including:
 - a transverse bar;
 - two support arms, the two support arms being coupled to the transverse bar, the two support arms extending parallel to one another; and,
 - an assembly corresponding to each of the two support arms, the assembly including:
 - a wheel, the wheel being coupled to a base of the frame;
 - a hinge, the hinge including a first support plate and a second support plate, the first support plate being coupled to the respective one of the two support arms to form a cantilevered hinge;
 - a rope; and
 - a pulley system, the pulley system comprises:
 - a first set of pulleys, the first set of pulley being coupled to the transverse bar;
 - a second set of pulleys, the second set of pulleys being coupled with the second support plate; and
 - a third set of pulleys, the third set of pulleys being coupled with the second support plate, wherein the rope passes sequentially through the first set of pulleys, the second set of pulleys, and the third set of pulleys, and wherein an end of the rope extends beyond the third set of pulleys, a direction of the rope being changed by the second set of pulleys.
2. The mobile dynamic body weight support device as recited in claim 1, wherein the assembly further comprises:
 - a second angle encoder, the second angle encoder being coupled to the second support plate, wherein the second angle encoder is disposed adjacent to the third set of pulleys to sense a second offset angle of the rope.

3. The mobile dynamic body weight support device as recited in claim 2, wherein the wheel comprises a drive wheel, and wherein the second angle encoder is configured to generate a second signal to the drive wheel responsive to the second offset angle.

4. The mobile dynamic body weight support device as recited in claim 3, wherein the assembly further comprises:

a first angle encoder, the first angle encoder being coupled to the second support plate, wherein the first angle encoder is disposed adjacent to the second set of pulleys to sense a first offset angle of the rope, and wherein the first angle encoder is configured to generate a first signal to the drive wheel responsive to the first offset angle.

5. The mobile dynamic body weight support device as recited in claim 4, wherein the first angle encoder is configured to calculate an angular offset between two ropes corresponding to the two support arms, and wherein the first angle encoder is configured to send the first signal to the drive wheel in response to the angular offset.

6. The mobile dynamic body weight support device as recited in claim 4 or 5, wherein a differential movement between two of the drive wheel is dependent on the first signal, each of the drive wheel corresponding to a respective one of the two support arms.

7. The mobile dynamic body weight support device as recited in claim 4, wherein an actuation of the drive wheel is responsive to a detection of a parallel offset angle of the rope with respect to the frame.

8. The mobile dynamic body weight support device as recited in claim 7, wherein the rope is coupled to a respective shoulder strap of a harness, and wherein the

drive wheels are configured to be driven independently of one another to position a user in the harness in a center position relative to the frame.

9. The mobile dynamic body weight support device as recited in claim 1, further comprising:

a motor, the motor is coupled to the frame, the rope is coupled to a main shaft of the motor, a length of the rope from the second set of pulleys to the end of the rope being determined by a rotation of the main shaft; and

a braking device is coupled to the frame, wherein in a power-off state the braking device is configured to prevent a rotating motion of the main shaft.

10. The mobile dynamic body weight support device as recited in claim 9, wherein the braking device comprises:

a sprocket fixedly coupled with the main shaft, the sprocket having a plurality of teeth, adjacent ones of the plurality of teeth being spaced apart to define a corresponding plurality of gaps between the plurality of teeth; and

a brake pin, the brake pin is coupled with an electromagnet of the braking device, wherein the braking device is configured to lock the main shaft in response to either a power failure or an emergency braking signal, the brake pin being configured to be inserted into one of the plurality of gaps to lock the main shaft.

11. The mobile dynamic body weight support device as recited in claim 1, wherein the wheel further comprises a compression spring, the compression spring being provided with a preload.

12. The mobile dynamic body weight support device as recited in claim 4, further comprising a harness, the harness comprises two shoulder straps, each of the two shoulder straps may be coupled with the end of the corresponding rope.

13. The mobile dynamic body weight support device as recited in claim 4, in operation, the drive wheel is configured to displace the frame to align the frame with a position of a user, in response to the first signal and/or the second signal.